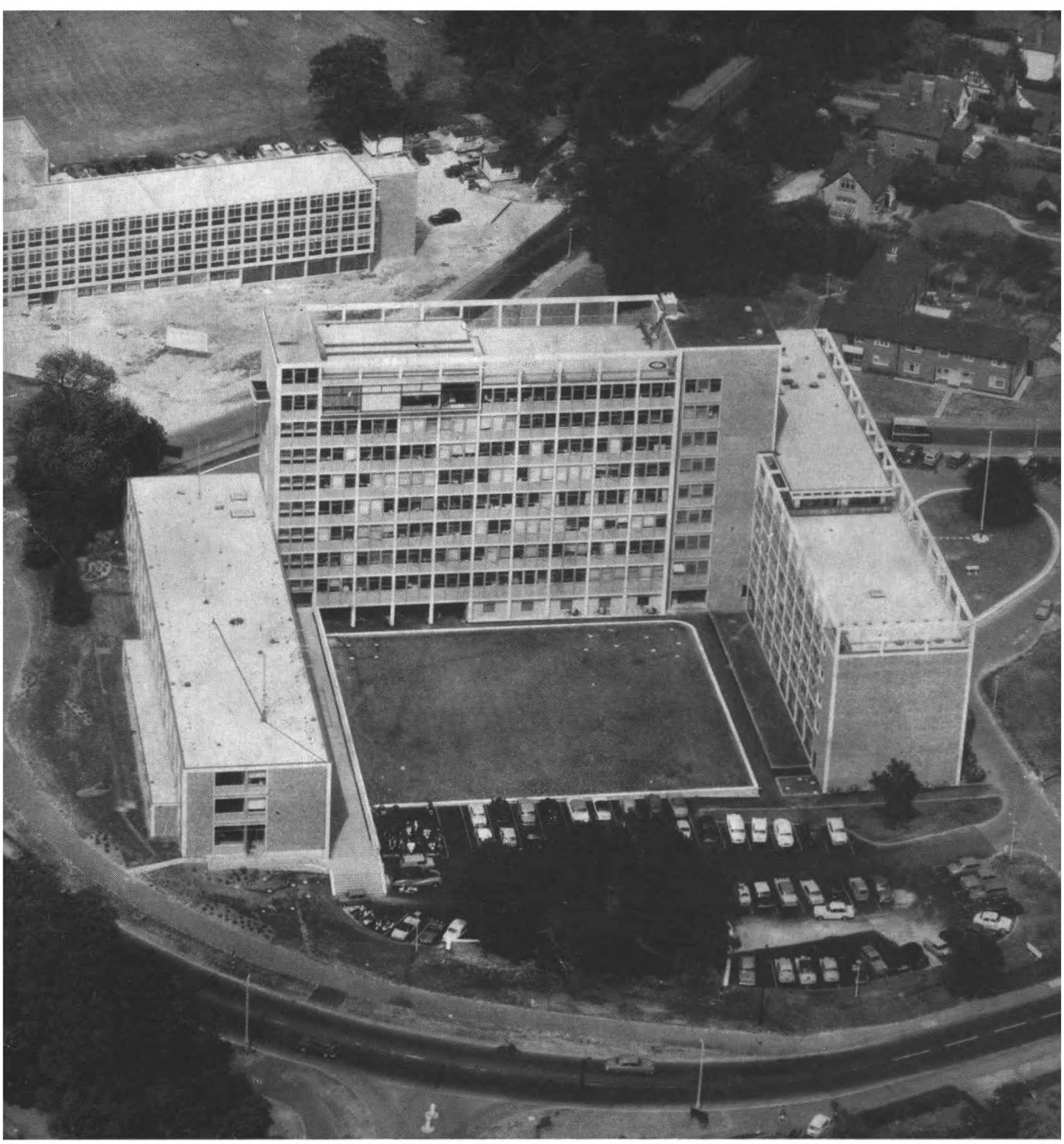
METEOROLOGICAL OFFICE

ANNUAL REPORT 1965



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ANNUAL REPORT
ON THE
METEOROLOGICAL OFFICE
1965

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

LONDON
HER MAJESTY'S STATIONERY OFFICE
1966

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FOREWORD BY THE DIRECTOR-GENERAL

This report records another year of steady progress and ever-increasing demand for the services of the Meteorological Office by aviation, industry, and the general public. The number of forecasts for aviation rose by 8 per cent to nearly $1\frac{1}{4}$ million, non-aviation inquiries by 20 per cent to well over a million, and the calls on the Automatic Telephone Weather Service by 12 per cent to nearly 8 millions. There has also been a considerable increase in the frequency of weather bulletins on sound radio, which now total 108 minutes each day on the three BBC services. This rapid increase in demand is most gratifying because it shows that meteorology is making an ever-increasing contribution to the economic and social welfare of the country. We are actively exploring new areas of industry which might benefit from meteorological advice because we are convinced that the economic value of our services to agriculture, industry and transport greatly exceeds their cost.

High among the more important events of the year were the commissioning in July of the English Electric-Leo-Marconi KDF9 computer, and the introduction of routine numerical forecasts on 2 November. Computed surface and upper air charts, produced twice daily, are now assimilated in the daily routine of the Central Forecasting Office and are transmitted by facsimile to London Airport and other important offices. These computed forecasts are already as good as those produced by an experienced forecaster and will almost certainly form the basis of operational forecasting in the near future.

The long-range (monthly) forecasts have had their striking successes (e.g. October) and failures (e.g. November) but, on the whole, continue to show an encouraging degree of skill. As described in the special article on page 47, nearly three-quarters of the 50 forecasts issued so far have been in good or moderate agreement with events. In view of the difficulties of finding good historical analogues, and the overall empirical approach, it would be optimistic to expect rapid improvements in reliability, but the present forecasts are judged by a wide variety of customers to be useful and a good deal better than no guidance at all.

Forecasts for one to two days ahead are accurate on more than 80 per cent of occasions. The production of reliable numerical forecasts for up to five days ahead is now being much discussed, especially in the United States of America. This may be feasible with more complete observational data from the whole northern hemisphere, especially from the oceanic and tropical regions, and with much larger computers than are available at present. This is the motive behind the proposals for a World Weather Watch, an international programme of world-wide weather observations backed up by a massive research study of the global behaviour of the atmosphere. This scheme, which is estimated to cost 100–200 million dollars per annum, will be seriously considered by the World Meteorological Organization in the next year or two, and Britain may well be asked to play an important part. International co-operation, which forms the subject of the first special article this year, is of vital importance in meteorology and will become even more so as weather forecasting expands in both area and duration.

Looking now at meteorology as a science, it is evident that, after a long period of steady but unspectacular development, it has recently received strong impetus from the new technology of high-speed computers, rockets, satellites,

radar, etc. and from the prospect of weather modification and control. The remarkable growth of interest and effort over the last few years, especially in the United States and Russia, is illustrated by the fact that the United States Federal Government expenditure on the atmospheric sciences increased by 440 per cent between 1959 and 1965, during which period nearly 1000 million dollars were spent on research and rather more than this on weather services. Even more revealing is the fact that whereas the United States spends rather more on atmospheric research than on nuclear physics, the ratio in Britain is only one to twenty.

Of course we cannot hope to match the American effort across the whole spectrum of atmospheric research but, by concentrating on a few areas of particular importance and promise, we can make a major contribution. The priority and provision for meteorological research should reflect the scientific and economic importance of the subject. I therefore look forward to a larger and more concentrated effort within the Meteorological Office over the next few years. I am also anxious that the Office should work in close collaboration with other government establishments and the Universities and so make maximum use of manpower and facilities. In all this, much will depend upon the ability of the Meteorological Office to attract high-calibre physicists and mathematicians to whom it can offer an exciting and rewarding career.

B. J. MASON

Meteorological Office,
Bracknell, Berks.

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PLATES

(Between pages 36 and 37)

I. The new experimental instrument screen.
II. The KDF9 computer installation operating area at HQ Bracknell.
III. A more extended view of the KDF9 computer.
IV. Completion of a weather map at London Weather Centre.
V. Window display, London Weather Centre, High Holborn.
VI. Prototype of Mk3 radiosonde with internal insulation removed.
VII. Prototype of Mk3 radiosonde showing internal insulation material.
VIII. The Meteorological Research Flight Building.
IX. The Headquarters Building of the World Meteorological Organization.

FUNCTIONS OF THE METEOROLOGICAL OFFICE

The Meteorological Office is the State Meteorological Service. It forms part of the Air Force Department of the Ministry of Defence. The Director-General is responsible to the Secretary of State for Defence through the Minister of Defence (RAF) and the Second Permanent Under Secretary of State (RAF).

The general functions of the Meteorological Office are:

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

(ii) Liaison with the Naval Weather Service of the Navy Department 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 at certain stations overseas.

(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 for the Meteorological Office, including that on the common services, is of the order of £7,200,000. Of the amount chargeable to Defence (Air) Votes, about £5,100,000 represents expenditure associated with staff and £1,900,000 expenditure on stores, communications and miscellaneous services. Some £1,700,000 is recovered from other Government Departments and outside bodies in respect of special services rendered, sales of meteorological equipment, etc.

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.

The membership of the Committee on 31 December 1965 was:

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

Members: Mr S. Earl
Colonel A. Raymond Mais, O.B.E., T.D.
Professor J. Proudman, F.R.S.
Professor P. A. Sheppard, C.B.E., F.R.S. (Chairman, Meteorological Research Committee) (*ex officio*)

Secretary: Mr B. M. Day (Secretary, Meteorological Office)

The Committee met three times in 1965.

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.

The membership of the Committee on 31 December 1965 was:

Chairman: Dr B. J. Mason, F.R.S. (Director-General, Meteorological Office)

Members: Professor J. N. Black, F.R.S.E. (University of Edinburgh)
Mr J. B. Dempster (Scottish Development Department)
Mr W. O. Kinghorn (Department of Agriculture and Fisheries for Scotland)
Dr R. W. H. Stevenson (University of Aberdeen)
Mr J. Paton, F.R.S.E. (Royal Society of Edinburgh)
Professor P. A. Sheppard, C.B.E., F.R.S. (Royal Meteorological Society)
Dr C. H. Mortimer, F.R.S.E., F.R.S. (Royal Society)
Professor D. W. N. Stibbs, F.R.S.E. (University of St Andrews)
Professor P. A. Sweet (University of Glasgow)
Dr J. Steele (Department of Agriculture and Fisheries for Scotland)

Secretary: Mr R. Cranna (Meteorological Office)

The Committee met on 5 May 1965.

METEOROLOGICAL RESEARCH COMMITTEE

Terms of reference:

The Meteorological Research Committee will advise the Minister of Defence for the Royal Air Force 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.

The membership of the Committee on 31 December 1965 was:

Chairman: Professor P. A. Sheppard, C.B.E., F.R.S.

Members: Dr A. C. Best, C.B.E. (Director of Services, Meteorological Office)

Professor R. L. F. Boyd

Instructor Captain G. P. Britton, R.N. (Naval Weather Service of the Navy Department)

Wing Commander P. H. J. Buddery, M.B.E. (Air Force Department)

Professor D. R. Davies

Dr G. E. R. Deacon, C.B.E., F.R.S.

Dr E. R. R. Holmberg (Army Department)

Dr B. J. Mason, F.R.S. (Director-General, Meteorological Office)

Mr D. E. Morris (Ministry of Aviation)

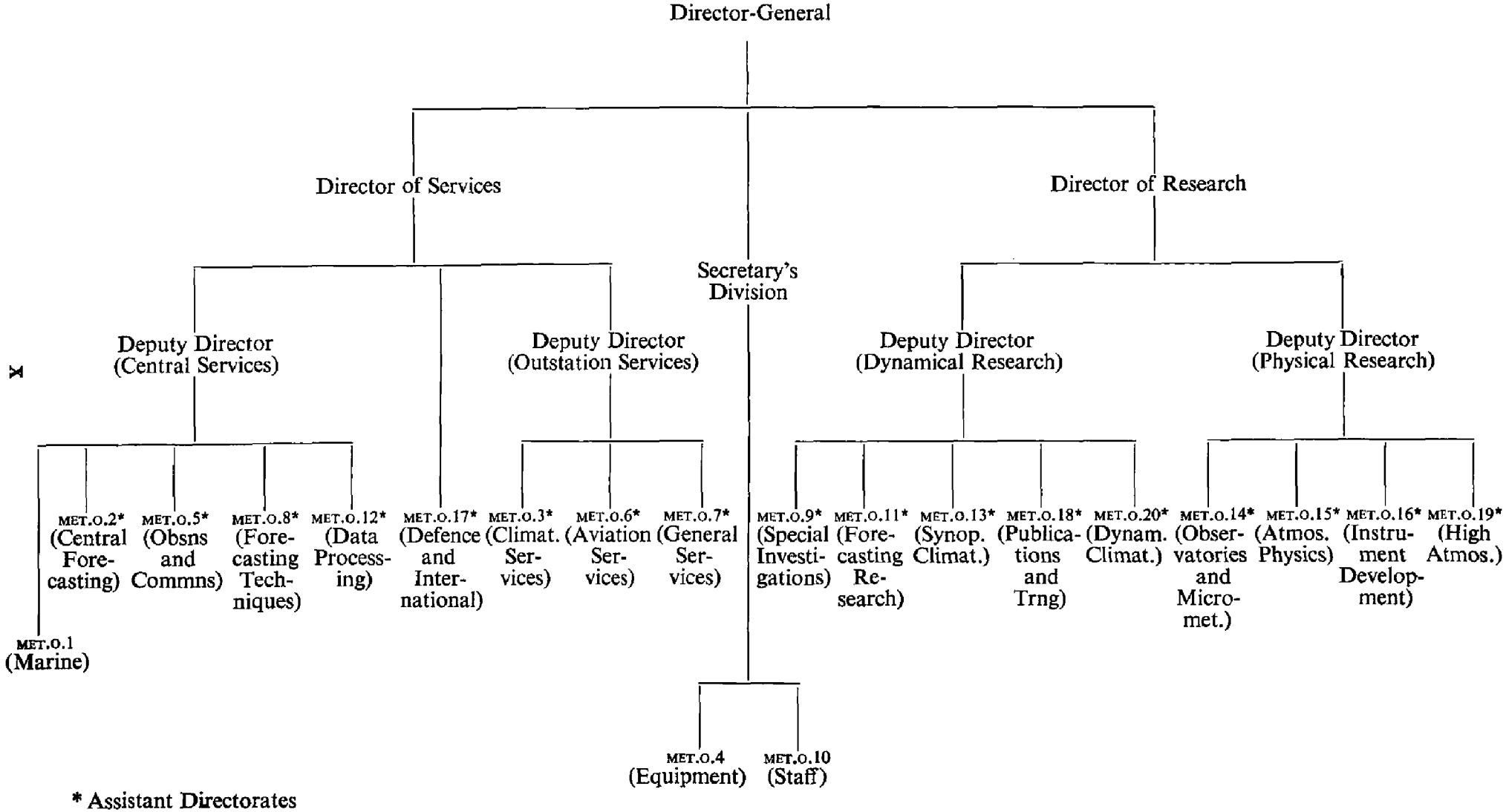
Mr J. Paton, F.R.S.E.

Mr J. S. Sawyer, F.R.S. (Director of Research, Meteorological Office)

Secretary: Mr. F. E. Dinsdale (Meteorological Office)

The Committee met twice in 1965 and its sub-committees seven times.

METEOROLOGICAL OFFICE HEADQUARTERS ORGANIZATION



* Assistant Directorates

PRINCIPAL OFFICERS OF THE METEOROLOGICAL OFFICE

(on 31 December 1965)

DIRECTOR-GENERAL

B. J. Mason, D.Sc., F.R.S.

DEPUTY TO DIRECTOR-GENERAL

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

DIRECTOR OF RESEARCH

J. S. Sawyer, M.A., F.R.S.

DEPUTY DIRECTORS

Physical Research	G. D. Robinson, Ph.D., F.Inst.P.
Dynamical Research	E. Knighting, B.Sc.

ASSISTANT DIRECTORS

Special Investigations	A. G. Forsdyke, Ph.D., A.R.C.S.
Forecasting Research	F. H. Bushby, B.Sc., A.R.C.S.
Publications and Training	C. J. Boyden, B.A.
Synoptic Climatology	M. H. Freeman, O.B.E., M.Sc.
Observatories and Micrometeorology	L. Jacobs, M.A., M.Sc.
Atmospheric Physics	R. F. Jones, B.A.
Instrument Development	A. L. Maidens, B.Sc.
High Atmosphere	R. Frith, O.B.E., Ph.D.
Dynamical Climatology	G. A. Corby, B.Sc.

DIRECTOR OF SERVICES

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

DEPUTY DIRECTORS

Central Services	P. J. Meade, O.B.E., B.Sc., A.R.C.S.
Outstation Services	B. C. V. Oddie, C.B.E., B.Sc.

ASSISTANT DIRECTORS

Central Forecasting	V. R. Coles, M.Sc.
Climatological Services	R. H. Clements, M.A.
Observations and Communications	L. H. Starr, M.B.E., M.Sc.
Aviation Services	J. K. Bannon, B.A.
General Services	J. Harding, B.A., M.Sc.
Forecasting Techniques	T. N. S. Harrower, M.A., B.Sc.
Defence and International	C. W. G. Daking, I.S.O., B.Sc.
Computing and Data Processing	N. Bradbury, B.Sc.
Marine Superintendent	C. E. N. Frankcom, O.B.E., R.D., Commander, R.N.R. (retd)

SECRETARY, METEOROLOGICAL OFFICE

B. M. Day, B.Sc. (Econ.)

THE DIRECTORATE OF SERVICES

SPECIAL TOPIC

International Collaboration in Meteorology

History. The earth's atmosphere is a whole which cannot be divided to conform to political frontiers. It is for this reason that the nations of the world awoke early to the necessity of large-scale international co-operation to study the vagaries of the weather and to apply the knowledge thus gained to the various activities of men. The first effort towards international collaboration in meteorology occurred in 1853 when a meeting of sea-going nations drew up a programme of weather observations over the oceans to contribute to the safety of life at sea. To organize the necessary international collaboration in making and collecting weather observations not only at sea but also on land, the International Meteorological Organization (IMO) was established in 1878 by the Directors of National Weather Services. This organization developed steadily over the next seventy years concentrating, during the early period in particular, on improving the services provided by meteorologists for navigation and agriculture and the system for exchanging weather information between different countries. During the present century, the birth and development of aviation created a need for meteorological information along air routes and at airfields. This gave a tremendous impetus to the study of the weather. At the same time, revolutionary advances in other branches of science and technology, such as telecommunications, greatly helped meteorologists in meeting this new challenge.

The World Meteorological Organization (WMO). The creation of the United Nations (UN) provided a new framework for international collaboration in many areas including science and technology. Consequently, the Conference of Directors of National Meteorological Services, which met in Washington, D.C., U.S.A. in 1947 adopted the World Meteorological Convention establishing a new organization founded on a formal agreement between governments. Thus, in 1951 the new World Meteorological Organization began its activities, the former Organization, IMO, having been dissolved. In December of that year the General Assembly of the United Nations approved an agreement whereby the WMO was recognized as a Specialized Agency of the United Nations. Among the purposes of WMO is the furtherance of the application of meteorology to aviation, shipping, agriculture and other human activities. The world-wide exchange of meteorological observations provides the basic information for forecasting and research for the benefit of aviation, shipping, agriculture, commerce, industry, public utilities and so on. This is why international co-operation in meteorology is a necessity, and through WMO this co-operation has become a daily reality. To make weather observations from stations throughout the world comparable and have meaning, it is necessary to standardize methods of observation and to agree on codes for the transmission of the coded observations. To achieve this, WMO issues internationally-agreed guides and regulations. Thus the unique character of meteorological collaboration between countries lies in the daily implementation of international decisions.

The supreme body of WMO is the World Meteorological Congress which meets every four years in Geneva. It brings together the national delegations of Members and some non-Members and representatives of sister agencies and other bodies with an interest in meteorology. Its main tasks are to determine the policies of the Organization for the following four years, establish the technical programme and fix the budget for the four calendar years following each session. The last Congress (April 1963) took encouraging action to promote all aspects of the atmospheric sciences with particular emphasis on the concept of a World Weather Watch. The ultimate objective is a world-wide meteorological system composed of co-ordinated facilities and services provided mainly by individual Members, to ensure:

(i) the obtaining of systematic information on the state of the atmosphere,
(ii) the timely and co-ordinated collection and dissemination of weather data and processed information on the state of the atmosphere, carried out by a system in which every National Service will disseminate information it has collected for use by other Services and can, in its turn, receive the global information it needs, and,
(iii) the processing of data and weather analysis and forecasts by a system of world, regional and national centres in which products appropriate to the type of centre, and to the users' needs will be prepared. National Services will have access to those products required to meet their national needs.

Planning for the World Weather Watch is proceeding in three phases.

Phase I July 1964–April 1965. General design study providing a preliminary plan for:

(i) Location and functions of world and regional meteorological centres,
(ii) Characteristics of global communications networks,
(iii) Characteristics of present observational system and identification of deficiencies.

Phase II June 1965–April 1966. Detailed design of World Weather Watch, including new technological developments especially relating to global communications and data processing systems.

Phase III June 1966–February 1967. World Weather Watch implementation plan for presentation at Fifth Congress (April 1967).

In considering these plans and the increase in meteorological data expected to be available, both conventional and satellite, great concern has been expressed that the necessary improvements in international meteorological telecommunications will not be realized soon enough to make the information available satisfactorily. Similar concern has been expressed regarding the vast gaps over oceanic areas in the world-wide network of reporting stations, particularly upper air stations. These problems have, therefore, been chosen for particular attention by WMO in the early stages of planning for the World Weather Watch.

The delegation of the United Kingdom to the Congress of WMO usually consists of the Director-General of the Meteorological Office as Principal Delegate, the Director of the Naval Weather Service of the Navy Department, a representative of the Permanent Under Secretary of the Air Force Department who is primarily responsible for financial and administrative matters, and the Assistant Director (Defence and International). A delegation of four is required since there are three committees working full time.

The Members of WMO are not all Sovereign States. Membership is open to any State or Territory which administers a meteorological service of its own, and all Members whether States or Territories enjoy equal technical rights within WMO. By the end of 1965 after some 14 years of its existence WMO had a membership of 126, consisting of 114 States and 12 Territories. When a Territory attains complete independence, that is, becomes wholly responsible for its international relations, it becomes a State, thereby acquiring additional voting rights on non-technical matters which it will not previously have had.

While Congress concerns itself with major long-term matters, the implementation of its decisions rests with the 21-member Executive Committee which meets annually. Its members include the President and Vice-President of WMO, the Presidents of the six Regional Associations and 12 elected members. All meteorological questions of international interest come within the terms of reference of the Executive Committee, which is in effect the operational governing body of the Organization. It sends information and directives to the other main bodies, the Regional Associations and the Technical Commissions and of course to the Secretary-General, for appropriate action.

The Regional Associations, of which there are six, in effect one for each continent, are mainly operational rather than scientific bodies, and deal with such matters as networks of stations, telecommunications, codes and the regional application of decisions of Congress, the Executive Committee and the Technical Commissions. Regional Associations are composed of Members of WMO, whose networks of stations lie in or extend into the Region. Thus, a Member of WMO may elect to belong to more than one Regional Association. The Regional Associations meet once every four years, but between meetings they may by correspondence make decisions on matters of concern to themselves. To look after meteorological organization in the Antarctic the Executive Committee has a working group composed of members nominated by countries which are signatories to the Antarctic Treaty. For this purpose the Antarctic area is chosen to begin at latitude 60° south. The United Kingdom is a Member of Regional Association VI (Europe) and is represented on the Executive Committee Working Group on Antarctic Meteorology.

The scientific and technical work of WMO rests mainly with the Technical Commissions which are as follows:

Commission for Aerology
Commission for Aeronautical Meteorology
Commission for Agricultural Meteorology
Commission for Climatology
Commission for Hydrometeorology
Commission for Instruments and Methods of Observation
Commission for Maritime Meteorology
Commission for Synoptic Meteorology

The eight Technical Commissions are composed of individuals who are experts in the technical fields concerned and who are designated by governments. These Commissions also meet once every four years, usually at the invitation of various Members who wish to act as host country. The United Kingdom is represented on all eight Commissions and sends delegations to their meetings.

Whenever it is desirable that a particular problem should be studied by a small group of experts, the Technical Commission or Regional Association concerned establishes a working group so that progress may be made between sessions of the particular parent body.

As one of its principal actions following the UN Resolutions on the Peaceful Uses of Outer Space, Fourth Congress created a WMO Advisory Committee with broad Terms of Reference in the fields of research and operations relating to the atmospheric sciences.

Eminent scientists from all parts of the world are members of this Committee which meetso nce a year at WMO Headquarters in Geneva. Professor R. C. Sutcliffe, formerly Director of Research, has been a member of this Committee since its creation in 1963 and was Chairman at its second session in February 1965. The membership includes scientists familiar with the activities of the International Council of Scientific Unions (ICSU), (see page 6).

At the heart of WMO is the Secretariat, under the Secretary-General, Mr D. A. Davies of the United Kingdom. The system of central, regional and technical bodies described above enables this nucleus to be very much more compact than would otherwise be the case. Besides providing the central administrative machinery of the Organization and of its many meetings, the Secretariat has a considerable role to play in the production of actual technical material. It prepares specialized publications, many of them standard works, and some of them are kept continuously up to date, so that publication never really ceases. It carries out the Organization's public relations, with non-Member States as well as with the general public. Also, the Secretariat is an important link between Meteorological Services of the world.

The basic principle of the system under which WMO operates is that the technical strength of the Organization lies with the National Meteorological Services and not, as is the case with many other UN Specialized Agencies, with the Secretariat. The National Services themselves contribute in many ways to the activities of the Organization, of which they are virtually an integral part. This system operates very successfully. It also does much to maintain the international spirit of comradeship between meteorologists throughout the world; this is in many ways unique.

The International Civil Aviation Organization (ICAO). The first attempt to reach international agreement on standards concerning procedures for civil aviation was made in 1910 by nineteen European nations but it resulted in failure. The next effort was made in 1919 at the Versailles Peace Conference after World War I had helped to develop the aeroplane into a more effective means of transport. Thus the International Commission for Air Navigation (ICAN) came into being to deal with the technical details of international flights. ICAN had a sub-commission to deal with meteorological matters on which the United Kingdom was represented by the Meteorological Office. In November 1944, following the vast expansion of the use of aircraft during World War II for passenger and freight carriage, the U.S.A. invited 55 allied and neutral States to meet in Chicago to discuss the problems which would arise in the civil aviation field unless international agreement was reached. After five weeks of strenuous work, the outcome was the Convention on International Civil Aviation containing ninety-six Articles relating to privileges of and restrictions on all contracting States, the adoption of standards and recom-

mended practices concerning air navigation, the installation of navigation facilities and the facilitation of air transport. A provisional organization operated until the Convention was ratified by twenty-six States but on 4 April 1947 when the required number of ratifications had been obtained ICAO officially came into existence.

Like WMO, ICAO is a UN Specialized Agency. It maintains close liaison with many of its sister agencies especially WMO, the International Telecommunications Union, the World Health Organization and the Universal Postal Union, for reasons which do not need explanation.

Each UN Agency, being autonomous as regards internalstructu re, has developed on lines best suited to itself. Thus ICAO encompassing every facet of civil aviation activity has a more complex structure than WMO. Its supreme body is the Assembly, which meets once every three years and is attended by delegations of contracting States. At these sessions, the work of ICAO in the technical, economic, legal and other fields is reviewed and guidance given to the other bodies of ICAO for their future work.

The Council is a body in permanent session, responsible to the Assembly and is composed of representatives of 27 States elected by the Assembly for a three-year term. It provides the continuing direction of the work of ICAO. Among its major duties is the adoption of international standards and recommended practices. In general, it may take whatever steps are necessary to maintain the safety and regularity of operation of international air transport.

Among the Council's subordinate bodies is the Air Navigation Commission which is composed of twelve members appointed by the Council after nomination by member States. The Commission has responsibility for the work of a number of Divisions dealing with such matters as Airworthiness, Communications, Search and Rescue, Air Traffic Control and naturally Meteorology. The Meteorological Division of ICAO is responsible for all the operational aspects of the meteorological support to civil aviation, including procedures at meteorological offices, exchanges of data for air operations, and ground–air exchanges of meteorological information, while WMO is responsible in this field for basic matters such as the provision and maintenance of adequate networks of surface and upper air observations and the exchange of these data together with analyses of surface and upper air charts taking into account the aeronautical requirements for these analyses. Further details of the co-operation between ICAO and WMO will be commented on later in the section on collaboration between international bodies.

In dealing with international civil aviation, ICAO considers that there are many subjects which should be dealt with on a regional basis instead of on a world-wide scale. ICAO has therefore set up eight geographical regions in which Regional Air Navigation meetings are held from time to time. The Meteorological Office has a primary interest in the North Atlantic Region and is always represented at meetings of this body. It also has to watch the interests of British operations in such areas as the Africa–India Ocean Region and the European-Mediterranean Region.

ICAO has always been aware of the need to provide air navigation facilities in regions of undetermined sovereignty, e.g. the high seas, and for this reason has fostered a number of joint support projects. One of these is the ICAO North Atlantic Ocean Station project. Nine stations are manned and their cost shared by nineteen nations whose aircraft fly across this ocean. Their purpose is to fill

gaps in the weather reporting networks of the northern hemisphere, to provide meteorological and radio navigation aids for aircraft and serve as floating search and rescue bases. Canada, France, the Netherlands, Norway, Sweden, the United Kingdom and the U.S.A. have accepted the responsibility of providing ships to man the stations while twelve other nations regularly make cash payments to assist in defraying the costs of the service. Several hundreds of people have been saved from the Atlantic as a result of the presence of these ships. This is an outstanding example of international co-operation, providing as it does a three-fold benefit to human activities.

The International Council of Scientific Unions. It should now be made clear that so far consideration has been given to international collaboration brought about by governmental organizations of the UN family.

ICSU, to which the Royal Society adheres on behalf of the United Kingdom, originated as the International Research Council in 1918 and arose from the need of scientists throughout the world to co-operate in scientific enterprises. The nature of ICSU as a non-governmental body cannot be too strongly stressed. Most of its National Members adhere through their National Academies or Societies, a few through research councils and some through their governments in the absence of any other appropriate body. There are fourteen Unions constituting ICSU. The most important from the meteorological aspect is the International Union of Geodesy and Geophysics (IUGG) which is composed of seven constituent associations, one of which is the International Association of Meteorology and Atmospheric Physics (IAMAP). IAMAP and WMO maintain close relations and many of the recommendations made by the former have been subsequently endorsed and implemented by WMO through its Members. Notable examples of this type of collaboration are afforded by the International Geophysical Year (IGY) and the International Years of the Quiet Sun (IQSY).

For each of the 14 scientific unions of ICSU a British National Committee has been formed. The Meteorological Office has membership of several of these and their sub-committees. Examples of the disciplines in which there is a meteorological interest are geomagnetism, seismology, hydrology and scientific radio. The functions of these Committees are the promotion of the science with which they are concerned especially as regards international requirements.

In addition to its affiliated Unions, ICSU has created three Scientific Committees—on Oceanic Research, Antarctic Research and Space Research. The meteorologist is concerned in all these activities and the Meteorological Office plays its part in furthering research and meteorological knowledge in association with the appropriate bodies of the Royal Society.

Technical Co-operation. Technical co-operation between countries takes place mainly in one or other of the following two ways: the first is under the auspices of a UN programme and the second is by bilateral agreement between two nations. Its purpose is to assist developing nations in strengthening their industry, commerce, agriculture and resources generally and training their people in the sciences, administration and so on, to enable them to achieve ultimately a higher standard of living.

The UN itself and several of its associated Agencies including WMO and ICAO participate in the Expanded Programme of Technical Assistance (EPTA). Under this scheme assistance usually takes one of two forms:

(i) expert advice and assistance, or
(ii) individual training.

Experts may be requested individually or in teams, to advise on or assist with a general field of activity or to train local staff. They are often recruited for specific assignments from relevant institutions in the countries of the more-developed nations. Training is provided for by fellowships and scholarships granted to individuals or as part of a comprehensive project, or by group training within the developing country itself. Such group training may include the holding of seminars and training courses, as well as the organization of permanent training institutes. There are now Chairs of Meteorology in the Universities at Nairobi and Leopoldville (Congo) and Regional Training Centres in Lagos, Nairobi and Leopoldville for students training to become forecasters and observers. All these projects received assistance from EPTA sources. In 1964, the number of countries in receipt of technical assistance under the EPTA programme of WMO was 68, while 111 fellowships were awarded; the latter figure was double that of 1963. The remarkable increase in fellowships awarded demonstrates the increasing interest of recipient countries in the training facilities offered by WMO, and carried out by National Meteorological Services, Universities and Meteorological Institutes.

The UN Special Fund was created in 1958 to assist developing countries with large projects, designed to accelerate their economic development, which would involve heavier budgetary commitments than would be appropriate for EPTA. In general, the Governing Council of the Special Fund provides an amount of money varying between one-third and one-half of the cost of a project, the recipient country providing the remainder, but there are exceptions. Since this Fund was introduced WMO has been Executing Agency for nine projects in the fields of meteorology and hydrology. Notable examples are the creation of a Central Meteorological Institute in Israel for training and research, and projects in Ecuador and Peru to expand the Meteorological and Hydrological Services in these countries. The International Meteorological Centre in Bombay and the Institute of Tropical Meteorology in Poona have both received aid from the Special Fund. In the International Meteorological Centre a computer is in use for the processing and analysis of data collected during the Year of the International Indian Ocean Expedition (1964)—this computer was supplied as part of Special Fund assistance.

A third activity of the UN in Technical co-operation is provided by the Operational and Executive (OPEX) scheme—Technical Assistance in Public Administration. Under this scheme experts are provided for operational and executive functions. That is, the experts actually carry out specific duties within a Service and at the same time pass their skill and knowledge to the people of countries receiving such assistance. The following examples are given:

(i) A Director and Scientific Officer in the East African Meteorological Department.
(ii) Two forecasters, Meteorological Service, Nigeria.
(iii) One forecaster, Meteorological Service, Bahamas.
(iv) Assistant Director for Technical Affairs, Meteorological Service of Libya.

Reference has been made to bilateral assistance between Meteorological Services. This may take one of several forms. Many National Services operate Training Schools for professional meteorologists. Among these is the Meteoro-

logical Office which provides post-graduate courses for Scientific Officers, courses for Forecasters and Observers, courses in upper air techniques for students training for duties at radiosonde and radar wind stations, and special courses in Climatology and Maritime Meteorology. Students from countries all over the world are admitted to the Meteorological Office Training School whenever there are places to spare and it is significant that the demand for these places continues at a high level. As is to be expected most overseas students come from the Commonwealth countries but others have come from the United Arab Republic, Indonesia, Switzerland, Syria and Turkey. In 1964, 61 students other than Meteorological Office staff attended courses at the school.

Sometimes, the Office is approached by the Ministry of Overseas Development, or the Crown Agents for the Colonies seeking its help either to release operational staff to work in countries of the Commonwealth owing to the grave shortage of trained personnel, or to release staff for tours in those countries as advisers on specific meteorological problems. These requirements are independent of the vacancies in the WMO and ICAO Technical Assistance programmes or in the WMO and ICAO Secretariats themselves, which are notified to the staff of the Meteorological Office as they occur. Thus considerable strain is placed on the trained manpower of the Office, for no reserve pool exists for the purpose of manning posts overseas other than those for which there is a British requirement. Consequently it is not always possible to release members of the staff for appointments with WMO or ICAO, much as it is desirable to do so.

Apart from formal training at the Training School, requests are received from other countries for facilities for 'on-the-job' training either at Headquarters, e.g. in the Climatology Division, or at an upper air station, or even for a short tour of all the major types of Meteorological Office establishments to gain knowledge over the whole field of modern meteorological practice. Such visits are welcomed because they also may help to encourage good relations between people of different nationalities, leading to an international outlook which is an essential for all meteorologists who have to travel the world in the course of their duties.

Agreements and Working Arrangements between International Organizations. The UN and its Specialized Agencies have agreements between themselves and the parent body which set out procedures for co-operation and consultation, reciprocal representation, exchange of information and documents, administrative and technical services, primarily to establish official recognition by the UN of the responsibilities attaching to each Agency for such actions as may be appropriate under its Charter or Convention.

Similarly, UN Specialized Agencies have agreements between themselves, usually in the form of a document setting out working arrangements. Thus WMO has working arrangements with the World Health Organization (WHO), Food and Agriculture Organization (FAO), International Civil Aviation Organization (ICAO), United Nations Educational, Scientific and Cultural Organization (UNESCO), International Telecommunications Union (ITU) and Inter-Governmental Maritime Consultative Organization (IMCO). Probably the most essential one of these is that between WMO and ICAO since each of these agencies is concerned in the science and technical methods and practices of meteorology. As would be expected, the working arrangements between WMO and ICAO delineate their respective spheres of activity in the

fields of aeronautical meteorology, provide machinery for their collaboration, and give guidance for the conduct of sessions of representative bodies and to the Secretariats of the two Organizations. In determining primary responsibility for sectors of common interest the two Organizations have agreed that the following broad principles shall apply:

(i) Matters requiring collaboration with other aeronautical services or concerning planned or actual airline operations are regarded as lying primarily within the responsibility of ICAO.

(ii) Matters which relate to basic meteorological facilities required to provide service to international navigation or to meteorological techniques and practices employed in providing such service are regarded as lying primarily within the field of responsibility of WMO.

(iii) Matters not falling clearly within category (i) or (ii) are regarded as having mutual interest and are dealt with by appropriate collaboration between the two Organizations.

As would be expected ICAO and WMO freely advise and consult each other. Each Organization has the right to participate in the meetings of the other and exchange copies of communications sent to Members (such as ICAO State letters and WMO letters) relating to matters of interest to them both. Recommendations concerning technical material related to the world-wide application of meteorology to international air navigation are prepared by simultaneous meetings of the appropriate technical bodies of the respective Organizations. Each recommendation includes an allocation of responsibility for follow-up action in accordance with the principles stated above. Since most Member States of WMO are also Contracting States of ICAO, internal arrangements can usually be made within countries to ensure the closest co-ordination on matters pertaining to the two Organizations. In fact ICAO and WMO provide a splendid example of collaboration between two UN Specialized Agencies at Secretariat level and by the meteorologists of Members of those Agencies engaged in or concerned with aeronautical meteorology.

Mention must now be made of working arrangements between WMO and non-governmental international bodies. The chief of these is probably that between WMO and the International Council of Scientific Unions (ICSU) to which reference has already been made (page 6). Again, spheres of primary interest have been laid down and broadly these are as follows. WMO recognizes ICSU as an international forum for the advancement of meteorology as a science, and of allied scientific disciplines. Accordingly, WMO keeps ICSU advised of all activities within its purposes which have a bearing upon the interests of ICSU. In implementing its side of the working arrangements ICSU recognizes the primary responsibility of WMO for the international organization of meteorology for the furthering of its application to all human activities through inter-governmental co-operation. Other aspects of the agreement provide for the appointment of liaison officers, participation at meetings of appropriate bodies of the other organization and the formation of joint committees. In effect, the WMO Advisory Committee (see page 4) is a joint committee of WMO and ICSU. In these ways, the closest liaison between ICSU and WMO is maintained to the benefit of both Organizations. Precisely the same arrangements have been agreed between WMO and the International Union of Geodesy and Geophysics (IUGG) which is the Union, in the form of its Association for Meteorology and Atmospheric Physics, primarily responsible for meteorology

as a science. In 1961, it was agreed by the two organizations that the working arrangements shall apply to activities which involve meteorological considerations in the field of hydrology and other physical disciplines which are within the competence of WMO.

Defence Treaty Organizations. The United Kingdom is signatory to three major international defence treaties, the North Atlantic Treaty, the Central Treaty and the South-east Asia Treaty. The aim of each treaty is the promotion of the well-being of the member nations, not only by joint defence against armed attack but also by co-operation in other fields such as in economic development and in the promotion of scientific research and the application of the results. Under the terms of the treaties, organizations have been built up in each case that seek means of achieving this aim. In all three organizations, known as the Northern Atlantic Treaty Organization (NATO), Central Treaty Organization (CENTO) and South-east Asia Treaty Organization (SEATO), co-operation between the meteorological services of the member nations has a part to play in economic and scientific development and in defence.

Although most of the international work on the meteorological aspects of economic and scientific development is being done through UN Agencies, the Treaty Organizations have been able to assist in the planning and execution of particular schemes of economic or scientific importance. A few examples will illustrate. For some time NATO has been active in many spheres including scientific co-operation. Its Science Committee studies means for strengthening science in NATO nations and has formulated programmes for supporting national efforts in the fields of pure and applied science as well as of defence research. These programmes include study scholarships which have enabled many research workers and students to carry out work in other countries for periods of one year or more. In addition, visits to various institutes for advanced studies have been organized, thus enabling scientists to work together for several weeks. A research fund has also been founded in order to finance researches undertaken by scientists in different countries. The Science Committee has an Advisory Group of Experts from NATO countries to assist it in formulating programmes in meteorology under the three types of activity mentioned above.

In a similar way to NATO, CENTO has Secretariat Staff and Committees which deal with subjects other than military matters. The Economic Committee is responsible for measures designed to develop and strengthen the economic and financial resources of member countries. It has a Civil Aviation Working Party whose task is to develop and equip an air route between Ankara, Tehran and Karachi. In connexion with this CENTO airway, the United Kingdom has agreed to provide meteorological instruments and telecommunications equipment. Meteorological requirements have been assessed by staff of the Meteorological Office in consultation with the other Government Departments concerned. Under these arrangements not only have upper air stations been equipped but meteorological staff from CENTO countries have been trained to operate the equipment at locations in this country. (The section on International Co-operation gives details of meetings attended and staff released for duties overseas during the year.)

GENERAL DESCRIPTION OF THE SERVICES DIRECTORATE

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

In the following paragraphs of this Section an outline of the work of each Branch is given. A greatly amplified account of one category of work in the Services Directorate is given in the Special Topic—International Collaboration in Meteorology. Important events and innovations during the year are described in the Section titled Major Events and Changes in the Services Directorate, which is followed by Notes on the Weather of 1965. Finally the Section named Statistics provides some measure of the volume of work.

Central Forecasting Office (*Met.O.2*). The Central Forecasting Office (CFO) 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 communication system and consists mainly of actual and forecast charts, both surface and upper air, supplemented by written commentaries. Secondly CFO is responsible for the preparation of forecasts and 'warnings' which have a nation-wide application. These forecasts fall into three main categories, general forecasts for land and sea areas for dissemination by the Press and by broadcasting, forecasts for some public utilities such as the Central Electricity Generating Board, and certain special forecasts for periods up to three or four days ahead. Parallel services in the first two categories are provided by local meteorological offices which prepare more detailed forecasts applicable to smaller areas. CFO 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 meteorological organization for civil aviation in the United Kingdom consists of a Principal Forecasting Office at London (Heathrow) Airport, Main Offices at air traffic control centres, subsidiary offices at other civil airports and observing offices at some minor civil aerodromes. The provision of forecasts for medium-range and long-range flights is largely the responsibility of the Principal Forecasting Office at Heathrow. This Office prepares such forecasts and associated information for transmission by facsimile to other meteorological offices which issue them to aircrew and operators. The functions of the Main Meteorological Offices include the provision of meteorological information for aircraft in flight. Such information may relate to the occurrence or expected occurrence of *en route* conditions such as thunderstorms, severe turbulence and heavy hail; it may also be flight and aerodrome forecasts or weather reports.

At civil aerodromes where there is no meteorological office, meteorological forecast services are usually provided by telephone or teleprinter from a suitable

meteorological office in the vicinity. Air traffic control staff are trained in the making and reporting of weather observations at these aerodromes.

Meteorological services for civil aviation overseas are provided at a number of joint-user aerodromes (i.e. RAF and Civil) in the Near and Middle East Commands.

The pattern of outstation meteorological service for the Royal Air Force largely conforms with the RAF organization. There is a Principal Forecasting Office at the Headquarters of Bomber Command, and Main Offices, functioning throughout the 24 hours, are located at the Headquarters of some RAF Groups 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 RAF. 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 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.

General Services (*Met.O.7*). This Assistant Directorate has a triple function. Firstly, it co-ordinates and in some cases supervises the supply of services for the general public through many different channels, 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 CFO.

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

Thirdly, the Assistant Directorate is responsible for liaison with the Army Department of the Ministry of Defence on meteorological services for the Army. Ballistics work involves maintaining meteorological offices at a few establishments (Army Department 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.

Many of the data are collected from voluntary co-operating stations maintained by private individuals, local authorities, river authorities, private firms, schools, public utilities, etc; this is 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 inspection of 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, to operate the Ocean Weather Ships in all respects, to arrange for meteorological services to the Merchant Navy and to deal with marine inquiries.

Meteorological observing by the British Merchant Navy is entirely voluntary and unpaid; nevertheless over 700 ships are participating. An analysis of the Voluntary Observing Fleet is given in Section 5 (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, and six-hourly upper air observations—combined radiosonde and radar wind soundings at 0000 and 1200 GMT, and radar wind soundings only at 0600 and 1800 GMT. In addition to their meteorological duties the ships also provide the following services:

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

The Marine Branch publishes monthly charts, with an interim chart every 10 days, showing the distribution of sea ice in the northern hemisphere. Monthly average values and standard deviations of under-surface sea temperatures for ocean weather stations are given in diagrammatic form on the back of the ice chart. These are derived from the routine daily bathythermograph observations made aboard North Atlantic weather ships. Details of surface ocean currents are extracted from ships' meteorological logbooks and used in the preparation of ocean-current atlases. The Branch also arranges with HMSO for the printing

of ocean-current atlases, and the printing of meteorological and climatological atlases of the oceans. The correction and arrangements for printing of various technical books, code cards and forms supplied to the Voluntary Observing Fleet, Ocean Weather Ships and Port Meteorological Officers as well as the production of the *Marine Observer*, a quarterly journal of maritime meteorology, are also done in the Branch.

Observations and Communications (*Met.O.5*). Surface observing stations within U.K. reporting in international code include 100 manned by Meteorological Office personnel, 120 manned by voluntary observers, 5 manned by personnel of the Weather Service of the Navy Department, 16 on civil airfields where air traffic control staff observe and report, 1 each in Guernsey and Jersey, and 8 manned by personnel of the USAF.

In self-evident codes, 17 Automobile Association and 10 Fire Service or Police Offices report from urban locations and 10 road maintenance depots report from locations along motorways.

Upper air stations are maintained at 8 locations in the U.K. and at 7 locations overseas. At 3 of these in the U.K. and at all overseas stations surface observations are also reported.

The sferics organization remains the same as that described in the 1964 report.

Landline teleprinter networks are the principal system used for the national and international collection and dissemination of observational data. Where such systems are not available or are uneconomic, any requirement for data for forecasting is met by radio broadcasts. These broadcasts, formerly made by wireless telegraphy, are almost wholly made by radio-teleprinter and largely duplicate the service which the landline systems provide. Processed data—analysed or forecast charts and plotted weather charts—are made available in graphical form using facsimile transmissions. For these, too, landlines are preferred but facsimile radio broadcasts cater for international requirements for the interchange of processed data between different countries. The complex system of communications necessary for the success of modern meteorology owes its existence and success to co-operation within WMO. The Bracknell meteorological communications centre is responsible, within this organization, for transmitting into the International Meteorological Teleprinter Network in Europe the observational reports of the U.K., Ireland, Iceland, Greenland, three ocean weather stations, and all reports from merchant ships received via British coastal radio stations, for two radio-teleprinter broadcasts containing the data for the whole of the north-western section of Europe, and for a radio-facsimile broadcast of the processed products of the Bracknell forecasting centre. Domestically the communication centre operates the teleprinter and facsimile landline networks necessary for the collection of data from reporting stations and the distribution of data to forecasting offices within the U.K. The formal responsibility for communication facilities needed by the Meteorological Office rests with the Director-General of Signals, Royal Air Force.

Computing and Data Processing (*Met.O.12*). This Assistant Directorate controls the computing laboratory and the punched-card installation and is responsible for the development of data processing and automation. The heart of the computing laboratory is an electronic computer—currently an English Electric-Leo-Marconi KDF9 computer installed during 1965. This

computer has been named COMET and the whole electronic computing organization is known as the COMET computing laboratory. The laboratory is operated by Met.O.12 staff and satisfies a large proportion of the computing needs of the Office. Staff of English Electric-Leo-Marconi Ltd provide, under contract, the necessary maintenance. The punched-card installation is equipped with modern machinery and backed by a library of over 40 million cards. The installation can quite rapidly extract and tabulate data from the card library but its output is limited to fairly simple calculations, frequency distributions and tabulations.

The Branch has specialist staff to write programmes for, and to operate, COMET and the punched-card machinery. It is responsible for writing general programmes, such as input/output and library routines for use with COMET. Many specialist programmes are, however, written by other branches with assistance and advice as required from Met.O.12 programmers. The Branch also provides courses of instruction in KDF9 User Code and in Algol computer languages. Current work on the development of data processing and automation includes an automatic chart plotter and line drawer.

Forecasting Techniques (*Met.O.8*). Met.O.8 is charged with the development of short-range forecasting techniques, especially those related to mathematical development of high speed computer programmes for the preparation of actual methods for routine use, and manuals on operational forecasting techniques. To this end it is divided into two sections. Met.O.8a is responsible for the and forecast numerical synoptic charts to meet the needs of the Central Forecasting Office and of outstations. These requirements, with appropriate priorities, are determined through a working group comprised of heads of branches concerned.

Actual and forecast charts form the essential basis of forecasting but when such charts have been constructed various techniques are needed for forecasting the details of weather; the intensity and timing of precipitation, surface and upper winds, temperatures, local variations in weather are all examples. The second section of the Branch, Met.O.8b, is responsible for the surveillance of such techniques, for general guidance on the improvement of techniques in the light of current research and operational practice and for keeping under review manuals on operational forecasting techniques.

Met.O.8b also co-ordinates research and investigations carried out by loca meteorological offices. The staff of such offices are encouraged to undertake research and indeed there are many problems of 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. But almost any worthwhile investigation needs to be carried out at a number of different stations, according to a fixed plan. Some central planning and co-ordination is therefore necessary and is provided by Met.O.8. The Branch also analyses some results because it has direct access to the Headquarters computer and punched-card machinery.

Advice on such local investigations and problems is provided by two working groups, one concerned with statistical problems and the other with synoptic problems.

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. 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. 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 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 U.K. 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.

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

The Ministry of Defence (Defence Secretariat, Air Force and Army Departments) and other Government Departments regularly require advice or comment on administrative, financial and technical aspects of meteorological matters which arise in the International and Defence fields. These matters are dealt with by Met.O.17 in co-operation if necessary with other appropriate branches of the Office.

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.

MAJOR EVENTS AND CHANGES IN THE SERVICES DIRECTORATE

Central Forecasting Office (*Met.O.2*). Surface and upper air forecast charts produced by the Meteorological Office's KDF9 computer COMET were introduced in November into the routine of CFO where they are used as guidance by the forecasters. A revised scheme was introduced for the notification of spells of fine weather to the farming community. The service is now designed to inform the customer of the expectation of a spell of 72 hours without measurable rain and also of the expectation of 48 hours without measurable rain with an even chance that the following 24 hours will also be dry.

Arrangements were made for weather forecasts to be supplied to ships at sea by direct telephone link between the ship and the forecaster at CFO.

A Decca Weather Radar 42A was installed in July.

Charts depicting the air flow at very high levels of the atmosphere (50 and 30 millibars) are now constructed once a day.

Aviation Services (*Met.O.6*). Meteorological services for aviation cater for all types of flying from relatively high-speed, high-altitude operations over long distances to short-haul low-level operations including those by helicopters.

The number of forecasts issued for civil flights was again higher than in the previous year with a noticeable increase in the number of flights by private and executive-type aircraft to destinations throughout Europe.

During the year, forecasting for medium-range and long-range routes over Europe and the North Atlantic has been largely centralized at the Principal Forecasting Office at London (Heathrow) Airport. This office has been nominated as the European Area Forecast Centre for the North Atlantic. Facsimile charts prepared at London (Heathrow) are being disseminated by facsimile to five major civil aerodromes in the United Kingdom.

Reporting of turbulence encountered by aircraft flying above 20,000 feet has continued throughout the year as part of a world-wide programme of investigation, sponsored by the ICAO, into the incidence of high-level turbulence.

The responsibilities for the two Main Meteorological Offices in Scotland have been reallocated so that Prestwick is the forecast centre for civil aviation in Scotland and Pitreavie the forecast centre for services to the RAF in Scotland and Northern Ireland.

There have been improvements or extensions to the meteorological services provided for the RAF overseas. A radar set has been installed at Labuan in North Borneo to provide measurement of upper winds in that region. A small office has been opened at Kuantan in Malaya. Subsidiary meteorological offices in Germany are now connected to the Main Meteorological Office at HQ RAF Germany by a landline facsimile system.

A special forecast office was provided for the World Gliding Championship at South Cerney in May and June.

The change of wind with height (wind shear) within 300 feet of the ground can have a significant effect on an aircraft during take-off and landing. A detailed study of wind shear is being made and meteorological offices on airfields are collecting and documenting reports received from pilots of serious wind-shear occurrences.

Forecast charts computed by the COMET electronic computer have been transmitted by facsimile since October to the Principal Forecast Offices at London (Heathrow) Airport and HQ Bomber Command.

General Services (*Met.O.7*). The public demand for weather information grows apace and non-aviation inquiries have doubled during the past five years. For the first time they have topped the million mark during the year and the grand total, at 1,162,107, represents a rise of no than less 20 per cent on the figure of 1964. Increases were registered in every category of inquiry, with outstanding percentage rise over the 1964 number of inquiries relating to building (46 per cent), industry and commerce (36 per cent), agriculture (35 per cent), holidays (29 per cent) and public utilities (23 per cent).

London Weather Centre moved to Penderel House, High Holborn, in January and in order to obtain a good exposure the roof instruments are installed on the nearby State House. Accommodation is being sought for a new weather information centre in Newcastle-upon-Tyne; this will facilitate meteorological services to industry, commerce and the general public in the north-east.

The number of weather bulletins on BBC Sound has continued to rise. 'Coastal waters' forecasts in respect of Scotland, England and Wales, and Northern Ireland were introduced early in the year and are broadcast by the appropriate Home Service transmitters at close-down. Later in the year, personal presentation of sound broadcasts by 'Weathermen' from the studio at London Weather Centre was extended by the introduction of short bulletins on the Light Programme at 0650, 0710, 0750 and 0810 clock time. On the same

day, the 0830 weather bulletin was deleted and 'Metcast' moved from 0855 to immediately after the 0830 news bulletin. Together with the pre-existing weather bulletins at 0630 and 0730, this schedule of new broadcasts ensures weather bulletins every 20 minutes from 0630 to 0830, and there are plans to extend this coverage to the period 0530 to 0830. This schedule is designed to meet the needs of the ever-changing listening audience at these hours. The autumn saw the introduction of a new form of question-and-answer weather presentation, at first on the Home Service 'Farming Today' programme at about 0645, and now extended also to the Third Network sports programme at 1230 on Saturdays. Another contribution to the weather service on radio was the introduction of FLASH weather messages on the Light Programme. These messages give warnings of the occurrence of weather which might cause considerable inconvenience to a large number of people, and warnings of fog and snow have actually been broadcast. Close liaison was maintained with BBC Television, and services to the independent television companies continued throughout the year.

Special broadcasts were made on sound radio, including the overseas service, and on various television channels. Among the topics discussed were the work, organization and facilities of the Meteorological Office, various aspects of climatology, current and forecast weather, tropical storms, and water supplies in the United Kingdom.

London Weather Centre continued to supply routine forecasts and warnings for drilling operations being carried out in the search for oil and natural gas under the North Sea. Increasing awareness of the hazards of driving on motorways in fog led to a marked increase in liaison between forecasting offices and county police forces for the exchange of warnings and motorway reports; and a good start was made to the flow of routine weather reports from road maintenance depots on motorways.

Following the questionnaire sent to subscribers to *Monthly Weather Survey and Prospects* in 1964 and an analysis of the many useful replies, the content and layout of the publication were changed during 1965.

A Press conference was held on 2 November to mark the inauguration of the assimilation of computed forecast charts into the operational forecasting routine of the Office. It was attended by some 60 reporters and photographers, and was widely reported in the national Press.

The Army Department and a number of establishments engaged in ballistic work were again provided with the necessary meteorological services. Upper air ascents for ballistic purposes numbered 4158. Assistance and advice were given in the training of Army personnel engaged on specialized meteorological duties. The theoretical and practical study of the variations of wind of concern in external ballistics continued to make progress.

Investigational work concerned with agricultural meteorology continued throughout the year, and a number of memoranda have been issued dealing with a wide variety of subjects such as weather factors and crop yields, weather factors and sheep diseases, transpiration, shelter by plastic screens, insect migration, and sugar-beet production. Experimental work continued in the spring-frost investigation at Thetford Chase in conjunction with the Forestry Commission.

Further assistance has been given on the new town plan for Cumbernauld. Notifications of 'Smith' and 'Beaumont' periods were provided on much the

same scale as in 1964 and advice was given as necessary to farmers and growers on irrigation needs. Close liaison was maintained with the Pathology and Veterinary Laboratories and with the Rothamsted Experimental Station.

Climatological Services (*Met.O.3*). The year 1965 was encouraging in that several inquiries of a major nature arose, providing evidence of the increasing awareness in industry of the advisability of taking climatic factors into account. As a result of the reading of a paper on temperature statistics relevant to gas consumption in London, at the Annual General Meeting of the Institution of Gas Engineers, requests were received from Gas Boards for other relevant statistics not only for London but also for other areas of the country. It was gratifying to receive requests for climatological information in connexion with the planning of large urban development schemes, a field in which there is much room for meteorological advice and investigation. Again, in the planning of major construction work, e.g. earthworks on new motorway routes, attention should be paid to the probability of occurrence of certain weather conditions during the operating period and the Branch is now being consulted on such matters; in one case the inquiry concerned the inclusion of relevant climatic statistics in 'critical path analyses' to be performed by computer. The Branch was asked to specify the wind conditions at the time of the collapse of cooling towers at Ferrybridge in Yorkshire, and to estimate the probability of the occurrence of such winds. Our evidence concerning probable wind speeds also led to the withdrawal of an objection to the use of a tower crane on an important development site in London. The Branch was also asked for estimates of fog frequencies on various motorways; these estimates must play a part in studies of the cost/benefit ratio for possible warning systems. Data were also given to the Board of Trade relevant to the adoption of a fixed spring Public Holiday to replace Whit Monday.

In the marine climatological sphere, much information has been provided for the work of a British Standards Institution Committee on climatic hazards in the storage and transport of goods, and on conditions that are relevant to the design and operation of hovercraft in inshore waters. A paper completed towards the end of the year is considered to give a sound basis for the estimation of wind speeds from the various states of the sea surface in the open oceans.

On the hydrometeorological side, work increased in amount and diversity. Close liaison has been established with the technical staff of the Water Resources Board and members of the Board visited the Office in November. Notable amongst the projects requiring our aid is a proposed experiment on the feasibility of devising methods for the more efficient operation of river-regulating reservoirs. This will involve the forecasting of rain occurrence, duration and amount, the rapid assessment of actual rainfall using rain-gauges which can be remotely interrogated, and the regular assessment of the moisture retention capabilities of the catchment area. The experiment may well mark the true beginnings of hydrometeorological forecasting in this country, although the Office now provides services of value in flood forecasting by River Authority engineers.

Two studies of probable maximum rainfall, which were necessary for the design of dam-spillways, were completed during the year, one for an area in Ghana and the other in North Borneo. During the construction of the Mangla Dam, one of our officers visited Pakistan in September to help assess the risk in diverting the river Jhelum in that month, rather than waiting until a comple-

tely safe period later. A flood following soon after a diversion in September could have had serious consequences; yet the maximum time possible was needed to carry out the next stage of work before possible floods in the 1966 monsoon season. The river diversion was carried out almost on schedule.

Statistics for an improved version of the annual publication *British Rainfall* were produced for the first time using the electronic computer.

Marine Branch (*Met.O.1*). In 1965 the British Ocean Weather Ships completed 18 years of service in the North Atlantic. The four 'Castle' class frigates, which replaced the former 'Flower' class vessels between 1958 and 1961, continue to give satisfactory and reasonably economical service. The total annual operating cost of each of the ships is about £145,000; this compares favourably with the average operating cost of weather ships operated by the other European countries. About 40 per cent of this cost is recovered from other countries operating aircraft across the Atlantic; 75 per cent of the residual cost is borne by the Ministry of Aviation.

Weather Reporter and *Weather Surveyor* played a useful part for the second year running in an international oceanographic project lasting a whole month. During this period they kept in constant visual and radar touch with a small buoy and gave navigational aid to other ships taking part in the project; over 60 bathythermograph observations per day were made aboard *Weather Surveyor*.

On 1 November, towards the end of her period on station, *Weather Monitor* answered a distress signal from the British ship *Newfoundland* bound from Liverpool to St John's, Newfoundland. A dangerous fire had broken out and the Master required ships in the vicinity to stand by. *Weather Monitor* immediately proceeded at full speed towards the ship's position and arrived on the scene some seven hours later, having been delayed by gale force winds and heavy seas. By this time the fire was under control but still considered to be dangerous. *Weather Monitor* escorted the *Newfoundland* to Cobh meanwhile maintaining her normal meteorological programme of surface and upper air observations.

There were two other occasions when British weather ships took action on distress calls from merchant ships and five occasions of alerts from aircraft in difficulties. All the distress calls and alerts were later cancelled.

Frequent air-sea rescue exercises were carried out by day and night— in which volunteer frogmen played a prominent part. RAF aircraft took part in some of these exercises and dropped newspapers and mail to the ships.

An average of 62 aircraft per day were given navigational aid by the weather-ship on duty at station 'Juliet' (52½°N,20°W), the busiest station.

The total number of voluntary observing merchant ships, fishing vessels and lightvessels at the end of the year was 761—almost the same as in 1964. Details are given in Tables XV and XVI. This total of 761 is about 19 per cent of the world total of about 4000 voluntary observing ships and the total number of British registered ships is about 11 per cent of the world total of merchant ships. These facts, combined with a study of the trade routes served (Table XVI), show that British shipping's contribution to world meteorology is considerable, for all these ships send observations by radio to some Meteorological Service or other throughout their voyages.

The decision, taken in 1964, to equip certain distant-water trawlers with instruments and thus to bring them into the category of supplementary observing

ships has been amply justified, and the keenness and enthusiasm shown by observers in these ships have been found to be at least equal to that shown by observers in the passenger liners.

The falling off in the number of radio weather messages received from trawlers, which was a matter of some concern in the early part of 1965, was traced, in part at least, to certain trawler skippers' reluctance to disclose their positions to their competitors. It is hoped that this difficulty has been overcome by devising special ciphers, whereby the position group is enciphered before transmission, the decipher being held by the meteorological station (in Canada, Faeroes, Greenland, Iceland, Norway or the United Kingdom) to which the message is addressed.

Liaison with scientific bodies has continued on an ever-increasing scale in connexion with non-meteorological observations noted in ships' meteorological logbooks. During the year the National Institute of Oceanography produced a report, 'Notes on the Nature and Occurrence of Marine Bioluminescent Phenomena', which was built round observations derived from the meteorological logbooks of British ships over the past hundred years.

The number of inquiries handled during the year was about 10 per cent more than last year. They were of a varied nature and, as in past years, the majority came from solicitors and insurance companies. Civil engineers, contractors and designers of hydrofoil craft applied on a number of occasions for weather and wave data in various parts of the world. Information in connexion with the North Sea drilling operations was a frequent request.

Observations and Communications (*Met.O.5*). The network of observing stations within the United Kingdom has been augmented during the year by the addition of 13 new stations manned by voluntary observers. At 3 locations voluntary observers ceased reporting. Observing stations manned by voluntary observers now outnumber those manned by Meteorological Office personnel. Additionally, arrangements have been made to obtain brief reports of weather and road conditions from 10 locations along the motorways M1 and M6. It is the intention to extend this arrangement to other motorways.

The new radar equipment, introduced last year and used for measuring winds aloft, has been commissioned at two additional upper air stations, making six in all, and installation is practically complete at two others.

Arrangements were completed to close the wireless telegraphy (W/T) receiving station at Dunstable. The use of W/T for meteorological transmissions has dwindled over recent years and during the past year reached a volume which could be amalgamated with radio-teleprinter and radio-facsimile reception under RAF control at Bampton. The Ocean Weather Ship W/T shore terminal was transferred from Dunstable to the Bracknell office.

The RAF has improved the equipment used for the radio-facsimile broadcast carrying analytical and prognostic charts produced by the Central Forecasting Office, Bracknell, to Europe and other nearby areas. This broadcast is now made on greater power than before and on a selection of frequencies adapted to changing day and night radio propagation conditions. The Office has also acquired facsimile equipment which transmits two charts side by side in half the time formerly taken to transmit one. At receiving stations the two charts are recorded at half scale but no modification of recorders is required. The Main

Meteorological Offices serving RAF Transport Command, the RAF in Germany and the RAF in Cyprus now have facilities for facsimile transmission over land-line networks to their outstations.

The routine and emergency servicing of electrical equipment, used in increasing quantities in recent years to obtain observations and for communications, is now the responsibility of Met.O.5. A regional servicing scheme has been set up and is based jointly on two centres, Bracknell and Watnall, and on selected radiosonde stations. Some expansion of the scheme is already necessary and is being planned. To overcome a shortage of appropriate technical grades, suitable volunteer scientific assistants have been given the opportunity to transfer to technical duties, and arrangements have been made with the RAF for initial technical training.

Computing and Data Processing (*Met.O.12*). The Ferranti Mercury computer (known as METEOR) was dismantled and removed in October 1964 to permit the preparation of the computing laboratory for the installation of the English Electric-Leo-Marconi KDF9 computer ordered in 1963. During the earlier part of 1965 the Meteorological Office had no computer at Bracknell and temporary arrangements were made for the use of computing facilities at other institutions with the kind co-operation of their controlling authorities. METEOR had been reassembled at the Chemical Defence Experimental Establishment, Porton, near Salisbury, and arrangements were made for some of the computations formerly carried out on METEOR to be performed there. Arrangements continued for carrying out operational and other urgent computing work, mainly at night, on the Mercury computer at the Royal Aircraft Establishment, Farnborough. Some work on the development of programmes for use on the new computer was performed on the KDF9 computer installed at the National Physical Laboratory, Teddington. The helpful co-operation of these authorities was of great benefit and is gratefully acknowledged. In addition, under the terms of the purchase contract, English Electric-Leo-Marconi Ltd made time available on the KDF9 machine installed at their bureau at Kidsgrove, Staffordshire. About 170 hours of computer time was used on that machine.

The Office KDF9 computer, (named COMET), was installed during the summer, and achieved a satisfactory standard during its site trials which were carried out in July 1965 in co-operation with the Ministry of Technology. After acceptance, the development of programmes using COMET at Bracknell proceeded at an accelerated pace and work formerly carried out at some of the distant locations named in the preceding paragraph was progressively transferred to COMET. Production of some numerical forecasts commenced in September and sufficient progress was made to justify the introduction on 2 November of numerical forecasting twice per day on a fixed operational timetable. A start was made on the large task of compiling a library of meteorological data on magnetic tape. In the initial stages the task is primarily one of direct conversion from existing punched cards. The computer was increasingly used by the research and service branches. By the end of the year the work load necessitated the operation of COMET for 16 hours a day, seven days a week. Future developments seem likely to require full-time operation throughout the 24 hours from some date in 1966. In order to utilize more fully the capacity of COMET to run more than one programme simultaneously, an order has been placed to increase its high-speed memory by one third.

Training of staff in programming for, and operating, COMET continued. Some staff attended training courses arranged by English Electric-Leo-Marconi Computers Ltd but, during the year, Met.O.12 staff progressively assumed more responsibility for training. In particular, courses for programming in KDF9 User code and in Algol were given.

Work in the development of automation continued. Delays have occurred in the production, under contract, of an automatic chart plotter and delivery from the manufacturer is still awaited. During the year a contract was placed for the construction of an automatic line drawer, designed to work directly from the computer or independently from paper tape. It will produce a graphical output on microfilm and will be used primarily to draw the isopleths on meteorological charts computed in the numerical forecast programmes. When under computer control it is expected that the line drawer will draw the isopleths of a typical meteorological chart in rather less than three minutes. Work has commenced on the preparation of a computer programme to drive the line drawer.

During the year several of the machines in the punched-card installation were replaced by modern ones and a tape-to-card converter was added to the equipment.

Forecasting Techniques (*Met.O.8*). Met.O.8a is concerned with devising an operational system for the production by computer of actual and forecast charts, and for developing the appropriate programmes. Development work was carried out early in the year on the English Electric-Leo-Marconi KDF9 computer at Kidsgrove and, later, on the Meteorological Office computer COMET when it had been installed at Bracknell. Trial analyses and forecasts began in August 1965.

The process involves extraction by computer of required data from several international meteorological broadcasts containing observations from most of the northern hemisphere. Analyses and forecasts are then produced for three standard levels. The methods adopted for data extraction by computer have proved highly successful so far. Computation of the actual charts has also proved successful though it is evident that provision will be needed, probably permanently, for some human direction at this stage. This is being allowed for in a more advanced set of programmes now under development. The forecasts themselves have so far proved to be of good quality, particularly in respect of pattern of development; certain systematic errors have appeared, which will be the subject of further investigation.

The present charts are intended to be used by the Central Forecasting Office as a guide; they are also being transmitted experimentally by facsimile to the Principal Forecast Offices at London (Heathrow) Airport and Headquarters, Bomber Command, RAF. Future plans provide for extension in the number and type of charts produced to meet the requirements of CFO and outstations.

Met.O.8b is concerned with general guidance on forecasting techniques and for the co-ordination of local research and investigations. A memorandum has been distributed which summarizes a survey of forecasting methods and techniques in use at outstations and of action being considered or taken as a result of the survey.

A study of original radiosonde records has shown that little significant detail of the temperatures and humidities in the lower layers of the atmosphere is lost purely on account of present procedures for coding; the radiosonde itself does not provide sufficiently detailed data for the forecasting of fog and stratus.

It is hoped that this deficiency will be made good in future by instruments mounted on high masts. Because of the difficulties in maintaining such instruments an investigation has been made into the length of time for which muslins of wet-bulb thermometers can be left unchanged without appreciable loss of accuracy in the readings. An abbreviated report of this investigation has been published in the *Meteorological Magazine*.

Results are being received of tests made at outstations into forecasting techniques from various sources (including foreign publications). The tests are co-ordinated by Met.O.8b and necessary summaries and tables supplied.

A study has been made of techniques used at outstations for forecasting night cooling and the variation from place to place of the methods used for this purpose.

Diagrams have now been prepared for the objective forecasting of visibility at London (Heathrow) Airport for three-hour and six-hour forecasts for most periods of the day and night during the months October to March. Forecasts from five of the diagrams were tested against the subjective forecasts for the same occasions; the objective forecasts from each diagram were slightly superior to the corresponding subjective forecasts.

Studies of the relationship between winds at the surface and at 900 mb are being published as a Scientific Paper.

Work continued on the preparation of additional entries and the revision of the existing entries in the publication 'Aerodrome Weather Diagrams'. A scheme has been inaugurated involving the registration of experts who will eventually assist with the task of revision of the 'Handbook of Weather Forecasting'.

The creation of Met.O.8a to develop operational synoptic analysis and forecasting by computer has given considerable impetus to the application of computer methods to producing forecasts for aviation. Pilot studies of the analysis and forecasting techniques at present in use for levels near the jet stream suggest that these techniques are not generally suitable for conversion into numerical methods for computer operation; but a study of experimental numerical 300 mb forecasts, prepared by the use of a regression equation technique and ideally suited to computer operations confirmed that this regression method is capable of producing reliable wind forecasts for aviation. An experimental programme to produce wind speeds from current 500 and 200 mb computer forecast programmes is under test. Results so far are encouraging and there has been little tendency to smooth horizontal shears near strong wind belts in the numerical product.

A. C. BEST
Director of Services

NOTES ON THE WEATHER OF 1965

On the whole 1965 was dull, cold and rather wet. This unfortunately was particularly so during the holiday period June to September when holiday makers enjoyed only brief fine spells. Temperature rarely exceeded 25°C even during the height of the holiday season. Though rainfall was a little below average during a cool and showery August, September was exceptionally wet with more than three times the monthly average of rainfall in parts of southern England; over England and Wales as a whole it was the wettest September for 40 years.

The two months January and February were not unusually severe, for although temperature was below the average and snowfall was heavy at times, snow-cover did not last long except on high ground; January's stormy periods were relieved by a good deal of sunshine whilst February was very dry.

The spring and autumn were the 'best' seasons of the year with some sunny and warm days at the end of March, when temperature at Wakefield rose to record March levels (25°C) for the British Isles; during mid-May, when afternoon temperatures in parts of southern England rose 10°C above average; and also during an exceptionally dry October which, apart from 1947, was the driest October over England and Wales as a whole for more than 150 years.

The winter season started unusually early with heavy snowfall in Scotland and northern England during the second half of November; in north-east England the level snow was 2 feet deep in some areas and drifts up to 15 feet deep blocked many roads. December was wet and stormy but much milder, and will be remembered in Wales and the west country because of the floods produced by heavy rain and rapidly melting snow.

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 based on some 50 stations 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.

Figure 1 shows the distribution of rainfall over the country expressed as a percentage of the average.

Tables II–XIII for the 12 stations shown in Figure 2 give, for each month, details of temperature (extremes and mean daily maximum and minimum), sunshine (percentage of 1931–60 average), rainfall (percentage of 1916–50 average) and also the number of days of

(i) frost (when temperature in the screen fell below 0°C)
(ii) thunder (when thunder was heard by the observer at any time during the 24 hours of the day)
(iii) snow falling (when snow or sleet was observed to be falling sometime during the 24 hours of the day)
(iv) snow cover (when at least half the ground within sight of the observing station appeared to be covered with snow at 0900 GMT)
(v) fog (when visibility was below 220 yards at 0900 GMT)
(vi) gale (when mean wind speed rose to 34 knots or more over a period of 10 minutes at any time during the 24 hours of the day).

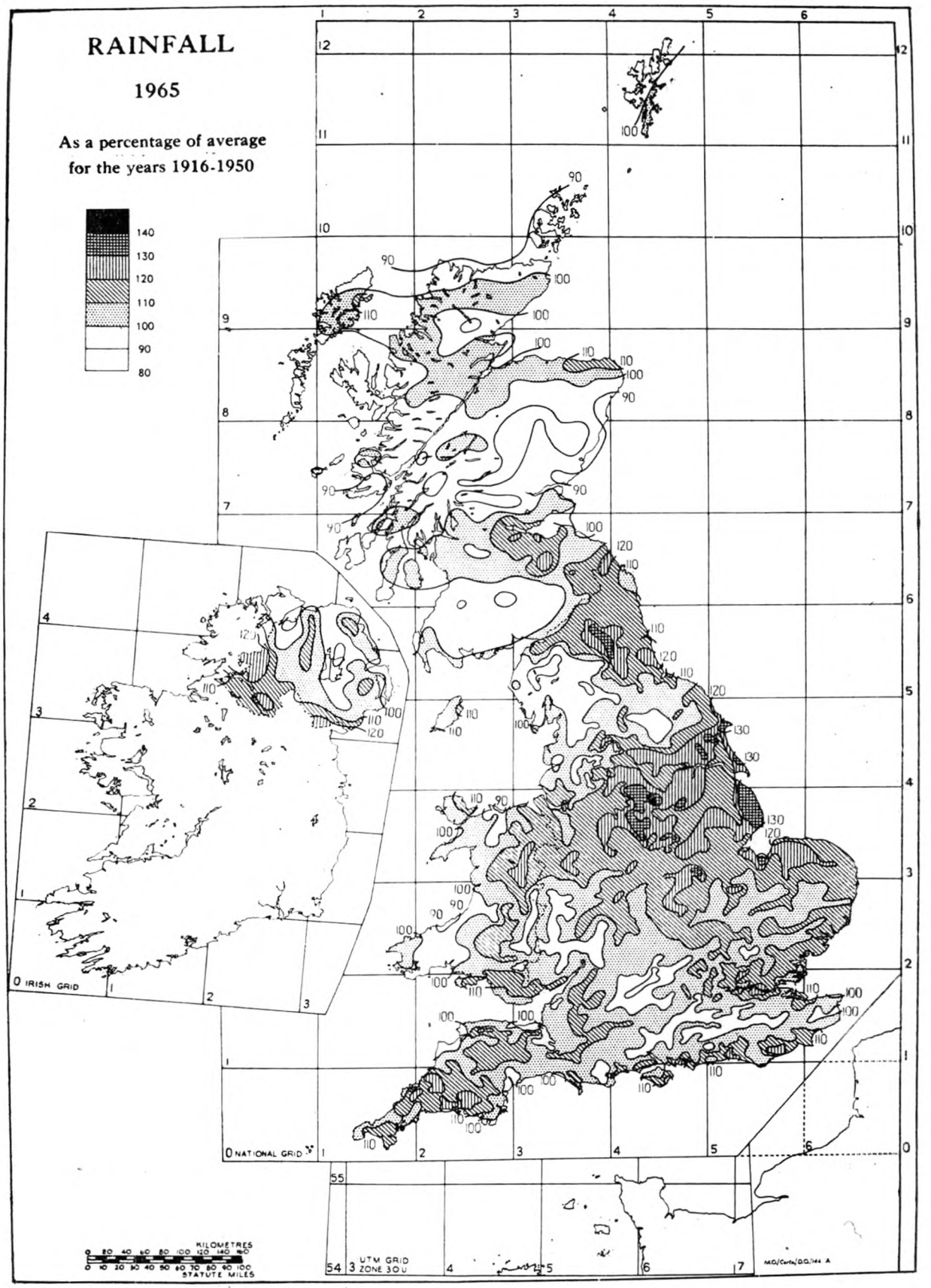


FIGURE 1—Rainfall 1965

FIGURE 2—Stations included in Tables II–XIII

TABLE I—CLIMATOLOGICAL DATA FOR 1965

ENGLAND AND WALES	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	Year
Highest maximum temperature °C	14·4	11·7	25·0	21·7	28·9	26·1	25·0	27·8	22·9	26·1	18·3	14·4	28·9
Lowest minimum temperature °C	−13·9	−12·2	−21·7	−6·7	−5·0	−1·7	−1·7	−0·6	−0·6	−8·8	−11·1	−9·4	−21·7
Mean daily maximum temperature °C	6·1	5·6	9·1	12·1	15·4	18·4	17·7	19·2	16·1	14·7	7·7	7·5	12·5
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	1·3	1·0	1·6	4·2	7·7	10·1	10·6	11·0	9·0	7·7	2·2	2·1	5·7
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	133	53	113	94	87	91	65	101	80	112	133	145	101
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	105	27	127	104	101	129	122	89	187	33	114	181	110
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	3·04
SCOTLAND													
Highest maximum temperature °C	13·3	12·2	20·6	19·4	25·6	24·4	26·1	25·3	21·7	22·2	15·0	12·5	26·1
Lowest minimum temperature °C	−14·4	−13·9	−20·0	−7·2	−6·1	−2·2	−0·6	−1·1	−2·2	−3·8	−13·9	−11·2	−20·0
Mean daily maximum temperature °C	5·0	6·4	7·3	10·4	12·6	16·0	15·0	16·3	14·2	12·5	6·0	5·2	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	0·2	1·3	1·0	2·8	6·2	9·1	8·4	9·3	8·4	6·8	1·2	0·5	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	134	78	104	114	67	79	95	107	67	104	129	123	100
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	102	39	92	120	106	137	110	95	135	85	79	110	101
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	4·36
NORTHERN IRELAND													
Highest maximum temperature °C	12·8	10·6	21·7	17·5	24·6	23·9	22·3	23·9	20·2	18·9	13·8	13·4	24·6
Lowest minimum temperature °C	−7·2	−7·2	−12·8	−3·9	−3·3	0·6	2·2	0·6	−0·6	−2·2	−7·2	−9·6	−12·8
Mean daily maximum temperature °C	5·7	6·8	8·9	12·1	14·8	17·6	16·8	17·3	14·8	13·5	7·1	7·1	11·9
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	0·3	1·2	1·7	3·9	7·4	9·4	9·4	10·3	8·1	7·6	2·0	1·5	5·2
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	119	73	105	98	69	83	91	90	67	72	118	123	92
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	120	17	141	125	107	140	80	100	108	77	115	127	105
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	3·49

TABLE II—JANUARY 1965

	Temperature °C				Sunshine		Rainfall		Number of days with					
	Mean maximum	Mean minimum	Highest	Lowest	Percentage of average	Average (hours)	Percentage of average	Average (inches)	Snow falling	Snow cover	Thunder	Fog	Frost	Gale
Kew	6·5	2·7	12·3	–3·3	144	46	91	2·14	7	1	0	1	6	0
Gorleston	6·0	2·3	11·5	–1·8	123	54	84	2·21	6	1	0	0	5	2
Boscombe Down	5·8	1·2	11·1	–5·4	145	56	100	2·90	8	5	0	0	11	3
Plymouth	7·5	3·3	11·5	–4·3	107	60	153	4·33	6	0	2	0	5	6
Elmdon	5·7	0·8	11·9	–5·6	166	44	99	2·51	10	4	0	1	15	1
Valley	7·0	2·8	10·5	–2·6	134	58	130	3·60	7	0	0	0	7	9
Manchester	5·3	1·5	11·3	–7·1	149	34	101	3·00	9	1	0	3	10	1
Tynemouth	5·6	2·1	11·5	–3·6	129	43	120	2·34	15	3	0	0	6	2
Renfrew	5·5	–0·2	11·3	–7·9	168	35	92	4·66	10	1	2	1	16	1
Dyce	4·4	–1·0	10·4	–10·7	93	54	100	3·14	17	13	0	0	18	1
Stornoway	5·6	1·1	10·8	–5·8	117	35	123	4·18	14	0	2	0	13	3
Aldergrove	5·1	–0·1	10·9	–5·4	136	45	109	3·68	17	3	0	2	20	2

Often stormy but with sunny periods

The year opened bright and cold, with an anticyclone off the coast of Ireland bringing more than 8 hours of sunshine to most western and southern districts during each of the first 3 days. Northerly winds associated with the anticyclone brought wintry showers to eastern districts. Winds backed towards the west in Scotland on the 4th as the anticyclone moved southwards, and weather became gradually milder as rain, preceded by snow, spread slowly southwards reaching southern England on the 5th.

Nearly 2 weeks of generally unsettled weather followed. Winds reached gale force at times and rain was often heavy as vigorous depressions from the Atlantic moved eastwards between Scotland and Iceland or over Scotland. The 9th and 10th were particularly wet days and gales were widespread and at times severe on the 13th and 16th, gusts of 80 kt being recorded at a number of places on both days. Long periods of heavy rain led to widespread flooding.

Many western and southern districts had rather frequent snow showers on the 18th as a small polar depression approached western Scotland and another depression from the Atlantic moved into the Bay of Biscay. A depression moving south-east across Ireland to the English Channel brought renewed heavy falls on the 20th; at Tredegar, south Wales, snow accumulated to a depth of 12 inches. The 21st was dull, the cloud thickening and lowering with the approach from the west of a trough of low pressure which brought further heavy falls of snow that night. Next morning level snow lay five inches deep in parts of the Chilterns.

A rapid rise of pressure to the north of Scotland on the 22nd led to the establishment of an east to north-east airstream over most of the country which persisted until the end of the month. Weather was generally cold, dull in the east with scattered snow showers, but sunny in the west.

TABLE III—FEBRUARY 1965

	Temperature °C				Sunshine		Rainfall		Number of days with					
	Mean maximum	Mean minimum	Highest	Lowest	Percentage of average	Average (hours)	Percentage of average	Average (inches)	Snow falling	Snow cover	Thunder	Fog	Frost	Gale
Kew	5·9	2·1	10·8	−3·6	51	64	23	1·55	5	1	0	0	3	0
Gorleston	5·3	2·0	9·8	−1·1	60	69	93	1·60	12	0	0	0	2	1
Boscombe Down	5·5	0·3	9·7	−4·4	66	74	6	2·05	3	1	0	0	17	0
Plymouth	6·6	1·9	9·5	−1·5	71	80	3	3·11	4	0	0	0	5	0
Elmdon	5·3	0·8	10·4	−8·2	36	65	18	1·90	6	0	0	1	11	0
Valley	7·3	1·8	9·3	−3·9	74	79	17	2·29	4	0	0	0	9	0
Manchester	5·7	1·2	9·0	−4·2	62	55	10	2·37	4	0	0	0	10	0
Tynemouth	5·8	2·8	10·4	−1·5	55	66	48	1·65	7	0	0	0	1	1
Renfrew	7·2	−0·4	10·7	−8·0	106	60	18	3·19	2	0	0	2	17	0
Dyce	6·4	1·9	11·6	−5·4	55	80	60	2·36	10	3	0	0	7	1
Stornoway	7·1	2·4	10·3	−3·4	51	62	53	2·68	5	0	0	0	6	2
Aldergrove	6·2	0·3	9·0	−5·9	76	65	23	2·39	3	0	0	1	13	0

Very dry and rather cold

Weather throughout the month was dominated by a strong and persistent anticyclone. During the first three days it covered the British Isles, maintaining bright rather cold weather in most districts. Northern districts had a few scattered snow showers but snow cover, in places as far south as Dartmoor, was associated mainly with the snowfall during the latter part of January.

Feeble troughs moving round the periphery of the anticyclone, which from the 4th to the 8th was centred off the west of Scotland, brought generally dull and progressively colder weather to most districts with some light rain or drizzle in the east and south-east. On the 9th the anticyclone moved southwards and a frontal system, associated with a depression in high latitudes, brought occasional rain to most districts and persisted until mid-morning the next day along the south coast. By the 11th the anticyclone had moved far enough south for mild westerly weather to become general over the country.

Two stormy days followed. A depression deepened considerably on the 12th as it moved eastwards to the north of Scotland and winds reached gale force in many northern districts on both the 12th and 13th. A gust of 85 kt was recorded in Scotland on the 12th. Rain was widespread and locally heavy with snow in the north.

The anticyclonic régime was renewed on the 14th as a ridge of high pressure began to spread northwards over Ireland. After two rather dull days an east to north-east airstream became established over the British Isles bringing snow showers to most northern districts. By the 19th an anticyclone was centred off the north of Scotland and a belt of rain spreading westwards across the country turned to snow during the night. Snow lay 1–2 inches deep locally on the 20th and 21st.

As the anticyclone moved away north-westwards on the 22nd, troughs in a cold northerly airstream brought light snow showers to most districts, and this type of weather continued with little change until the end of the month.

TABLE IV—MARCH 1965

	Temperature °C				Sunshine		Rainfall		Number of days with					
	Mean maximum	Mean minimum	Highest	Lowest	Percentage of average	Average (hours)	Percentage of average	Average (inches)	Snow falling	Snow cover	Thunder	Fog	Frost	Gale
Kew	10·3	3·2	22·0	−5·9	120	113	125	1·46	5	3	2	1	10	0
Gorleston	7·3	2·8	20·4	−5·2	96	125	113	1·35	5	1	1	1	6	0
Boscombe Down	9·7	1·6	20·6	−9·6	109	126	181	1·79	4	7	0	2	12	0
Plymouth	9·2	3·7	18·3	−7·0	98	133	131	2·73	2	0	0	0	9	3
Elmdon	9·5	0·5	23·7	−11·6	125	107	150	1·69	6	5	0	0	11	0
Valley	9·8	2·9	18·4	−4·5	111	128	98	2·09	5	3	0	0	9	4
Manchester	9·5	1·7	21·7	−6·5	140	99	85	1·77	7	0	0	0	9	0
Tynemouth	7·0	2·1	21·4	−8·0	101	100	115	1·54	6	4	0	0	6	1
Renfrew	8·3	0·9	17·2	−12·5	103	91	87	2·51	8	5	0	0	9	0
Dyce	7·2	−0·2	20·4	−15·8	103	108	54	2·12	13	10	0	0	18	0
Stornoway	7·6	2·4	12·8	−4·0	101	108	128	2·29	7	1	0	0	7	3
Aldergrove	8·1	1·5	20·2	−9·9	109	104	160	2·01	6	2	0	0	8	1

Wintry at first, very warm last few days

The very cold weather at the end of February continued during the first week of March. A small but vigorous depression in the Irish Sea brought north-easterly winds to most districts on the 1st as it moved southwards and heavy snow showers to northern England. Snow accumulated to a level depth of 10–12 inches in parts of the Pennines and north-east England. A ridge moving southwards behind the depression gave generally sunny weather the next day, but winds backed to south in Scotland in the evening and on the 3rd a deep depression moved southwards from the west of Scotland across Ireland. Winds reached gale force in most areas and a broad belt of snow moved southwards over the country. Snowfall was heavy locally in the west and Midlands and continued in the south for much of the 4th. High winds caused considerable drifting. In the Somerset–Wiltshire area it lay 9 inches deep with drifts of 6–10 feet in places.

An improvement began on the 5th as the depression, then over France, filled rapidly. Mild south-westerly winds brought occasional rain to northern districts but in the south weather remained dry and sunny for about a week as an anticyclone moved from south-west England to Germany. After a cold start weather became milder towards the end of the week as winds backed towards the south.

Frontal rain from the Atlantic reached western districts on the 12th, and from then for about two weeks weather was mild and unsettled with heavy rain at times as a series of troughs of low pressure moved across the country. Cold easterly winds on the northern side of a deep depression off southern Ireland brought renewed snowfall to the Midlands and the north on the 21st.

The month ended with an exceptionally warm spell. As an anticyclone moved northwards from the Bay of Biscay on the 26th towards southern England, temperatures rose very rapidly and exceeded 21 °C over wide areas on the 28th and 29th.

TABLE V—APRIL 1965

	Temperature °C				Sunshine		Rainfall		Number of days with					
	Mean maximum	Mean minimum	Highest	Lowest	Percentage of average	Average (hours)	Percentage of average	Average (inches)	Snow falling	Snow cover	Thunder	Fog	Frost	Gale
Kew	13·2	5·6	18·6	1·4	84	160	78	1·81	0	0	5	0	0	0
Gorleston	10·1	4·7	16·0	1·4	74	166	160	1·67	1	0	4	1	0	0
Boscombe Down	12·7	3·7	18·3	–0·9	93	167	67	1·96	1	0	2	0	2	1
Plymouth	12·0	5·5	14·3	–0·3	100	182	89	2·20	0	0	0	0	1	2
Elmdon	12·3	3·5	18·2	–4·8	89	151	94	1·98	2	0	2	0	5	1
Valley	11·9	5·2	17·1	–0·1	113	178	95	1·89	0	0	0	0	1	3
Manchester	11·7	4·1	18·1	0·2	102	138	120	1·89	2	0	2	2	0	0
Tynemouth	10·2	4·5	14·7	0·5	122	147	122	1·62	1	0	1	0	0	2
Renfrew	12·0	3·8	16·5	–1·1	114	142	103	2·32	3	0	0	0	3	0
Dyce	11·2	1·6	17·0	–3·3	108	148	106	2·29	3	0	0	0	6	0
Stornoway	9·9	3·1	13·3	–1·6	108	142	150	2·33	5	0	0	0	3	0
Aldergrove	11·7	3·6	15·3	–0·8	101	149	107	2·19	2	0	2	0	1	0

Cold and showery after a warm start

The warm sunny weather at the end of March continued into April. In southern England many places recorded more than 10 hours of sunshine during each of the first three days and afternoon temperatures rose to 20°C locally on the 3rd.

The dry spell which had lasted about a week was broken on the night of the 3rd/4th by a belt of light rain associated with a deep depression approaching Ireland. The rain-belt moved slowly eastwards across the country but owing to further developments persisted in south-east England for about 24 hours as also did a second rain belt which reached western districts during the afternoon of the 6th.

Weather during the second week was dominated by a vigorous depression which deepened considerably as it moved north-eastwards from mid-Atlantic and passed slowly between Scotland and Iceland. Widespread and locally heavy rain on the 9th and 10th gave place in the north-west to thundery showers during the afternoon of the 10th. Generally showery weather continued for most of the remainder of the week with occasional snow showers in the north-west.

Periods of heavy rain on the 14th gradually died out the next day as a depression near Iceland moved away north-east. The 16th was a generally sunny day but rain from another Atlantic depression reached western districts during the evening. Widespread rain that night gave place to frequent showers on the 17th as the depression moved south-east from Scotland into the North Sea. Thundery showers with sleet or snow at times continued throughout the 18th and 19th but these gradually died out during the next two days as pressure rose over the country.

The 23rd was a generally fine day with an anticyclone centred over central England, but during the next five days disturbances moving round a large anticyclone in the South-West Approaches brought rain to many districts on the 24th and 25th and showery weather on the 26th and 27th as winds veered towards the north. Winds were mainly easterly and weather was generally warm and sunny, and dry, apart from scattered showers, during the last three days of the month, but rain from the Atlantic reached western districts on the night of the 30th.

TABLE VI—MAY 1965

	Temperature °C				Sunshine		Rainfall		Number of days with					
	Mean maximum	Mean minimum	Highest	Lowest	Percentage of average	Average (hours)	Percentage of average	Average (inches)	Snow falling	Snow cover	Thunder	Fog	Frost	Gale
Kew	17·0	9·1	27·1	3·5	96	199	76	1·81	0	0	1	0	0	0
Gorleston	14·0	8·7	20·0	2·9	86	209	95	1·51	0	0	5	0	0	0
Boscombe Down	15·9	6·9	25·4	−0·3	95	199	77	1·85	0	0	0	0	1	0
Plymouth	14·3	8·6	23·1	1·4	88	219	97	2·39	0	0	0	0	0	0
Elmdon	15·9	7·1	25·6	−1·8	90	185	78	2·22	0	0	2	0	2	0
Valley	14·1	7·9	20·8	0·9	88	223	100	2·26	0	0	0	0	0	0
Manchester	15·2	8·1	24·9	1·1	82	177	127	2·24	0	0	2	0	0	0
Tynemouth	12·6	7·6	23·6	2·5	91	172	142	1·99	0	0	1	0	0	2
Renfrew	14·7	7·2	23·0	0·3	80	185	117	2·63	0	0	2	0	0	0
Dyce	12·0	5·2	22·5	−0·6	57	181	72	2·78	2	0	0	0	1	0
Stornoway	11·7	6·4	16·6	−0·4	64	195	123	2·29	1	0	0	0	2	0
Aldergrove	14·6	7·0	22·3	−1·3	72	196	93	2·46	0	0	1	0	2	0

Changeable. Warm mid-month but a cold ending

The first eight days were dull and unsettled with about average temperature. Occasional light rain at first became heavy and thundery on the 3rd and 4th as a depression from the Atlantic moved eastwards across the British Isles. The 5th, a cool showery day with broken sunshine, was followed by two rather wet days as troughs from the Atlantic moved across the country in rapid succession. Heavy thunderstorms broke out in the north-west on the 8th.

The second week was mostly sunny and warm. An anticyclone spreading slowly northwards from the Bay of Biscay brought long sunny periods to most of England and Wales on the 9th and this fine weather spread to the whole of the United Kingdom the next day and persisted until the 13th as the anticyclone moved from southern England eastwards towards Germany. Many places had 13 to 14 hours of sunshine daily and afternoon temperatures reached 27°C. The warm sunny weather continued in south-east England until the 15th but there was rain in the west and north from the 14th.

Many places had more than an inch of rain on both the 16th and 17th as a depression from the Atlantic moved eastwards across the country. A cold northerly air stream behind the depression brought snow showers to many northern districts during the next two days, but the 20th was sunny and warmer as an anticyclone formed over southern England.

A depression from the Atlantic became almost stationary off western Ireland from the 22nd to the 25th as it filled. All districts had thundery rain or showers with broken sunshine but rain became widespread on the 26th as the depression moved south-east across Scotland to the southern North Sea.

Northerly winds became established over the British Isles behind the depression on the 27th, and these winds persisted over most of the country during the remainder of the month bringing dull, cold weather to eastern and central England though there were long sunny periods in the west.

TABLE VII—JUNE 1965

	Temperature °C				Sunshine		Rainfall		Number of days with					
	Mean maximum	Mean minimum	Highest	Lowest	Percentage of average	Average (hours)	Percentage of average	Average (inches)	Snow falling	Snow cover	Thunder	Fog	Frost	Gale
Kew	19·7	11·4	24·0	8·0	85	213	93	1·72	0	0	2	0	0	0
Gorleston	17·0	11·0	22·3	7·0	81	215	87	1·67	0	0	1	0	0	0
Boscombe Down	18·8	9·3	22·7	5·4	80	208	120	1·62	0	0	1	0	0	0
Plymouth	16·7	10·5	23·2	6·6	90	222	152	2·01	0	0	1	0	0	0
Elmdon	19·2	9·6	22·9	3·3	102	192	140	1·66	0	0	0	0	0	0
Valley	16·6	10·4	20·6	5·0	96	221	219	1·99	0	0	0	0	0	3
Manchester	18·9	10·5	23·3	5·4	101	179	96	2·34	0	0	1	0	0	0
Tynemouth	15·9	10·3	20·6	7·0	102	182	75	1·75	0	0	0	2	0	1
Renfrew	17·8	10·1	22·9	5·8	89	183	122	2·41	0	0	2	0	0	0
Dyce	16·4	8·2	23·6	0·8	78	181	63	2·15	0	0	1	0	0	0
Stornoway	14·5	9·2	16·8	3·8	76	173	131	2·56	0	0	0	0	0	0
Aldergrove	17·4	9·3	21·7	4·0	77	179	81	2·25	0	0	1	0	0	0

Dull and rather wet

Although the month began cold and dull over south-east England, the 2nd and 3rd were fine and warm with 14 hours of sunshine in many places as a ridge of high pressure moved southwards over the country. Rain from the Atlantic, locally heavy, reached Northern Ireland the next day and spread across northern Britain that night.

Feeble troughs moving across the country during Whit weekend gave occasional thundery rain, but there were also good sunny periods especially on the 5th and 7th. A complex area of low pressure moving eastwards across southern England gave periods of heavy thundery rain on the 8th and these persisted in eastern districts well into the 9th.

Three days of mainly fine warm weather followed the disturbance as a ridge of high pressure moved slowly east across the country. Many places had 12 hours of sunshine on the 9th, 10th and 11th and afternoon temperatures exceeded 20°C locally.

From the 12th to the 25th weather was mainly unsettled as a series of troughs and depressions separated by weak ridges crossed the country. The 15th–18th was a particularly wet period, but, on the other hand, there were good sunny periods, especially in southern districts on the 13th–14th and 19th–20th.

Weather became sunny and warm on the 26th as pressure rose over the country and this fine weather continued over England and Wales for most of the remainder of the month although there were outbreaks of thundery rain in the south-east on the 29th. In Scotland weather remained dull and changeable.

TABLE VIII—JULY 1965

	Temperature °C				Sunshine		Rainfall		Number of days with					
	Mean maximum	Mean minimum	Highest	Lowest	Percentage of average	Average (hours)	Percentage of average	Average (inches)	Snow falling	Snow cover	Thunder	Fog	Frost	Gale
Kew	19·3	12·3	23·6	7·0	62	198	88	2·44	0	0	5	0	0	0
Gorleston	17·6	11·6	22·5	5·6	62	210	131	2·30	0	0	6	0	0	1
Boscombe Down	18·4	10·1	21·6	4·4	72	191	151	2·48	0	0	3	0	0	0
Plymouth	17·2	11·7	19·7	7·5	84	198	158	2·58	0	0	4	0	0	0
Elmdon	17·5	10·0	21·7	1·2	65	178	110	2·60	0	0	5	0	0	0
Valley	17·2	11·4	21·2	7·8	95	187	121	2·52	0	0	0	0	0	0
Manchester	17·1	10·8	22·0	6·3	68	154	92	3·09	0	0	1	0	0	0
Tynemouth	14·7	10·1	20·5	7·2	67	169	87	2·97	0	0	0	0	0	1
Renfrew	16·6	8·9	20·7	2·5	98	159	110	3·10	0	0	1	0	0	0
Dyce	14·2	7·8	18·1	0·1	66	157	76	3·45	0	0	0	0	0	0
Stornoway	14·5	8·4	19·9	3·0	119	128	37	3·08	0	0	0	0	0	0
Aldergrove	16·3	8·8	20·4	4·6	98	136	98	3·05	0	0	0	0	0	0

Cold, dull and wet

The fine sunny weather at the end of June continued on the 1st but during the next four days northerly winds brought progressively colder weather with scattered showers. In parts of the Midlands, air temperature fell within 1 deg C of freezing on the 4th, and ground frost was widespread. Troughs in the airstream brought periods of rain on the 6th and thunderstorms broke out over southern England on the 7th as a small depression moved rapidly eastwards along the English Channel, but the generally cold showery weather continued until the 9th.

The next five days were very wet. Rain ahead of a vigorous depression approaching from the Atlantic spread to all districts on the 10th becoming heavy in many places the next day as the depression moved eastwards across Scotland. Small wave disturbances crossing southern England gave more than one inch of rain over wide areas. During the next three days low pressure became established from south-west England to southern Scandinavia giving heavy and prolonged rainfall in many places. In the Cardiff area almost 3 inches fell during about 70 hours of more or less continuous rain. On the 14th sunny periods were broken by thunderstorms accompanied by heavy rain; during one storm 5½ inches of rain were recorded at Wadebridge in 3 hours 40 min.

The wet spell was followed by four days of mainly dry cold weather with good sunny periods as a ridge of high pressure moved slowly eastwards across the country.

Periods of thundery rain and thunderstorms were frequent especially during the early part of the next week. A depression moving across southern England on the 20th and 21st gave some unusually heavy falls just to the north of the London area including a fall of 1 inch at Stansted in 17 minutes. Two cool but mainly dry days preceded heavy rain on the 28th and 29th as a vigorous Atlantic depression crossed the country. The rain gave place to thundery showers on the 30th and the month ended with long sunny periods especially in the south.

TABLE IX—AUGUST 1965

	Temperature °C				Sunshine		Rainfall		Number of days with					
	Mean maximum	Mean minimum	Highest	Lowest	Percentage of average	Average (hours)	Percentage of average	Average (inches)	Snow falling	Snow cover	Thunder	Fog	Frost	Gale
Kew	20·7	12·5	25·8	9·1	100	188*	104	2·24	0	0	2	0	0	0
Gorleston	18·8	12·5	25·0	9·0	105	189	109	2·01	0	0	0	0	0	0
Boscombe Down	20·2	10·2	24·4	6·1	107	184	88	2·31	0	0	1	0	0	0
Plymouth	18·1	11·8	23·9	6·9	87	198	116	2·88	0	0	0	0	0	1
Elmdon	19·8	9·8	24·8	4·9	106	173	56	2·43	0	0	1	0	0	0
Valley	18·3	11·8	27·8	5·5	111	183	109	2·90	0	0	0	0	0	2
Manchester	18·7	11·1	25·0	6·0	112	151	61	3·19	0	0	3	0	0	0
Tynemouth	16·1	10·8	20·0	7·4	114	147	65	3·03	0	0	1	0	0	0
Renfrew	17·5	9·6	24·8	2·9	108	137	123	3·33	0	0	1	0	0	0
Dyce	16·6	8·4	20·4	2·0	100	147	71	3·10	0	0	1	0	0	0
Stornoway	15·1	9·1	20·6	2·4	100	133	130	3·35	0	0	0	0	0	0
Aldergrove	17·0	10·0	22·0	3·5	94	135	105	3·29	0	0	0	0	0	0

Cool and changeable

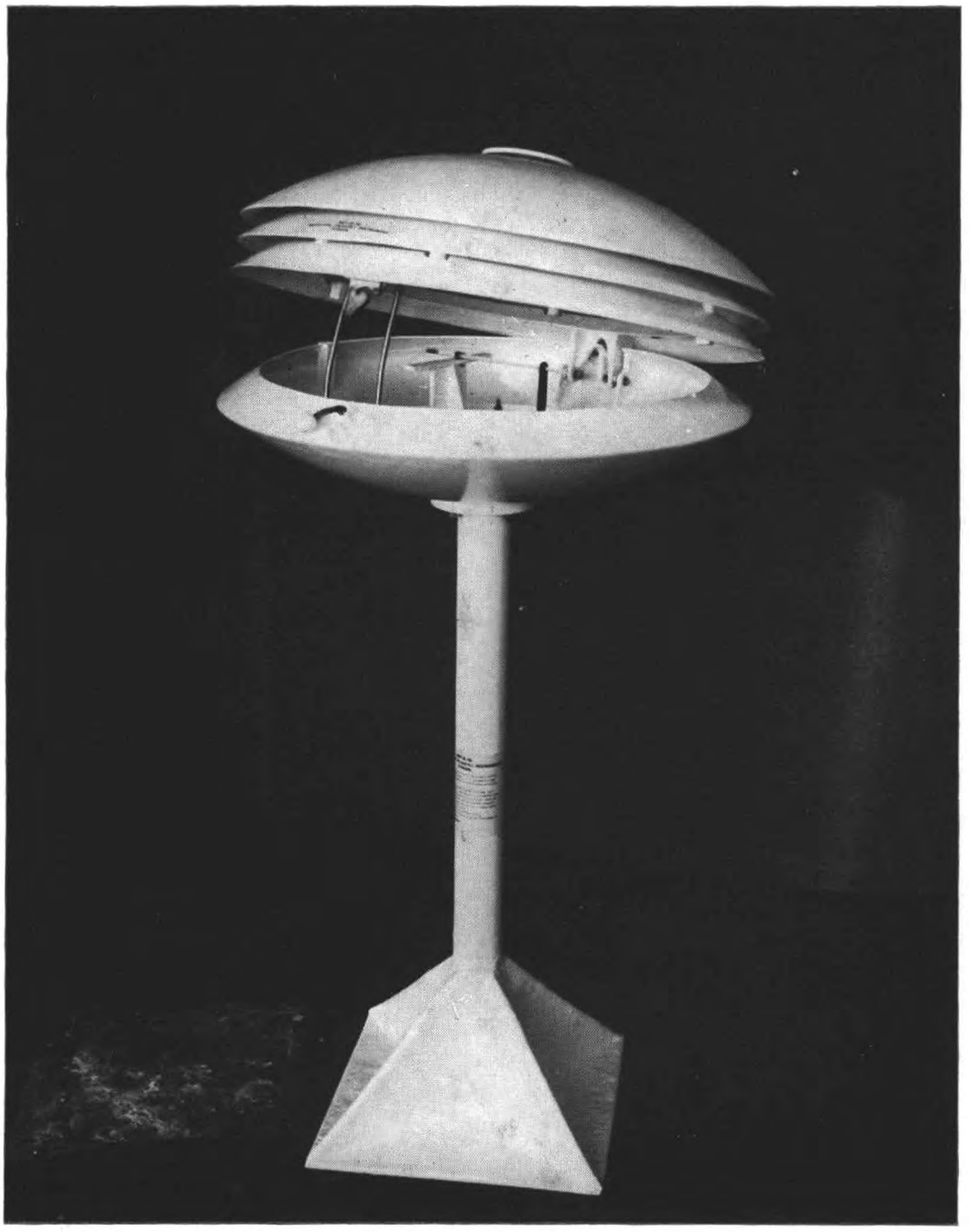
The cool, showery weather at the end of July continued on the 1st but a depression approaching western Ireland from the Atlantic brought more continuous rain to western districts during the evening, and rain became widespread and locally heavy the next day as the disturbance moved eastwards across the British Isles.

The 3rd began a spell of generally dry sunny weather with about average temperature which was maintained in south-east England for about two weeks, but a complex depression moving slowly from the west of Ireland to the north of Scotland brought periods of heavy rain to parts of the west and north on the 4th–6th. Weather became fine and cooler on the 7th–9th as a ridge of high pressure moved slowly eastwards across the country, but on the 10th a warm southerly air stream spread over the British Isles associated with an anticyclone which had become centred over the southern North Sea; afternoon temperatures rose fairly generally to 24°C and reached 28°C on the 13th.

The fine weather broke on the 18th as fronts associated with a disturbance approaching Iceland brought occasional slight rain to many western and northern districts, and rain became persistent and locally heavy on the night of the 19th/20th as a wave on a trailing cold front slowly cleared the country. Widespread rain on the 21st was associated with a complex depression moving eastwards across Scotland but this gave place to showers and scattered thunderstorms the next day with a cold northerly airstream in its wake. At Lincoln during a storm soft hail accumulated to a depth of 4 inches. After a sunny day on the 23rd a westerly régime was re-established and wind reached gale force on the 24th as a belt of heavy rain swept across the country.

During the last week of the month weather was changeable and rather cooler with high pressure to the south-west of the British Isles. Rainfall was mainly light and there were long sunny periods on the 27th and 29th. A north-westerly airstream on the 31st brought a renewal of thunderstorms with some heavy rain in south-east England.

PLATE I



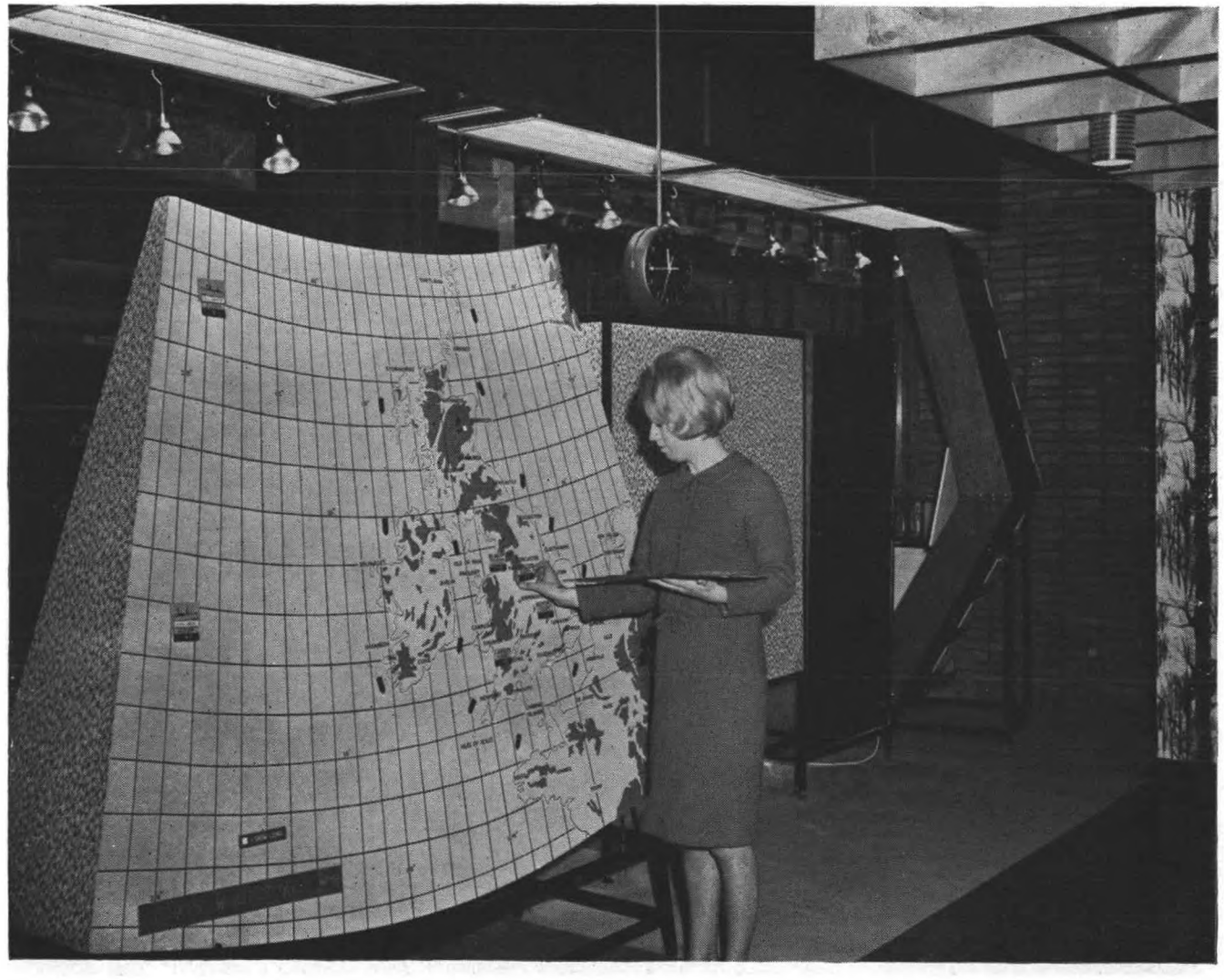
Experimental instrument screen made of fibreglass. This screen is undergoing assessment trials to determine its suitability as a replacement for the more familiar Stevenson screen. Although it is slightly more expensive, the virtual elimination of maintenance costs, the ease of repairs and the complete immunity from fungoid and insect attack offer considerable advantages.

English Electric-Leo-Marconi

A view of the operating area of the KDF9 computer installation at HQ Bracknell. Four of the six magnetic tape units are in the background behind the operator at one of the three paper tape readers. The operator's console is in the centre and prominent in the foreground is one of the three paper tape punches.

English Electric-Leo-Marconi

A more extended view of the KDF9 computer. On the left an operator is inspecting the monitor log at the operator's console; immediately behind her are a paper tape reader and the line printer. On the right an operator is attending to a magnetic tape unit. In the far background are some of the cabinets of electronic circuitry.

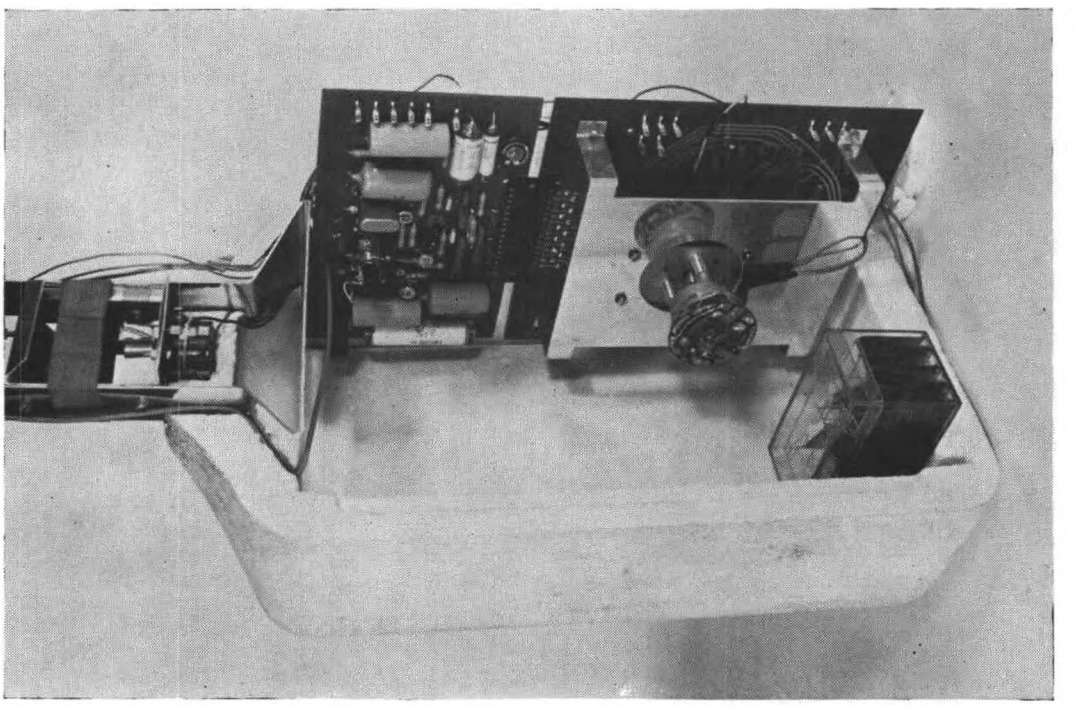


Assistant completing the weather map for display in the window of the London Weather Centre—the map is changed every hour.

Crown copyright

Window display, London Weather Centre, High Holborn.

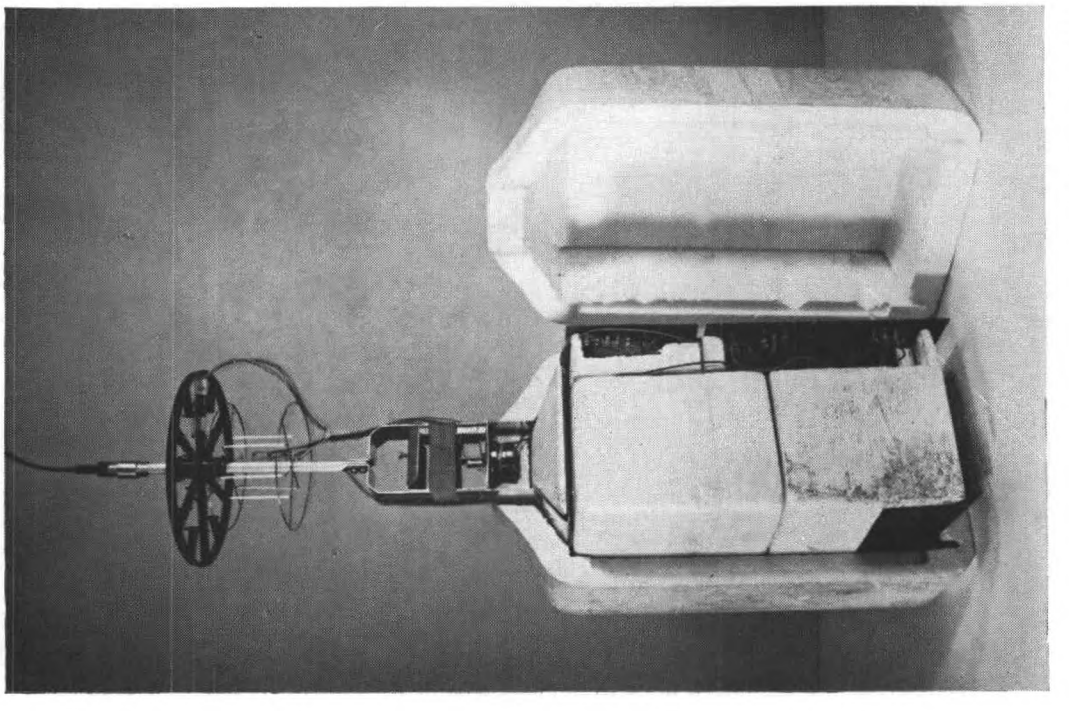
PLATE VI



Crown copyright

Prototype of Mk3 radiosonde with internal insulating material removed and showing motor-driven switch, circuit board and humidity element (at top).

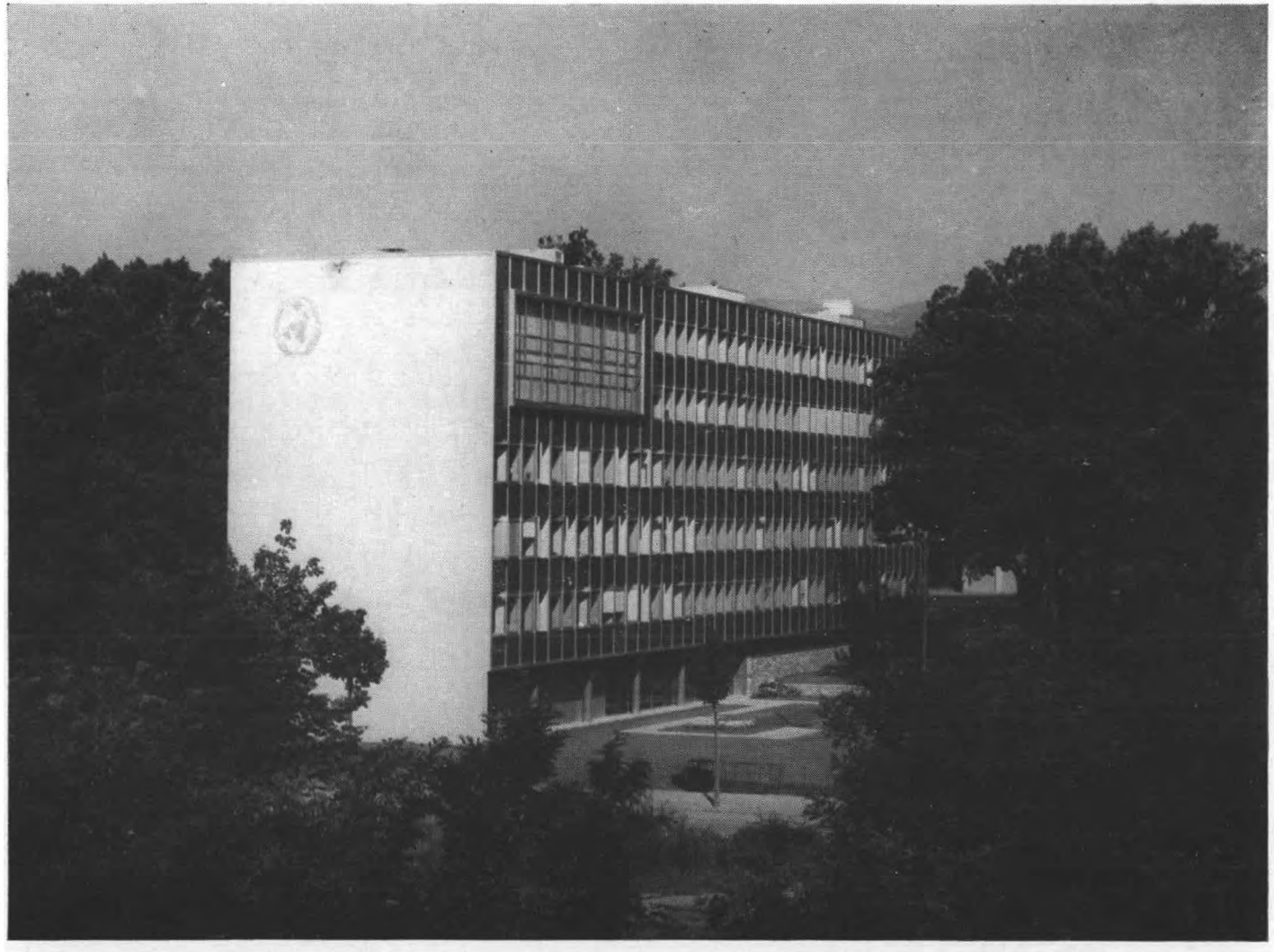
PLATE VII



Crown copyright

Prototype of Mk3 radiosonde showing internal insulation material and two experimental temperature-measuring elements at the top.

The Meteorological Research Flight Building, Royal Aircraft Establishment, Farnborough.



Reproduced by courtesy of the World Meteorological Organization

The Headquarters Building of the World Meteorological Organization.

TABLE X—SEPTEMBER 1965

	Temperature °C				Sunshine		Rainfall		Number of days with					
	Mean maximum	Mean minimum	Highest	Lowest	Percentage of average	Average (hours)	Percentage of average	Average (inches)	Snow falling	Snow cover	Thunder	Fog	Frost	Gale
Kew	17·1	9·5	19·8	4·9	92	142	212	1·98	0	0	2	0	0	0
Gorleston	16·7	10·4	20·7	6·4	86	152	158	2·23	0	0	2	1	0	4
Boscombe Down	16·2	7·6	19·4	2·4	85	137	158	2·36	0	0	1	0	0	1
Plymouth	15·6	9·4	18·4	3·7	91	152	175	2·88	0	0	0	0	0	1
Elmdon	15·7	8·7	19·8	3·9	77	127	210	2·17	0	0	1	0	0	0
Valley	15·2	10·3	17·4	5·0	75	139	138	3·16	0	0	1	0	0	0
Manchester	15·3	9·4	19·8	4·9	77	116	251	2·68	0	0	1	0	0	0
Tynemouth	14·2	10·2	19·5	6·2	62	124	211	2·31	0	0	0	0	0	0
Renfrew	15·2	8·8	18·7	3·3	62	111	142	3·57	0	0	0	0	0	0
Dyce	14·7	8·3	21·2	0·1	64	129	135	3·17	0	0	0	0	0	0
Stornoway	13·3	8·6	16·6	3·5	63	111	130	3·75	0	0	0	0	0	2
Aldergrove	14·8	7·7	18·4	2·6	75	107	111	3·02	0	0	0	0	0	0

Wet, dull and rather cold

During the first 12 days of the month pressure was generally low to the east and south-east of the British Isles with winds predominantly from a northerly direction and day temperatures well below the September average. Individual depressions in this persistent low-pressure area brought considerable rain to the eastern half of the country.

After two sunny days one such depression moving northwards from France brought exceptionally heavy rain to parts of east and south-east England on the 3rd and many places recorded more than 2 inches. The depression became complex as it moved further northwards over the North Sea and the next three or four days remained mainly cloudy with rain at times, though there were some good sunny intervals especially in south-east England on the 4th and 7th.

Gales and heavy rain in the Midlands and south-east England on the 8th were associated with a deepening depression moving eastwards across southern districts. A northerly airstream in the wake of the depression brought frequent showers on the 9th and weather remained generally showery until the 14th, apart from periods of more continuous rain due to minor disturbances on the 10th and on the night of the 12th/13th.

From the 15th to the 23rd, pressure was low to the west and north-west of the British Isles with high pressure building up first to the south and then to the east of the country. South-westerly winds predominated and day temperatures were about average.

Belts of frontal rain crossing the country on the 15th and 16th heralded one of the deepest depressions of recent times to cross England and Wales during September. Gales were widespread on the night of the 17th/18th and rain, locally heavy, persisted for much of the next day.

The only sustained spell of warm sunny weather during the month was ushered in on the 19th by an anticyclone moving eastwards over France which later became established over Germany with a ridge over southern England. Afternoon temperatures progressively increased, reaching 23°C locally on the 21st and 22nd.

The fine spell was brought to an end on the 23rd by rain associated with a deepening depression near Iceland. Weather became very unsettled as a complex low-pressure system formed over the British Isles and, during the remainder of the month, it gave periods of rain, sometimes heavy, between sunnier spells.

TABLE XI—OCTOBER 1965

	Temperature °C				Sunshine		Rainfall		Number of days with					
	Mean maximum	Mean minimum	Highest	Lowest	Percentage of average	Average (hours)	Percentage of average	Average (inches)	Snow falling	Snow cover	Thunder	Fog	Frost	Gale
Kew	15·9	8·4	24·3	1·4	143	98	37	2·25	0	0	0	5	0	0
Gorleston	14·9	10·2	19·0	3·3	124	111	37	2·43	0	0	0	2	0	1
Boscombe Down	15·2	7·4	22·4	1·7	116	103	27	2·93	0	0	0	5	0	0
Plymouth	15·4	10·1	20·7	4·3	125	114	22	3·83	0	0	0	0	0	1
Elmdon	14·3	6·0	21·2	–1·4	89	92	23	2·51	0	0	0	5	2	0
Valley	15·6	8·8	20·8	1·2	148	102	72	3·84	0	0	0	0	0	4
Manchester	15·1	7·7	22·7	–0·4	151	85	50	3·22	0	0	0	0	1	0
Tynemouth	12·9	8·9	20·5	3·4	84	92	45	2·47	0	0	0	4	0	1
Renfrew	12·9	6·9	18·1	–0·3	75	72	89	4·70	0	0	1	3	2	0
Dyce	12·9	6·5	19·6	–1·2	92	96	32	3·74	0	0	0	0	3	1
Stornoway	12·4	7·1	15·2	0·0	112	76	110	4·38	0	0	0	0	0	2
Aldergrove	13·0	7·6	16·8	–0·2	66	81	81	3·60	0	0	0	1	1	0

Very dry

October was an exceptionally dry month, the driest October in England and Wales since 1809, except for 1947. However, the cool unsettled weather of September continued during the first two or three days of the month as a depression moved north-west across the British Isles. The latter part of the first week was dry, sunny and rather warm with afternoon temperatures 5 to 7°C above the average in many places. Overnight fog was slow to clear especially on the 6th when much of the east coast from Caithness to Lincoln remained cool and foggy all day.

An anticyclone near the north of Scotland brought freshening easterly winds and much cooler weather on the 8th but it remained generally sunny until the 11th when cloud from the North Sea affected many north-eastern districts, and this cloud extended over much of the country on the 12th and 13th.

By the 13th the anticyclone had moved eastwards into Europe as a vigorous depression approached Iceland, and the next day an associated belt of frontal rain moved slowly south-eastwards across all districts.

This proved to be only a temporary break in the dry weather as, after a showery day with north-westerly winds on the 15th, pressure quickly rose again as an anticyclone from the Atlantic approached the British Isles.

This new anticyclone was centred over southern England on the 16th and 17th and thereafter moved slowly eastwards into Europe but the British Isles remained under its influence until the 25th with generally dry and sunny weather especially in the south-east.

The fine spell was brought to an end as rain reached Scotland on the night of the 26th/27th. A succession of vigorous disturbances from the Atlantic brought wet stormy weather during the last few days of the month; on the 31st some places in west Scotland recorded more than 2 inches of rain.

TABLE XII—NOVEMBER 1965

	Temperature °C				Sunshine		Rainfall		Number of days with					
	Mean maximum	Mean minimum	Highest	Lowest	Percentage of average	Average (hours)	Percentage of average	Average (inches)	Snow falling	Snow cover	Thunder	Fog	Frost	Gale
Kew	8·2	3·8	14·7	−3·0	182	53	115	2·49	4	1	0	0	6	0
Gorleston	8·0	4·2	15·0	−1·7	146	58	87	2·74	7	0	0	0	5	5
Boscombe Down	7·6	2·2	13·4	−6·4	136	62	126	3·19	3	0	0	0	11	0
Plymouth	9·9	5·2	14·7	−2·1	114	67	175	4·48	6	1	0	0	4	5
Elmdon	6·8	1·7	13·4	−7·6	142	50	117	2·68	9	0	2	1	13	1
Valley	8·7	4·1	13·6	−3·1	152	59	113	3·60	4	0	2	0	4	6
Manchester	6·9	2·2	13·0	−4·9	175	43	71	3·03	8	0	1	0	11	1
Tynemouth	6·4	3·2	12·2	−2·9	106	49	226	2·50	12	3	0	0	4	7
Renfrew	6·6	1·3	13·5	−5·2	179	42	39	4·12	11	4	1	1	16	1
Dyce	5·7	0·6	13·1	−7·6	77	59	87	3·67	17	11	0	1	15	1
Stornoway	6·6	2·1	12·4	−5·5	138	45	82	4·50	13	—	1	0	10	2
Aldergrove	6·5	2·2	12·5	−5·1	140	53	145	3·19	11	0	0	0	11	1

Cold. Considerable snow in northern districts

The stormy weather at the end of October continued on the 1st as an intense depression moved eastwards across Scotland during the early hours. Wind exceeded 65 kt at many places and a gust of 102 kt was recorded at Lowther Hill, Lanarkshire. A northerly airstream in the wake of the depression brought showers to most districts on the 2nd and 3rd. The next three days were quiet, sunny and mainly dry as an anticyclone moved slowly eastward from the west of Ireland to the North Sea.

The only really mild spell of the month was on the 7th–11th. It was also rather wet, rain being locally heavy in western districts on the 7th as a depression to the west of Ireland moved rapidly northward. On the 9th a small depression moved eastwards along the English Channel and produced heavy rain at times in the south.

Rising pressure to the north of Scotland on the 12th brought freshening easterly winds to all areas, and this proved to be the beginning of a bitterly cold spell which lasted until the 16th. Day temperatures, which had fallen progressively for several days, failed to rise above freezing-point in many parts of southern England on the 15th. Though there were good periods of sunshine, eastern districts had snow showers.

On the 16th a deep slow-moving depression off our south-west coasts brought strong to gale-force winds and periods of snow to most areas, but the snow turned to rain in the south the next day as temperatures rose a little. The unsettled weather continued for several days with heavy thundery rain at times in the south, and with snow in the north. Winds backed towards north on the 22nd bringing the cold weather with heavy snow showers back over southern districts. On the 23rd a depression deepened as it moved south-east across Scotland and this was followed by a series of vigorous depressions from the Atlantic crossing the British Isles in a more westerly régime which maintained stormy weather during the remainder of the month with periods of heavy snow in the north and heavy rain at times in the south. A blizzard in northern England on the 27th was described as the worst since 1947 and on the 30th an airlift relieved troops in County Durham cut off by 15 ft snowdrifts for more than a week.

TABLE XIII—DECEMBER 1965

	Temperature °C				Sunshine		Rainfall		Number of days with					
	Mean maximum	Mean minimum	Highest	Lowest	Percentage of average	Average (hours)	Percentage of average	Average (inches)	Snow falling	Snow cover	Thunder	Fog	Frost	Gale
Kew	8·2	3·5	13·2	−6·1	145	40	181	2·06	0	0	1	0	6	0
Gorleston	6·6	2·6	13·4	−4·3	120	46	150	2·16	3	2	0	0	7	3
Boscombe Down	7·8	2·2	12·5	−7·3	136	49	139	3·02	1	0	0	1	9	1
Plymouth	9·6	5·3	12·5	−2·4	120	52	200	4·51	2	0	0	0	4	8
Elmdon	6·9	1·7	13·3	−10·1	114	40	225	2·41	1	0	0	0	9	2
Valley	8·5	4·5	11·0	−1·8	124	43	188	3·53	3	0	0	0	4	6
Manchester	6·5	1·9	13·5	−7·2	146	32	257	2·75	3	1	1	0	7	1
Tynemouth	5·5	2·1	12·4	−4·6	146	33	96	2·39	4	1	0	0	6	1
Renfrew	6·0	0·9	12·5	−8·4	192	26	109	4·19	3	2	1	0	10	0
Dyce	4·1	−1·1	9·1	−9·7	67	45	116	3·28	13	5	0	0	23	0
Stornoway	5·9	1·0	10·7	−6·6	115	26	141	4·06	11	4	0	0	14	0
Aldergrove	6·2	1·0	12·0	−9·0	139	35	122	3·54	3	1	0	0	11	0

Sunny, but very wet in England and Wales

The month began bright and cold with most of the ground snow-covered from Derbyshire northwards. Rain, however, was widespread on the night of the 1st but gradually gave place to thundery showers, although it continued in north Scotland for much of the 2nd as a complex depression moved south-eastwards across Scotland to the North Sea. Another disturbance from the Atlantic brought considerable rain on the 4th and 5th, and heavy falls at times, as a developing centre moved eastward across southern England. Two sunny days with scattered thundery showers concluded a rather cold first week.

The 2nd week was milder and began wet. After two very wet days with widespread gales and more than 1 inch of rain in many Midland and southern districts on the 9th, a north-westerly airstream brought scattered showers on the 10th and 11th, but the previous heavy rain, and rapid thaw, due to the milder weather, led to widespread floods. The 12th was another wet day and the rain continued in eastern England for much of the 13th as a small disturbance moved eastwards across southern districts. Fairly widespread fog that night persisted in many places throughout the 14th.

The mild wet weather continued into the 3rd week and heavy rain about mid-week caused renewed and widespread flooding. The 17th was the mildest day of the month with afternoon temperatures over much of the southern half of England reaching 13°C. The 19th–21st was cooler with good sunny periods in a north-westerly airstream.

A complex area of low pressure covering the British Isles gave dull wet weather on the 23rd and 24th but, on Christmas Day, although rain persisted for a time in south-east England, northerly winds brought snow showers to parts of Scotland and there were long sunny periods in the west.

Fine sunny weather became general during the next few days but it was much colder with day temperatures about 6 deg C below average. Temperatures remained below freezing-point at many places throughout the 28th. The 29th was a stormy day with widespread rain preceded by snow in many places; snowfall was heavy in Scotland. The last day of the month was very mild and wet with temperatures in southern England about 5 deg C above average.

STATISTICS OF THE SERVICES DIRECTORATE

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 1965

	Within U.K.	Overseas
Principal Forecast Offices associated with the RAF	1	—
Main Meteorological Offices associated with the RAF	7	6
Subsidiary offices associated with the RAF	46	18
Observing offices associated with the RAF	7	5
Principal Forecast Offices associated with civil aviation	1	—
Main Meteorological Offices associated with civil aviation	3	1
Subsidiary meteorological offices associated with civil aviation	12	1
Observing offices associated with civil aviation	6	—
Upper air observing offices	8	7
Public service offices	4	—
CRDF offices	5	3
Port Meteorological Offices	5	—
Offices associated with the National Agricultural Advisory Service	3	—
Other offices	29*	7

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 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 certain large cities.

CRDF offices form the network for thunderstorm location.

Port meteorological offices are maintained at the bigger ports.

*Eight of these stations are administered by D.R. Met.O.

TABLE XV

OCEAN WEATHER SHIPS

To meet its obligation under the ICAO North Atlantic Ocean Station Agreement the United Kingdom operates 4 Ocean Weather Ships which work in rotation with 2 ships from France, 2 ships from the Netherlands and 2 ships jointly operated by Norway and Sweden. The British ships serve at 4 of the 5 ocean weather stations in the eastern North Atlantic; each vessel makes, on average, 8 voyages a year and spends 24 days on station during each voyage. Some statistics for 1965 for the British Ocean Weather Ships are shown below.

Total number of days on station	725
Total number of days on passage	171

	Station A	Station I	Station J	Station K
	Average number per voyage of 24 days			
Aircraft contacted	407	639	1511	305
Radar fixes to aircraft	284	408	1080	383
Weather messages to aircraft	22	66	324	75

TABLE XVI

MERCHANT NAVY SHIPS

A total of about 4419 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 4 specified times daily are known as 'selected' ships, those which report at the same times daily, but in a less complete form, are known as 'supplementary' ships. A number of coasting vessels, lightships, distant-water trawlers and 'auxiliary' ships also make and transmit meteorological observations. On 31 December 1965 the number of British ships reporting was:

Selected ships	502	
Supplementary ships	72	including 9 trawlers
Coasting vessels	125	
Lightships	13	
Trawlers	16	
Auxiliary ships	33	
Total	761	

The British Voluntary Observing Fleet includes ships of over 100 shipping companies; the numbers on the various routes are as follows:

United Kingdom to:		United Kingdom to:	
Australasia	103	South America	28
Far East	83	Pacific coast of North America	12
Persian Gulf	31	European ports	54
South Africa	45	Falkland Islands and Antarctica	2
West Indies	37	World-wide 'tramping'	88
North America	91		

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	73	83
	Foreign ships in eastern North Atlantic	103	103
	British trawlers in North Sea	18	6
	British merchant ships in North Sea	11	28
	Total (direct reception)	205	220
Reception via other European countries	Ships in eastern North Atlantic	358	328
	Ships in Mediterranean	146	57
	Ships in North Sea	64	91
	Ships off north Russia	13	48
	Ships in Pacific	128	118
	Ships in other European waters	77	127
	Total	786	769
Via U.S.A. and Canada	Ships in North Atlantic	453	509
	Ships in North Pacific	316	323
	Ships in other waters	66	23
	Total	835	855

TABLE XVII

CLASSIFICATION OF STATIONS WHICH RENDER CLIMATOLOGICAL RETURNS

A large amount of meteorological data is obtained for climatological purposes from 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 1965.

	Stations					Autographic Records		
	Observatories	Synoptic	Agro-meteorological	Climatological	Rainfall*	Sunshine	Rainfall	Wind
Scotland, north	1	9	0	25	316	23	8	9
Scotland, east	0	11	9	57	626	46	15	9
Scotland, west	1	13	3	46	497	31	20	11
England, north-east	0	11	4	25	437	27	16	5
England, east	0	13	14	19	503	26	24	10
England, Midlands	0	13	19	47	1279	59	41	7
England, south-east (including London)	1	18	19	46	854	65	83	17
England, south-west	0	9	8	21	576	34	12	6
England, north-west	0	5	4	21	476	24	21	12
Wales, north	0	2	2	13	233	10	8	2
Wales, south	0	3	9	15	322	22	5	5
Isle of Man	0	2	0	1	15	3	1	2
Scilly and Channel Isles	0	3	0	2	19	5	1	3
Northern Ireland	0	10	7	37	308	20	14	6
Total ..	3	122	98	375	6461	395	269	104

*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, and height performance of largest balloons.

Observations of temperature, pressure and humidity

	Number of observations	Percentage of all balloons reaching 100 mb 53,000 ft. (approx)	50 mb 67,000 ft. (approx)	30 mb 78,000 ft. (approx)	10 mb 100,000 ft. (approx)	Percentage of largest balloons reaching 10 mb 100,000 ft. (approx)
Eight stations in United Kingdom	5803	93·7	77·7	30·5	6·5	50·3
Seven stations overseas ..	4722	96·7	82·2	44·6	4·8	37·7
Four Ocean Weather Ships ..	1412	91·4	66·2	28·1	0·1	—

Observations of wind

	Number of observations	Percentage of all balloons reaching 100 mb 53,000 ft. (approx)	50 mb 67,000 ft. (approx)	30 mb 78,000 ft. (approx)	10 mb 100,000 ft. (approx)	Percentage of largest balloons reaching 10 mb 100,000 ft. (approx)
Eight stations in United Kingdom	11,324	86·3	55·5	13·5	3·4	50·5
Seven stations overseas ..	8133	88·5	68·1	26·6	3·2	42·7
Four Ocean Weather Ships	2812	83·7	50·5	13·2	0·1	—

TABLE XIX

THUNDERSTORM LOCATION

Number of thunderstorm positions reported by CRDF network 81,057

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 land-line. 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 1965 and, for comparison, some corresponding figures for one day near the end of 1964.

Communications traffic for one day

	Number of groups in one day			
Coded Messages	In	Out	Total	Total in 1964
Land-line teleprinter ..	393,433	331,557	724,990	687,600
Radio	91,006* 32,214	217,633	340,853	313,342
Facsimile Charts	**Number of charts in one day**			
Land-line	0	88	88	77
Radio	112*	74	186	157

*Received at Bampton and relayed to Bracknell 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 primarily for farmers)	1964	744	1965	642
Weekend temperature forecasts (a winter service primarily for industrialists) ..	1964–65	46	1965–66	43
Snow and icy road warnings (primarily for Local Authorities)	1964–65	257	1965–66	256

TABLE XXII

FORECASTS FOR AVIATION

Forecasting for aviation constitutes the primary function of many of the offices. The Central Forecasting Office is almost solely concerned with analysis of the weather situation, the issue of guidance in outline to other offices and the issue of forecasts to the BBC and the national Press. Thus the volume of work in the Central Forecasting Office shows little variation from year to year. The following figures indicate the numbers of forecasts issued for aviation and the numbers of meteorological briefings which took place during 1964 and 1965. They do not include warnings and routine general forecasts.

	1964	1965
Number of meteorological briefings for		
aviation in United Kingdom ..	370,119	348,806
aviation at overseas stations ..	63,809	68,863
Number of aviation forecasts issued for		
aviation in United Kingdom ..	908,767	951,932
aviation at overseas stations ..	235,385	283,356

TABLE XXIII

NON-AVIATION INQUIRIES

Non-aviation inquiries are handled by four weather centres specially established at London, Manchester, Glasgow and Southampton to meet the needs of the general public for forecasts for special purposes. Many of the forecast offices are established primarily to meet aviation requirements but also answer telephone requests, for forecasts and other weather information, from the general public, public corporations,

Press, commercial firms, etc. (the *Post Office Guide* lists the telephone numbers of 39 such offices). All but an insignificant proportion of these inquiries refer to current or future weather and are categorized according to the purpose of the inquiry in the figures below. Climatological inquiries are dealt with in Table XXV.

	1964	1965
Grand total of inquiries (all offices) ..	967,265	1,162,107
Percentage of inquiries connected with		
agriculture, etc.	10·2	11·5
building, commerce, industry ..	8·6	10·1
holidays	16·1	17·3
marine matters	17·7	16·5
Press	9·5	8·7
public utilities	8·5	8·7
road transport	15·0	12·8

TABLE XXIV

BBC FLASH WEATHER MESSAGES

FLASH weather messages, which are passed to the BBC for broadcast on the Light Programme, are effectively warnings of the actual occurrence of weather conditions which might cause considerable inconvenience to a large number of people. The first FLASH message was broadcast in October 1965 and the following table shows the kind of weather and areas of the country for which FLASH messages are broadcast and the number issued in 1965.

Area	Dense fog	Moderate or heavy snow	Very heavy rain	Glazed frost
Edinburgh	—	—	—	—
Central Clydeside	2	—	—	2
Belfast	—	—	—	—
Tyneside	—	—	—	—
Merseyside and south-east Lancashire	3	—	—	—
West Yorkshire	—	—	—	—
Industrial Midlands	—	—	—	—
Bristol and industrial south Wales ..	—	—	—	—
Greater London	3	—	—	—
Southampton/Portsmouth	—	—	—	—
Plymouth	—	—	—	—
Total	8	—	—	2

In addition, 4 snow warnings of a more general nature were issued.

TABLE XXV

AUTOMATIC TELEPHONE WEATHER SERVICE FORECASTS

The total number of calls made on the service during the year showed an increase of 12 per cent on that of 1964. Forecasts were made available at 4 more GPO Information Centres, bringing the total of such centres to 20. The number of forecast areas was increased by 3 to 17. The figures below are supplied by courtesy of the Postmaster-General.

Information Service Centre	Forecast area	Number of calls 1964	Number of calls 1965	Remarks
London	London	3,277,757	3,544,904	
London	Essex Coast	184,647	194,665	
London	Kent Coast	155,893	170,194	
London	Sussex Coast	237,294	241,138	
Colchester	Essex Coast	101,109	120,965	
Brighton and Hove	Sussex Coast	159,744	212,992	
Birmingham	Birmingham	391,303	446,666	
Liverpool	South Lancashire and North Cheshire	209,175	239,947	
Liverpool	Lancashire Coast	100,295	72,801	
Liverpool	North Wales Coast	22,492	41,605	Started March 1964

Information Service Centre	Forecast area	Number of calls 1964	1965	Remarks
Manchester	South Lancashire and North Cheshire	255,443	294,338	
Manchester	Lancashire Coast	49,394	60,506	
Manchester	North Wales Coast	18,211	28,672	Started March 1964
Cardiff	Cardiff	202,368	248,874	
Belfast	Belfast	203,035	208,944	
Glasgow	Glasgow	283,697	350,662	
Edinburgh	Edinburgh	249,409	234,947	
Bristol	Bristol	219,343	257,163	
Portsmouth	Southern Hampshire	117,040	146,339	
Southampton	Southern Hampshire	230,739	198,030	
Canterbury	Kent Coast	113,706	121,223	
Blackpool	Lancashire Coast	105,857	150,058	
Southport	Lancashire Coast	38,062	51,204	
Plymouth	South Devon and East Cornwall	—	44,538	Started May 1965
Exeter	South Devon and East Cornwall	—	11,538	Started September 1965
Newcastle	Tyne-Tees	—	57,397	Started September 1965
Blackburn	Central Lancashire	—	2,455	Started December 1965
Blackburn	Lancashire Coast	—	731	Started December 1965
	Total	6,926,013	7,753,476	

TABLE XXVI

CLIMATOLOGICAL INQUIRIES

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 inquiries and the percentage of this number arising from the main reasons for the inquiries.

	1964	1965
Total number of climatological inquiries	8521	9819
Percentage relating to		
Agriculture (farming, market gardening and forestry)		14·2
Building and design (including siting)		9·8
Commerce (sales, marketing and advertising) ..		6·0
Education and literature		7·0
Industrial and manufacturing activities		7·5
Law (damage, accidents, insurance)		15·7
Medicine and health		2·4
Press and information centres		5·1
Research		5·3
Water supply		9·6

TABLE XXVII

DATA PROCESSING

Punched-card installation

Number of cards punched by the Meteorological Office installation ..	912,590
Number of cards punched elsewhere on behalf of the Meteorological Office	869,200
Number of cards converted to paper tape	67,400
Number of non-routine investigations completed	143

Computer installation

The electronic computer COMET was used for computing during 1649 hours following its acceptance in July.

THE DIRECTORATE OF RESEARCH

SPECIAL TOPIC

Long-Range Weather Forecasting

The economic advantages of accurate forecasts of weather for a month or, better still, a season ahead are so great that considerable efforts to provide such forecasts are fully justified even though the enormous complexities of the subject make it probable that accurate predictions will be difficult to achieve.

The familiar methods of short-range forecasting can be extended to provide a medium-range forecast for up to about five days, but after that most of the depressions and anticyclones on today's charts will have died or moved away to be replaced by systems as yet unborn. Although it may be possible to indicate that a certain area is favourable for the formation of depressions, the prediction several days ahead of just where or when the next one will develop is not likely to be practicable.

Short-range forecasting techniques are largely dynamical or kinematic and depend very much on detailed information about the initial state of the atmosphere. A complex communications organization exists to enable this to be specified and computers are used to solve the dynamical equations of motion. For a period of a day or so, the supply of heat to the atmosphere from the sun and the earth plays a comparatively minor role in the way the situation develops; this is largely controlled by the dynamical consequences of the initial state.

For periods beyond about a week ahead the initial configuration assumes less and less importance and factors affecting the supply and removal of heat and energy from the system become dominant; most modern long-range forecasting techniques attempt in one way or another to take account of these thermodynamic factors.

Dynamical and thermodynamical processes are, of course, interlinked. Any imbalance in the heat budget of the atmosphere, such as a failure of the general circulation to convey enough heat to polar latitudes to offset radiative losses, will soon bring about substantial modifications to the temperature distribution of the atmosphere with consequent effects on pressure distribution and wind flow; such effects soon spread to the whole of the hemisphere. The complicating effects of land and sea, mountain barriers and cloud cover, and our imperfect knowledge of the heat sources and sinks, make the problem a prodigiously complex one for numerical solution. Any attempt to solve the problems of the general circulation by numerical processes must take account of both dynamical and thermodynamical principles and cover the whole hemisphere, if not the complete globe. In spite of the difficulties, the Meteorological Office is devoting a significant effort, as a long-term research project, to tackling the problem along these lines. Although the expectation of rapid success is small, the ultimate rewards may be great. In the meantime indirect methods have to be used for long-range forecasting.

It is well known that weather of a particular type often persists for several days and sometimes even weeks. Minor variations continually occur, but some basic features of the pattern may be maintained or constantly recur. Long-range forecasters seek to recognize and explain these persistencies of type.

Some patterns of the general circulation tend to be self-maintaining. Outbursts of cold northerly air behind vigorous depressions tend to produce zones of strong temperature contrast where new wave depressions may develop and deepen to produce further outbreaks of cold air. But once such a cycle is broken there is nothing in the circulation pattern itself which will tend to re-establish the cycle again. Nevertheless it is common experience that after a short break there is often a return to the previous régime. A good example of this occurred in October 1965. Figure 3 shows the average pattern of the October surface pressure over the northern hemisphere and Figure 4 the pattern that occurred in October 1965. In that month pressure was higher than usual over the British Isles and eastern Europe, and lower than normal over much of the North Atlantic. Rather frequent southerly winds gave Great Britain a warm dry month. This predominant pattern was broken around 13 to 15 October when a more normal westerly airflow covered the country (see Figure 5), bringing rain to all areas. The interruption was, however, short-lived and high pressure was soon re-established over the British Isles. The underlying cause for this type of persistence must be sought outside the atmosphere, and the state of the underlying ocean or ground is undoubtedly of considerable importance. Heat from the sun is fed into the atmosphere, largely by first warming the earth's surface, and persistent unusual circulation patterns are probably associated with abnormally warm or cold areas of sea or land. To have a significant effect on the atmosphere these areas must be of large extent, and their temperature anomalies must be persistent and of sufficient magnitude. Figure 6 shows the extent of ice and snow cover at the end of October 1965 and the areas where the sea was warmer or colder than usual. Of the various features of the state of the earth's surface which are likely to provide the atmosphere with an unusual source of heat or cold, there is little doubt that the sea temperature anomaly pattern is among the most important.

Freezing of the oceans is also a factor to be considered but areas of excessive ice cover are small compared with areas of anomalously warm or cold sea water, and any effect ice has is likely to be rather local in extent. Snow cover will affect the earth's reflective power and produce a net loss in heat by reflection of incoming radiation. This effect could be of some importance, especially in middle latitudes in spring and autumn when the sun is relatively high in the sky. A wet vegetated soil will lose heat by evaporation and act as a heat sink compared with parched ground, but it is difficult to assess the effects of this in producing anomalies of the atmosphere's circulation.

In fact, although it can be seen that all the factors mentioned must be important to a greater or lesser degree, it remains uncertain exactly what is likely to be the effect of a cold eastern Atlantic, for instance, on the weather of the British Isles, and there is scope for considerable investigation into this aspect of the long-range forecasting problem. Qualitative arguments based on the effect of anomalous surface features on circulation patterns enable some highly subjective forecasts for a month or so ahead to be made, but this type of method lacks precision and needs to be backed up by other techniques and, of these, analogue methods are perhaps the most widely used. The philosophy behind these is that if the problem cannot be solved by direct attack it is worth examining how nature solved similar problems in the past. The first step is to determine the essential features of the present situation and then to examine past records to find occasions which were similar in essentials. The sequels

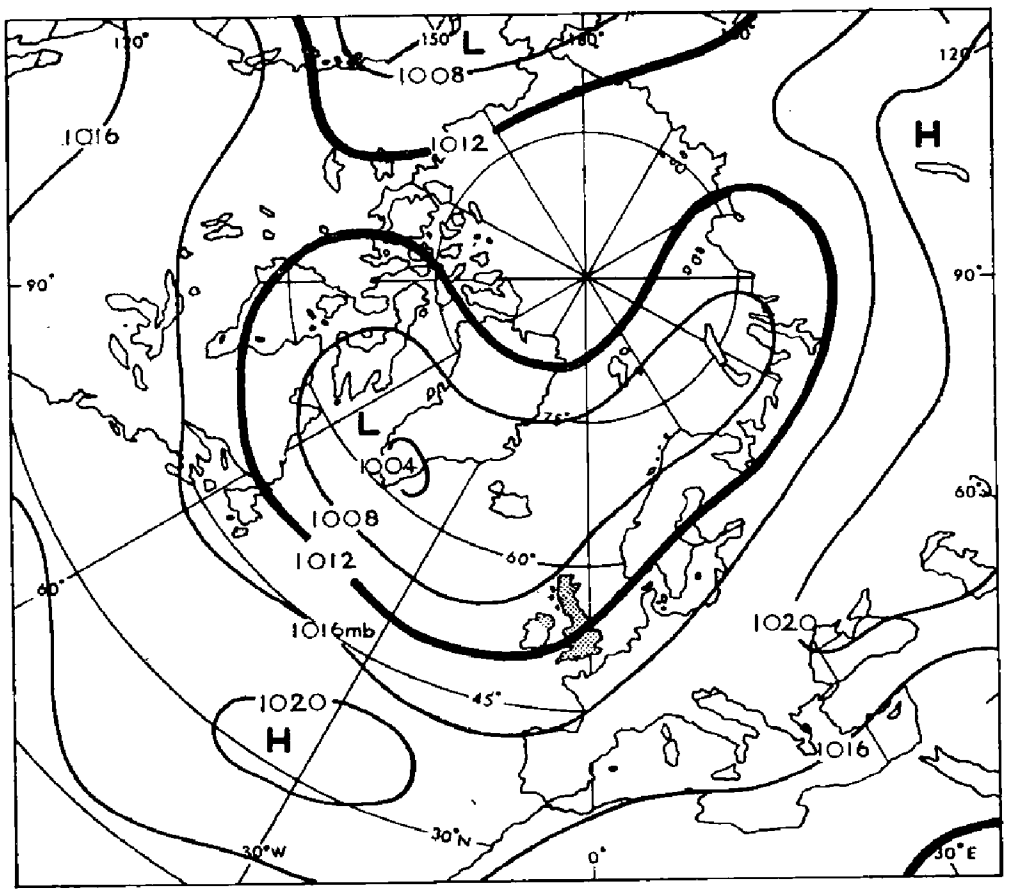


FIGURE 3—Average pattern of sea level pressure for October (1900–39)

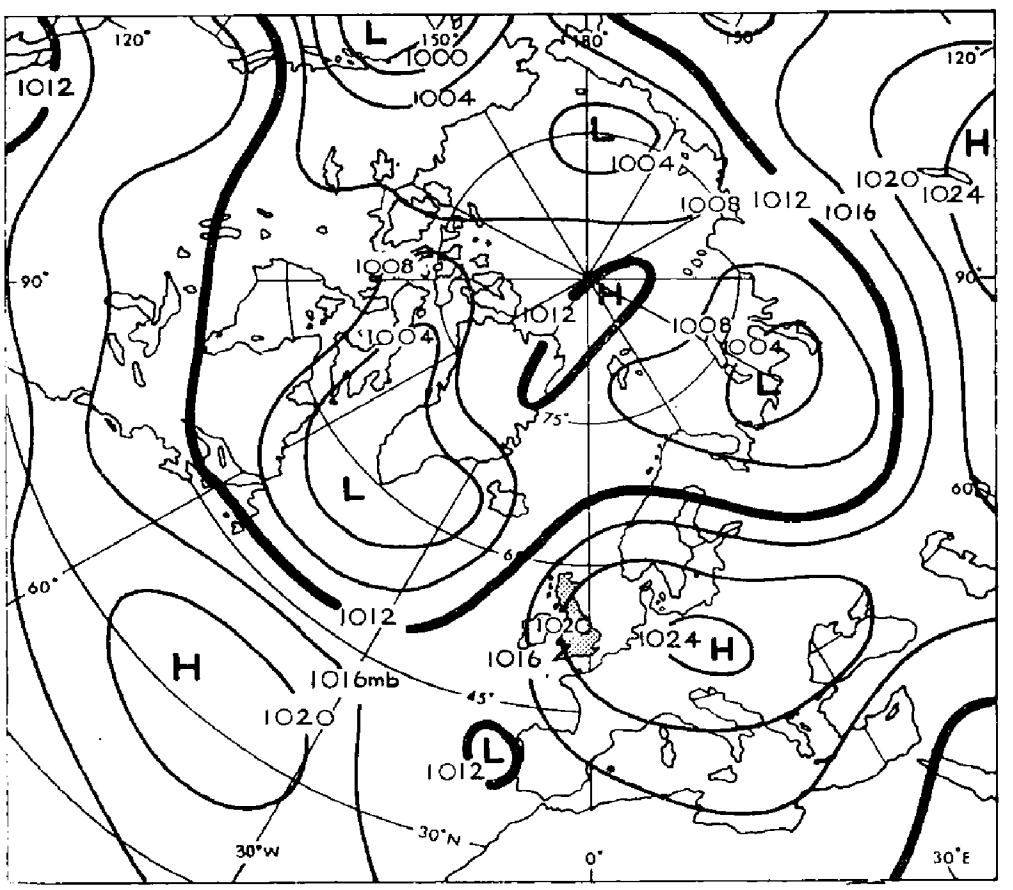


FIGURE 4—Mean pressure at sea level for October 1965

to these analogous occasions are studied; if they are in agreement it is reasonable to assume that the present situation will develop in a similar way, and to frame the forecast accordingly. If the sequels do not agree completely, the forecast can be confined to those aspects in which there is a reasonable similarity, or the basis for selection of the analogues may be re-examined to see which of them provide a close parallel with recent weather from the widest number of aspects.

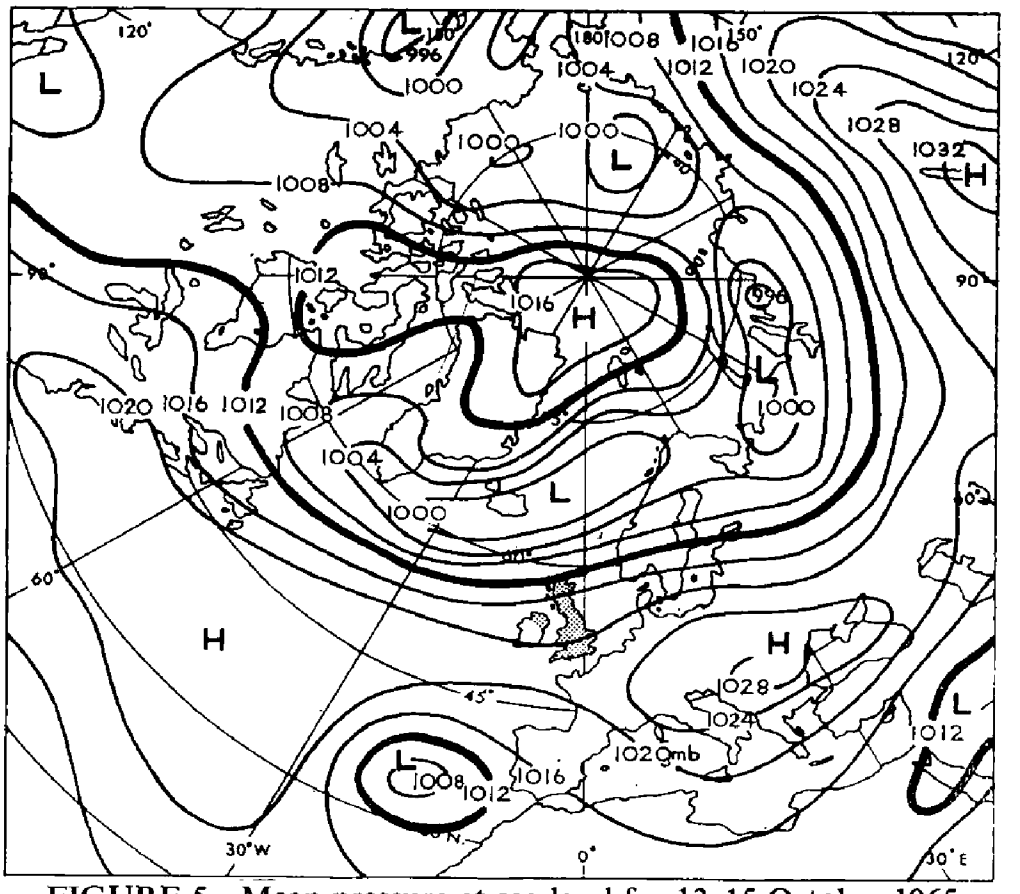


FIGURE 5—Mean pressure at sea level for 13–15 October 1965

One of the essentials of such a method of forecasting is to establish which factors are important and which largely irrelevant in selecting analogous weather régimes. Considerable experience has been built up in experiments over the last 10 years, but there is much room for further experiment and testing of trial forecasts.

Another essential requirement has been to establish an adequate library of records of past weather. It has been possible to collect suitable weather observations for Europe, and a few places elsewhere, extending back over 100 years or more, but relevant balloon observations of the free atmosphere are available only for the last 20 years or so. Even 100 years does not provide examples of all possible behaviours of the atmosphere and it is difficult to find suitable analogues of some occasions.

In the twice-monthly preparation of the 30-day weather forecasts for publication in *Monthly Weather Survey and Prospects* the selection of analogues is made in three different ways. These are based on:

(i) the distribution of the monthly mean temperature anomaly over the northern hemisphere,

(ii) the distribution of the monthly mean pressure anomaly over a similar area and

(iii) the sequence of daily weather types during the month over the British Isles.

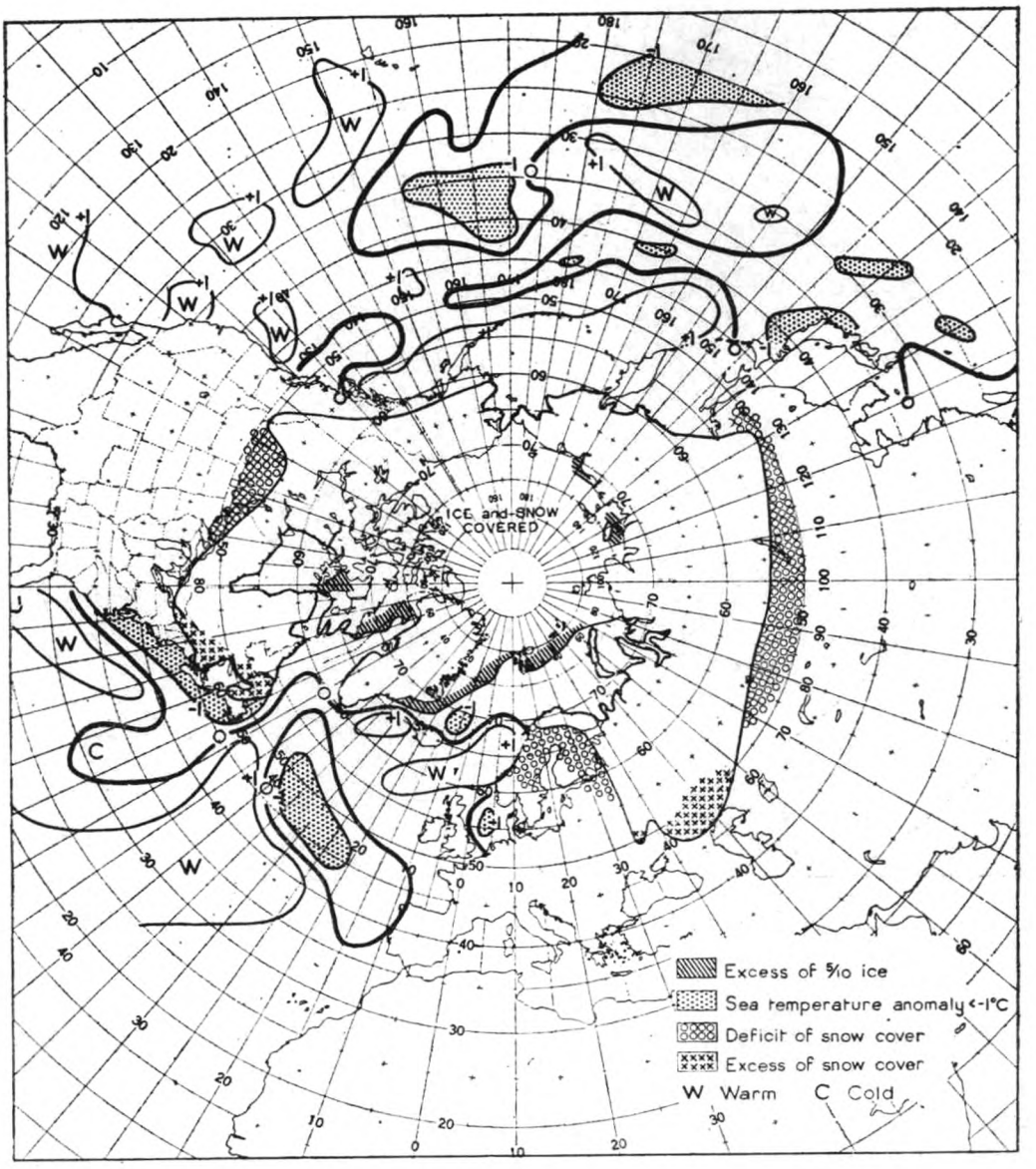


FIGURE 6—Ice and snow cover and sea temperature anomalies at the end of October 1965

An example of the charts used for comparison of the monthly mean temperature anomalies is shown in Figure 7. Such charts are available for every month back to 1881 (although necessarily rather less complete in the earlier years). The charts show the areas which were unusually warm or cold over much of the northern hemisphere and it is in respect of these that resemblance is sought when analogues are sought for the current month. If an analogue of January is required for preparation of the February forecasts, all the previous Januarys are examined. Similarity of mean surface temperature is regarded as a good basis for choosing analogues, not only because it is a measure of the anomaly of the heat supplied to the atmosphere and thus of its sources of energy, but also because the mean surface temperature is closely related to the mean upper air temperatures up to 10 kilometres above the ground and thus, in turn, with the flow of the upper winds throughout this layer.

A very similar series of charts, extending back to 1873, is used for the comparison of the surface pressure distribution with that of earlier years. (Charts before 1873 are available back to 1750 for January and July only).

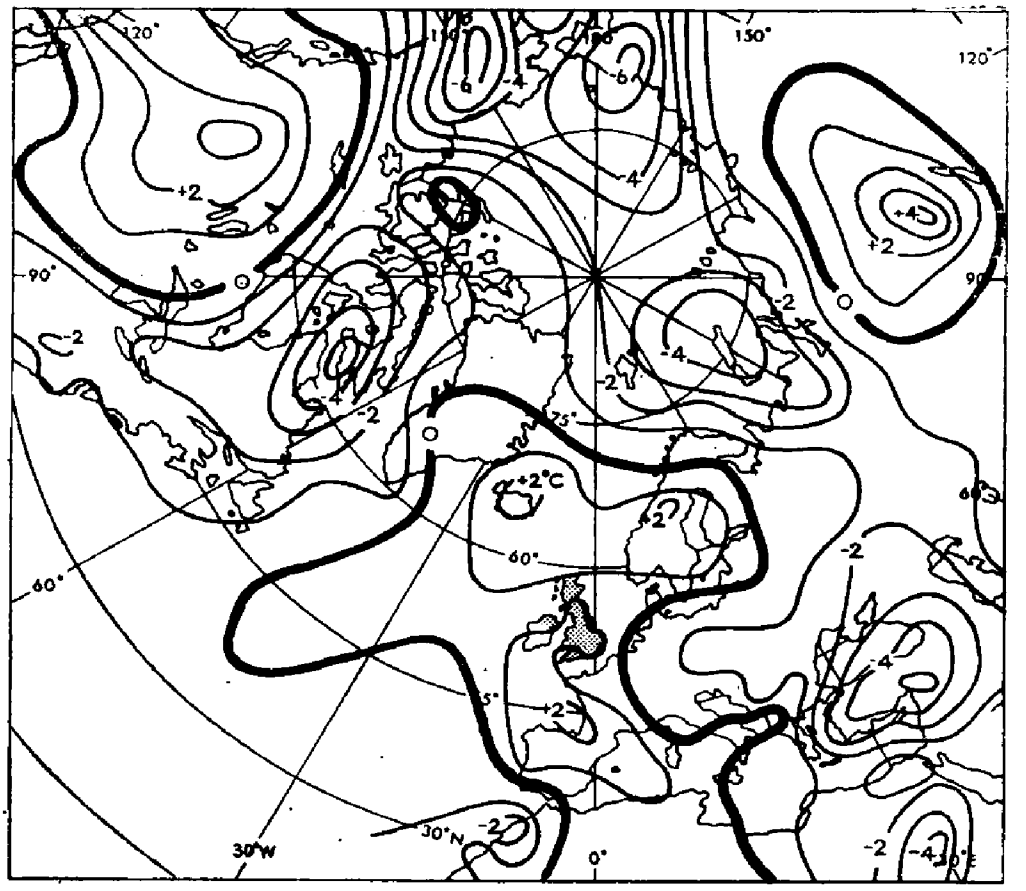


FIGURE 7—Air temperature anomalies for October 1965

The third method of matching is based on daily weather types over the British Isles. The weather situation over the region of the British Isles can be described concisely in terms of the prevailing wind flow and the presence of depressions or anticyclones. Anticyclonic weather is usually dry and warm in summer but cold in winter. A westerly weather type is marked by sequences of depressions and ridges of high pressure crossing the Atlantic and brings changeable weather to Britain. Over 33,000 charts have been classified as easterly, cyclonic, north-westerly, etc. to give a catalogue dating back to 1873. This is supplemented by another catalogue, referring to London rather than to the British Isles as a whole, which has been extended back (apart from some gaps) to 1723. The salient features of the sequence of weather types in the current month are assessed and the records are searched to find years in which the same month had a similar weather sequence, and which can therefore be used as analogues.

The selection of analogue years by all three methods is carried out by an experienced team of meteorologists. It has been found that it is particularly important that there should be good agreement in several respects (pressure, temperature and weather sequence) if there is to be reasonable confidence that subsequent weather will be similar. Future work on developing the analogue methods will have to concentrate on extending the bases for comparison to cover as many features as possible. This requires the extension of the library of data which is already very large.

In making the selection of analogous years the forecasters are aided by objective selections made by the electronic computer COMET. The objective

matching of sequences of daily weather types (in which a shift of several days either way is allowed) has already reached the stage where it gives comparable results to the subjective selection, and it should soon be possible for this part of the work to be left to the computer. The matching of temperature anomaly patterns objectively is much more difficult, since more weight is put on the distribution as shown on the chart than on the absolute values of the anomalies. Promising numerical methods are, however, under development and these facilitate the matching of the geographical patterns of temperature and pressure anomaly by the computer. One of the advantages of employing the computer for such matching is that it enables long series of experimental forecasts to be made from past data on various trial bases with a reasonable effort so that the results can be assessed. This is particularly important for improving the techniques of forecasting.

When the analogue selection has been completed a final conference is held at which the relative merits of the various analogues are discussed in the light of pointers based on physical arguments. The comprehensive display of charts used at this conference includes anomalies of sea-surface temperature and ice and snow cover. Sets of five-day mean northern hemisphere charts for surface pressure, 500 millibar contours and 1000–500 millibar thickness, and their anomalies, facilitate discussion on the recent behaviour of upper flow patterns and how they are likely to persist or change.

The weather at the beginning of the period in the analogue years is compared with the current short-range and medium-range forecasts for the immediate future. On the basis of all the evidence available the panel arrives at a coherent picture of the likely weather for the month ahead.

The forecast that is issued indicates whether the temperature for both the country and the period as a whole, is expected to be much above, above, near, below, or much below the average for the time of year. The limits chosen for these five classes are such that each class occurred equally frequently in the past. Rainfall has proved more difficult to forecast and the total rainfall expected for the month is given as one of three equally likely classes: namely above, near, or below average. Sometimes the indications may be sufficiently clear to justify some subdivision of the area or period by the inclusion of phrases such as 'rainfall is likely to be above average in the south-west and near average elsewhere' or 'the month is expected to start cool and become warmer later'. If the incidence of fog, frost, gales, snow, etc. is expected to be notably different from usual, some information on this may be given. A new forecast is issued in the middle of the month for the ensuing 30 days.

The standard of accuracy achieved in the past two years has turned out to be slightly higher than was expected from earlier experiments. Each forecast is assessed by a panel of meteorologists and marks are given for the accuracy of the forecasts of temperature, rainfall and additional information. Assessments are given below for the first 50 forecasts issued to the public.

Assessment	Temperature	Rainfall	Additional Information
Good agreement	28	14	20
Moderate agreement	9	17	16
Little agreement	13	19	14

Overall, nearly three-quarters of the forecasts proved to be in good or moderate agreement with events, greatest success being achieved with temperature and least with rainfall.

Up to 1964 only very limited research had been possible into forecasting for periods longer than a month ahead, but increasing effort is now being devoted to seasonal forecasting. However, there is no reason to suppose that progress will be notably more rapid than it has been for monthly forecasting.

ORGANIZATION OF THE RESEARCH DIRECTORATE

There were no material changes in the organization of the Research Directorate during the year. Responsibility for research is divided between two Deputy Directorates dealing respectively with 'physical research' and 'dynamical and synoptic research'. The former is concerned primarily with the physical structure of the atmosphere and with obtaining new observations outside the scope of the routine observations required for forecasting and climatology; it is also concerned with the interpretation of such observations in regard to the physics of cloud and precipitation, turbulence, the high atmosphere, etc. On the other hand, the Deputy Directorate for Dynamical Research is working mainly to improve our understanding of weather systems with dimensions varying from a few miles to the dimensions of the entire atmosphere. This Deputy Directorate uses largely the observations made and collected for the purposes of forecasting, and makes extensive use of numerical calculation to examine how the laws of physics and dynamics combine to produce the many large-scale weather phenomena that we observe. Its ultimate aim is to apply this knowledge to the improvement of weather forecasting.

The Deputy Directorate for Physical Research requires extensive facilities for laboratory work and for both experimental and regular observations of the atmosphere. Laboratories are available in the Headquarters buildings at Bracknell for instrument development, for the assembly and testing of equipment for probing the high atmosphere above 30 kilometres and for studies of atmospheric physics. Facilities for atmospheric observations and out-of-door experiment are available at a number of places. These include an experimental site on the outskirts of Bracknell, used for instrument testing and development, facilities at Cardington for studies of the lowest atmospheric layers, including observations from a moored balloon, observations of atmospheric turbulence at Porton in co-operation with the Chemical Defence Experimental Establishment, the aircraft of the Meteorological Research Flight at Farnborough, and the long-established observatories at Kew, Eskdalemuir and Lerwick. The use of radar for meteorological purposes is developed at Malvern in co-operation with the Royal Radar Establishment.

The Deputy Directorate for Dynamical Research, on the other hand, is concerned mainly with theoretical studies, statistical and chart analysis, etc. It makes much use of the Meteorological Office electronic computer COMET which came into operation during the year, and is responsible for the regular twice-monthly preparation of the long-range weather forecasts for the following 30 days.

The Meteorological Office gave assistance to the Professor of Meteorology at Reading University in the establishment of his new department in the autumn by arranging for three members of the Research Directorate to give series of lectures to undergraduates of his department.

The scientific research of the Office was kept under review by the Meteorological Research Committee and its Sub-Committees at their nine meetings during the year. The Meteorological Office is indebted to the members from universities and other Government departments for their advice and assistance.

Physical Research

Micrometeorology. This subject, which involves the study of the turbulent air motion near the ground, the diffusion of atmospheric pollutants and the evaporation of water, was the subject of a special article in the 1964 Annual Report. Work was continued on most of the projects described in that article. In two of them it is thought that sufficient observations have been accumulated and field work has been suspended whilst results are computed and examined. The first such project is that in which statistics of the motion of a balloon floating at a predetermined mean height are compared with statistics of the wind measured (by instruments on a barrage-balloon cable) at one point on the trajectory. The second is the collection, for practical use, of representative statistics of atmospheric turbulence at heights up to 1000 metres.

The application of modern computing methods to the study of diffusion in the atmosphere continued and two reports were prepared: the first, describing a slide-rule allowing a wide range of rapid computations of diffusion in field conditions, the second, summarizing experience in the use of analogue computers to calculate concentrations of diffusing gases and aerosols. Study by digital computer of diffusion in complex atmospheric situations continues.

The variation of surface wind, particularly of light winds, over short times and distances is of importance in the operation of modern aircraft whose payload is critically dependent on wind conditions on the runway during take-off. An investigation has begun, in collaboration with the Ministry of Aviation; activity in 1965 was restricted to the development of suitable anemometers and methods of display and processing of the readings from networks of such instruments.

Solar radiation. Recording of the intensity of the solar beam reaching the ground began at Kew Observatory about 1930 but it was not until 1946 that a continuous record of the solar energy and illumination falling on fixed surfaces began there. The measurement programme has been extended over the years and there are now seven land stations at home and four overseas recording the energy of solar radiation, and five home stations recording illumination. Solar radiation recording instruments are also carried by R.R.S. *Discovery*, R.R.S. *Shackleton* and R.R.S. *John Biscoe*, by three of H.M. Survey Ships and by the British Ocean Weather Ships. In addition the net inflow or outflow at the surface of all radiation—from the sun, the atmosphere and the earth's surface—is measured at three home and four overseas stations and on the Ocean Weather Ships. This radiation-measuring programme is primarily a contribution to world climatology and, in the long term, to the study of the general circulation of the atmosphere, but the measurements have also found useful application in agricultural science, building research and the study of atmospheric pollution. Technically it is not easy to maintain a useful degree of precision and accuracy in measurements of this kind with a network of instruments; calibration and control is centred at Kew Observatory and involves international comparison of instruments used as local standards.

Meteorological Research Flight. The ageing aircraft used by the Flight were more than usually troubled by unserviceability during the year; moreover, much time was lost by the grounding of the Hastings aircraft for modification following a structural failure in flight on another aircraft of this type.

The main event of the year was the detachment to Singapore of the Hastings and Canberra aircraft to carry out research flights in the inter-tropical convergence zones and around the tops of cumulonimbus clouds. So far as the Hastings was concerned the expedition was completely nugatory because of the grounding of this type of aircraft. The Canberra was able to carry out less than half of the planned sorties because of airframe and equipment unserviceability, but it made observations of flying conditions near cumulonimbus cloud and secured valuable instrumental records of very severe turbulence; such records are rare. Conditions encountered were so violent that it would be unwise to explore such conditions again with the Canberra.

Flying from their home base at Farnborough the aircraft made studies of turbulence in clear air and in medium and high cloud as part of an investigation into the characteristics and mechanism of turbulence. They also made measurements of wind and temperature structure in the lower atmosphere, and of the absorption of solar radiation in haze.

Problems associated with high-level flight and supersonic transport aircraft. A party of scientists from the Royal Aircraft Establishment, supported by research aircraft, visited the National Severe Storms Laboratory of the United States Weather Bureau at Norman, Oklahoma, from 21 April to 21 June. A member of the Meteorological Office staff accompanied them and took part in an investigation of conditions in and around the higher levels of deep and extensive thunderclouds using instrumented aircraft and airborne and ground radar. Many useful data were obtained; they are being analysed in collaboration with the Royal Aircraft Establishment and the National Severe Storms Laboratory. The American scientists concerned have visited this country for consultation and further visits are planned. During the visit to Norman, copies of films taken by U-2 aircraft from heights above 60,000 feet in the vicinity of severe storms were secured. These films had not previously been analysed; careful examination has revealed the presence of cloud tops exceeding 58,000 feet.

Formal collaboration continued with French and American meteorologists on research requirements and the specification of meteorological parameters in connexion with the certification and operation of supersonic transport aircraft. Little factual information was gained, however, apart from that in the neighbourhood of severe storms in Oklahoma and at Singapore, as no aircraft capable of gathering information in the range 55,000–65,000 feet is at present available for this investigation.

Radar meteorology. The Director of the Royal Radar Establishment continued his support of the small Meteorological Office unit at Malvern. Work with the narrow-beam 8-mm radar was discontinued. The measurements of the attenuation of this radiation in rain were scientifically interesting and will have application in the future planning of communication links at radar frequencies, but they did not provide the basis of a practicable method of rainfall measurement. Investigations using Doppler radar continued, most attention being paid to the measurement of the wind field and its convergence on occasions of widespread continuous rain. This project is yielding very interesting results but is hampered by the very large number of data which have to be analysed.

High atmosphere. A sustained campaign of firings of the Skua meteorological rocket from the South Uist range during the period January to April was very successful, a valuable series of temperature and wind measurements at heights up to 70 km being obtained. It is estimated that 75 per cent of possible data were obtained in this campaign—a very high figure for this type of project. A few firings were made during the summer and autumn, including two with a modified rocket, named Skua II by the manufacturer, which reached an apogee of 100 km. Some consideration was given to a suitable 'payload' for this rocket—the parachute sonde is well matched to the performance of the unmodified rocket and a different principle is required for measurements above 70 km.

To the disappointment of the scientists concerned, and for reasons largely beyond their control, the massive computation required to extract the results of the ozone experiment on satellite ARIEL II was not completed during the year. It is hoped that it will not be much longer delayed. Study of the few occasions selected for 'hand' computation continued, as did that of the associated Skylark rocket ascents from Woomera. There are hopes of interesting and novel results concerning the distribution of dust at certain levels in the atmosphere, as well as the expected information on ozone distribution. Construction and calibration continued of ozone-measuring equipment for mounting on lunar-stabilized Skylark rockets to be fired from Woomera and on unstabilized Skylark rockets to be fired from a European Scientific Research Organization (ESRO) range.

A serious difficulty arose in connexion with the proposed experiment to measure the distribution of molecular oxygen by equipment mounted on the Anglo-American satellite UK-3. The manufacturer failed to construct photomultipliers with the required spectral sensitivity characteristics, and the experiment originally proposed had to be withdrawn at a late stage. Work began immediately on an alternative device, employing ionization chambers, but at the time of writing it is not known whether this will be accepted for incorporation in the satellite.

Instrument development. A new type of radiosonde has been under development within the Meteorological Office for some years. The development effort was intensified in 1964, and early in 1965 action was taken to secure the manufacture of a trial batch of 100. Delivery began late in the year and a few trial flights have been made. The results of these are most promising. The sonde is designed to facilitate automatic handling of telemetered data and is expected to show a considerable improvement in accuracy over the current model.

Following paper studies, a contract was placed for components of an adaptable magnetic recording system which allows the recording on magnetic tape of the readings of a single meteorological instrument such as a rain-gauge or solarimeter, or of a collection of up to 12 sensors such as those of an automatic weather station, with subsequent processing of the tapes by a central unit to provide print-out, simple arithmetical operations followed by print-out, or preparation of input tape for a digital computer if more sophisticated processing is required. It is hoped to replace gradually the direct pen or electrical analogue type recorders now in general use, beginning with instruments in remote situations.

Orders were placed for a new design of rain-gauge, constructed of fibreglass and plastic. This design, which provides two sizes of catchment funnel, will replace a variety of designs of copper rain-gauge in current use, and will assist

in securing greater uniformity of measurement. With the optional addition of a tipping-bucket device for metering the rainfall, the new rain-gauge assembly becomes suitable for automatic weather stations—both distant recording and indicating—and for magnetic tape recording at remote unattended sites.

Instrument supply and maintenance. The number of instruments tested or calibrated continued to increase in both volume and variety. A total of almost £1500 was received in test fees from other authorities.

Dynamical and Synoptic Research

Research related to short-range weather forecasting. Last year saw the fruition of many years of research on numerical weather prediction and the transfer to the Directorate of Services of a working method of preparing forecasts of the pressure and wind distribution by numerical calculation for up to two days ahead. Many of the personnel who were actively engaged in the research were also transferred, to ensure that the numerical forecasts would be produced on a routine basis; the remainder were able to offer much advice and help in developing the computer programmes.

There is more than one fundamental way in which the numerical computations of a forecast of the future pressure field can be carried out. One of these ways has of course already been successfully investigated and is basic to the preparation of the routine numerical forecasts. Research has started into another fundamental way of expressing the equations in mathematical terms suitable for numerical integration using an electronic computer. This method uses the basic equations of hydrodynamics and thermodynamics directly without many of the simplifications which are used in the method currently in use, and presents a new and quite different range in mathematical problems. The current method of procedure is capable of giving forecasts for two or perhaps three days ahead; it is intended that the new methods will make use of data on a hemispheric basis and it is hoped that ultimately valuable indications of the future atmospheric state may be obtained for four or five days ahead.

The research continues into the study, by dynamical methods, of smaller-scale atmospheric motions. The current investigation makes use of the Science Research Council ATLAS computer because computationally the problem exceeds the capacity of the Meteorological Office computer COMET. Progress has been made in computing the amount of rain which may be expected. The calculations are designed to extend our understanding of the physical and dynamical processes which determine the distribution of cloud and rain, and promise ultimately to lead to a forecasting technique which will provide more detailed information on the atmospheric structure and weather than is available from present operational techniques.

Forecasting the amount of precipitation is one of the more important practical problems of meteorology; but difficulty occurs because of the great variability in the rainfall over comparatively small distances of a few miles. Work has continued on the examination of the rainfall features of different synoptic types and efforts have been made to isolate the fundamental parameters which determine the rainfall amount. Studies of the hourly rainfall at many stations have revealed that sometimes the small-scale features of the rain distribution preserve their identity as they move across the country, but at other times the behaviour is irregular. Clearly such descriptive studies need to be

continued before progress can be made towards more accurate rainfall predictions, whether they be numerically computed or inferred from the synoptic data plotted on charts.

Studies have been made of the distribution of showers in relation to the larger-scale features of the weather map and useful practical results have been found for the summer shower activity in southern and north-western England. Attempts have also been made to relate the occurrence and size of hail to upper air observations.

Research related to long-range forecasting. The experimental forecasts for a month ahead have continued and they have been made available to the public at the beginning and middle of each month. The method by which these forecasts are made has been described in the Special Topic on p.47 of this Report. The average standard of success continued to be much the same, with 75 per cent of the forecasts being at least in moderate agreement with events. The variability of success was clearly indicated by the forecasts for two successive months, that for October being almost exactly right while that for November was almost completely wrong.

The forecasting method requires that a knowledge of past weather conditions shall be easily available, and considerable advances were made in the extraction and processing of these data. The catalogue of daily weather types at London now extends back to 1723 with only two short breaks. A great deal of the basic data is available in a form suitable for using in a computer and considerable efforts have been devoted during the year to the production of a general-purpose computer programme for carrying out all the routine and investigational work in long-range forecasting. There has been interest in this programme from outside the Office and articles about it have been published.

A variety of methods is used to select the analogue years on which the long-range forecasts are based and it is the sum of these methods which determines the final forecast. The value of each individual method is now being scrutinized to determine those methods which make the most useful contributions; it seems that the predictive value of analogues based solely on weather sequence is not great. New methods of selection are added from time to time as the data for their application become available, and the method of making the monthly forecast may be regarded as subject to continuing modification and improvement.

Work has continued on the long-term effects on weather that may be caused by anomalous surface conditions, such as an excess of ice or an anomalously warm ocean, and a study has been made of the month-to-month shift of the main features of the northern hemisphere circulation.

General circulation of the atmosphere. The general problems of forecasting and of climatology demand a knowledge of the global atmospheric motions. Computations have been carried out, for a near-hemispheric area, which attempt to explain the mid-atmospheric motions on a large scale and to account for the effects on them of frictional forces near the ground and of mountain barriers. Even the simplest of such computations has presented new problems in mathematics, many of which have now been solved. The original work was carried out on METEOR and the programmes have been rewritten for the new Meteorological Office computer COMET. The work is now being extended to computations over the whole globe and the fundamental nature of the attack has been changed

from the use of simplified equations to the direct use of the basic dynamical and thermodynamical equations.

The mean meridional circulation (i.e. the average northward, southward and vertical motions) between about 25,000 and 120,000 feet has also received some attention; the circulation for July has been computed and appears to be realistic. The meridional circulation is important because of its influence on the movement of ozone, dust and radioactive particles. A by-product of the research was a new approach to the treatment of turbulent transfer at these levels, and the computations showed that in the summer the transfer of inert matter is due both to mixing processes and to the bodily transfer by the wind, neither effect being predominant.

Charts of the average seasonal flow patterns and temperatures at 50 mb (about 70,000 feet) have been added to the series which have already been prepared for lower levels and are almost ready for publication; studies of the mean seasonal flow at 30 mb have commenced.

Climatic change. The study of both recent and ancient climatic changes continued throughout the year. A substantial investigation into the relation between volcanic dust and climate was carried out and the associations between solar disturbances and atmospheric circulation were examined. The importance of climatic studies is pointed by the sharp rise in level of the East African lakes since 1960 which seems to be one result of a fairly recent world-wide change in wind circulation which has considerably altered the rainfall and temperature in many parts of the world.

Storm surges in the North Sea. Following the East Coast floods of 1953 a Storm Tide Warning Service was established and officers of the Hydrographic Department of the Navy issue warnings from Bracknell when strong winds over the North Sea are likely to lead to exceptionally high tides. A scientific officer of the Meteorological Office is now co-operating with the Storm Tide Warning Service in an endeavour to ensure that recent advances in understanding the dynamics of storm surges are incorporated in the practical tide prediction techniques and that the most efficient use is made of available meteorological information. Close collaboration is maintained with the Liverpool Tidal Institute and the National Institute of Oceanography.

Special investigations. A number of special studies were required for the preparation of advice on meteorological problems which fell outside the main research projects, both for Government departments and for outside firms, individuals and bodies of people. Most of the inquiries called for answers in a short time and a number involved a great deal of investigational work. Special studies included:

(i) advice on air pollution either from existing or proposed installations,

(ii) meteorological conditions at possible sites for a third London Airport,

(iii) the effect of meteorological conditions and wind structure on the landing and take-off of aircraft, both civil and military.

Through membership of a number of departmental and inter-departmental committees, advice was also given on atmospheric pollution, atmospheric turbulence and climatic extremes.

Geophysical Research

On 1 June the Natural Environment Research Council (NERC) assumed formal responsibility for research in geomagnetism and seismology. For the time being the Meteorological Office acts as agent for NERC in maintaining routine recording and research in these disciplines, principally at the Observatories at Lerwick and Eskdalemuir.

The Gassiot Fellowships in Seismology and Geomagnetism remained vacant during 1965, but an appointment was made in December of a Senior Research Fellow for work in geomagnetism, and he is expected to take up his duties early n 1966.

Operation of the seismographs at Eskdalemuir was satisfactory throughout the year, but tabulations of the readings fell behind schedule because of the large increase of data provided by the new equipment. Valuable experience was gained with the proton magnetometers at Eskdalemuir and Lerwick and, by courtesy of the Astronomer Royal, at Hartland and later Herstmonceux. Hartland was found to be an unsuitable location mainly because of incurable disturbances in the main electric supply. At the other localities there was some trouble with the data-handling and processing components of the system; the magnetometer itself showed every promise of becoming acceptable as a standard observatory instrument.

International Research Activity

The Annual Report for 1963 gave an outline of the complex arrangements for the international co-ordination of meteorological research. During the year, members of the Meteorological Office continued to take an active part at the meetings of the international bodies involved. In particular, scientists from the Office attended the WMO Advisory Committee (Geneva) in February, the 3rd International Years of the Quiet Sun (IQSY) Assembly (Madrid) in April, the 8th Plenary meeting of the Council on Space Research (COSPAR) (Mar del Plata) in May, the 4th Session of the WMO Commission for Aerology (Brussels) in July and the 4th Session of the WMO Commission for Instruments and Methods of Observation (Tokyo) in October.

The activities of these bodies are concerned with the co-ordination and standardization of research observations so that they can be used to study atmospheric phenomena extending far beyond the territory of individual nations. They are also concerned in stimulating new programmes of research in regard to such phenomena. As part of the co-ordination of observations of ozone in the stratosphere, the Meteorological Office has undertaken to examine, when called upon to do so, the observations of the total ozone in a vertical column from stations in Europe, and to advise the observing stations with a view to maintaining accurate and consistent results.

A broad plan for future research in the atmospheric sciences is emerging from the work of a committee of the International Association of Meteorology and Atmospheric Physics and the Advisory Committee of WMO. This calls for a substantially increased effort towards the observing and understanding of the large-scale circulation of the atmosphere below 30 km on a world-wide basis. It is not yet clear to what extent the Meteorological Office will be called upon to contribute to this programme, but the Director of Research is a member of a small committee set up by the Royal Society to examine the proposals and to make suggestions in regard to the United Kingdom's contribution.

Library and Publications

The National Meteorological Library, extending over much of the entrance floor of the Bracknell Headquarters, is used mainly by research workers in the Office but is also available to the general public. Besides being a comprehensive library of meteorological books and papers from all parts of the world, it includes material in other branches of geophysics.

The library is used mainly for reference and borrowing but, in addition, it gives an information service, providing answers to a wide variety of questions or linking the inquiries with the appropriate research branches. A measure of the activity is given by Table XXVIII on page 64. The holdings of the library include an increasing number of transparencies and photographic prints which are borrowed for such purposes as lectures, television talks and book illustrations.

Microtext is being used more frequently as a medium for recording and disseminating observations, so the old equipment in the library for viewing microfilm and microcards has been replaced. Four modern viewers are now available to any user of the library.

The Archives occupy a building about half a mile from the main Office. These Archives, like those at Edinburgh (for Scotland) and Belfast (for Northern Ireland), are appointed under the Public Records Act of 1958 as repositories for original meteorological observations and other records of the Meteorological Office. The Archives were established only four years ago and much time is still being spent on the task of checking, cataloguing and binding the material they contain. Current work continues to increase. In 1965 there was a 25 per cent increase in the amount of borrowing by research branches of the Office and there have been more visitors from outside it. An increase was also found in the number of requests, from this country and abroad, for prints and microfilms of original data.

The Editing Section prepares for printing most of the publications of the Meteorological Office. Preparation involves sub-editing and consultation with the author, followed by supervision of the publication through all subsequent stages. Results of research are published from time to time in the two series *Geophysical Memoirs* and *Scientific Papers*. Numerous publications not in a series come up for revision: *Tables of Temperature, Relative Humidity and Precipitation for the World, Part I*, for example, was reissued in August, 1965. An illustrated brochure on *Research in the Meteorological Office* was prepared for publication early in 1966. General editorial responsibility is undertaken for the *Meteorological Magazine*, a monthly journal containing accounts of research, reviews and items of interest to meteorologists.

The Cartographic Drawing Office is responsible for the preparation for printing of all diagrams for publication by the Meteorological Office. These include many charts which are used by forecasters for various areas of the world and which are frequently altered to meet changing forecasting needs. Many hundreds of diagrams are produced during each year.

Training

The Meteorological Office provides all the professional training required by its staff. Most of the instruction is given at the Training School at Stanmore but training in radiosonde work is provided at Hemsby.

The greater part of the work at Stanmore is the initial training of new recruits to the Meteorological Office, but there are also courses for staff who are being considered for more senior forecasting posts as well as refresher courses for forecasters with wide experience. In addition short courses are held in specialized subjects such as the meteorology of the Mediterranean and of tropical regions. The primary aim of the training is to maintain a forecasting service, but this does not imply any by-passing of fundamental theoretical studies. There is emphasis on practical training at Stanmore, but on the other hand the trainee is not regarded as efficient until he has worked for some months under supervision at an outstation.

The initial courses of a general character which are given at Stanmore vary in length, the shortest being of nine weeks for Scientific Assistants. Newcomers to forecasting who are in the Experimental Officer class have four or five months' training and newly appointed Scientific Officers are at the School for six months. The outstation training following this last course consists of attachment to several forecasting stations for a total of six months but, despite this emphasis on forecasting, the course is also intended to give the broad meteorological background which is needed for the student to begin research work at the end of his first year in the Meteorological Office.

Radiosonde work is taught at a school attached to the upper air station at Hemsby, in Norfolk. The instruction is given at three levels: there is an 8-week course for staff without previous radiosonde experience, a 4-week refresher course, and a 4-week advanced course for the more senior and experienced staff. These courses, like those at Stanmore, are arranged in conjunction with a separate period of supervised operational work.

Besides training its own staff at these two schools the Meteorological Office welcomes students from Commonwealth and foreign countries (see Table XXIX on page 64). Such students may come at the request of the meteorological services to which they belong or they may be sponsored by a body such as WMO. Specialized training for overseas students is also arranged in various branches of the Office. Further courses are held at Stanmore for a limited number of British trainees who are not Meteorological Office staff. These include members of the British Antarctic Survey, coastguards, and observers at hydroelectric stations and on lightships, most of whom contribute to the meteorological reporting network.

Apart from the training at the training schools, instruction is given at Bracknell to instrument technicians and communications staff. Special courses for meteorological officers-in-charge are arranged in co-operation with the Civil Training and Education Branch of the Air Force Department, and a few members of the staff have attended background courses organized by the Treasury. At the present time eight members of the Office are attending Sandwich Courses at Colleges of Advanced Technology. In 1965 over three hundred members of the staff, mostly in junior grades, were given assistance in pursuing study programmes in science subjects in their spare time.

J. S. SAWYER
Director of Research

TABLE XXVIII
LIBRARY STATISTICS

Items received including duplicates but excluding daily weather reports	7506
Individual books, pamphlets, articles, microfilms classified and catalogued	6121
Transparencies acquired	384
Publications lent (excluding daily weather reports and internal 48-hour loans)	11,109
New agreements for exchange of publications	5
Total number of exchange agreements	416
Total number of pages translated by Library translators	
Russian	1960
German	60
Norwegian	27
Total	2047

ARCHIVES

Number of loans	1064

TABLE XXIX
TRAINING

The following figures give details of courses which were completed during 1965 at the Meteorological Office Training School at Stanmore, the Radiosonde Training School at Hemsby, and the Air Force Department Civil Training and Education Establishment in London.

	Number of courses	Length of course in weeks	Number of students
Scientific Officers	1	22	5
Senior Forecasters	1	3	10
Forecasting (Preliminary)	2	4	26
Forecasting (Initial)	2	17	58
Forecasting (Advanced)	6	4	49
Tropical Meteorology	2	3	18
Mediterranean Meteorology	2	2	8
Climatology	1	4	3
Numerical Prediction	1	2	9
Instruments (Advanced)	5	2	28
Assistants	12	9	150
Auxiliary Observers	2	1	33
Voluntary Observers	1	1	19
Antarctic Observers	1	9	11
Radiosonde (Initial)	4	8	29
Radiosonde (Refresher)	1	4	1

Radiosonde (Advanced) ..	4	4	7
Radiosonde (Antarctic Observers)	1	8	4
Officers-in-Charge	1	1	11
		Total	479

During the year 54 individual students from overseas territories who attended courses completed their training. Their countries of origin were as follows :

Country	Number of students
Austria	2
Barbados	1
British Antarctica	11
Channel Isles	1
East Africa (Kenya, Uganda and Tanzania)	12
Ecuador	1
Hong Kong	3
India	2
Iran	1
Jamaica	2
Jordan..	2
Libya	4
Pakistan	1
Sierra Leone	2
Sweden	1
Switzerland	4
Syria	2
United Arab Republic	1
Zambia	1
Total	54

INTERNATIONAL CO-OPERATION

World Meteorological Organization

The Seventeenth Session of the Executive Committee was held at the Headquarters of the Organization in Geneva from 27 May to 12 June. Much time was given to discussion on the World Weather Watch and the Report of the WMO Advisory Committee. The reports and recommendations of the Commissions for Hydrometeorology and Maritime Meteorology and of Regional Association VI (Europe) were studied and decisions taken for future action by the Organization. The session was attended by Sir Graham Sutton who was a member of the Committee, Dr R. C. Sutcliffe, Director of Research, as Chairman of the WMO Advisory Committee and Mr C. W. G. Daking, Assistant Director (Defence and International).

There were no less than six other sessions of constituent bodies of the Organization during the year. In February, the Fourth Session of Regional Association I (Africa) was held in Lagos, Nigeria. Mr G. J. Day, Senior Meteorological Officer, Malta, attended as an observer for the United Kingdom.

The Fourth Session of the Regional Association VI (Europe) took place in Paris from 5 to 24 April. The United Kingdom delegation was led by Mr B. C. V. Oddie, Deputy Director (Central Services), who was assisted by Inst. Capt. G. P. Britton, Director of the Naval Weather Service of the Navy Department, Mr L. H. Starr, Assistant Director (Observations and Communications) and Mr H. C. Shellard (Met.O.3). Among the items discussed were the regional aspects of the World Weather Watch, telecommunications, codes, climatic atlases and problems concerned with maritime and aeronautical meteorology.

The Fourth Session of the Commission for Aerology held in Brussels in July, was preceded by a Symposium on Data Processing which was attended by Mr J. S. Sawyer, Deputy Director (Dynamical Research), Mr N. Bradbury, Assistant Director (Data Processing) and Mr E. J. Sumner (Met.O.12). Mr Sawyer was the United Kingdom Principal Delegate at the session of the Commission for Aerology. He was assisted by Professor P. A. Sheppard of the Department of Meteorology, Imperial College of Science and Technology, University of London, and Mr R. F. Jones, Assistant Director (Atmospheric Physics). Dr R. J. Murgatroyd (Met.O.20) also attended the session as Chairman of a Working Group of the Commission and gave a lecture. Questions relating to research on the physics and dynamics of the atmosphere, including such matters as high atmosphere data, hydrometeors and numerical weather prediction were discussed.

The Commission for Climatology met in Stockholm from 12 to 26 August. Mr R. H. Clements, Assistant Director (Climatological Services) and Mr H. C. Shellard represented the United Kingdom. Among the subjects discussed were data processing, climatic atlases, climatic fluctuations, statistical methods in climatology, and climatological aspects of the World Weather Watch.

The Fourth Session of the Commission for Instruments and Methods of Observation took place in Tokyo from 4 to 16 October. The United Kingdom delegation was led by Mr A. L. Maidens, Assistant Director (Instrument Development) who was assisted by Dr N. E. Rider (Met.O.16) and Inst. Lieut W. R. Linton of the Naval Weather Service of the Navy Department.

The uses of radar in meteorology, techniques for soundings in the lower troposphere, atmospheric electricity, psychrometry and radiosondes were some of the items discussed.

Regional Association II (Asia) met in Tehran from 4 to 16 October. Mr W. G. Harper, Chief Meteorological Officer, Middle East Command (Aden) attended as an observer on behalf of the United Kingdom.

Dr B. J. Mason, Director-General, while Professor of Cloud Physics, Imperial College, University of London, attended an IAMAP/WMO Conference on Cloud Physics in Tokyo and Sapporo, Japan, from 24 May to 1 June.

Central Treaty Organization

Mr D. G. Harley (Met.O.17) as a member of a United Kingdom delegation led by the Ministry of Overseas Development visited the Central Treaty Organization countries of Turkey, Iran and Pakistan from 6 to 26 May to discuss meteorological equipment and meteorological communications in relation to civil aviation requirements.

International Civil Aviation Organization

The North Atlantic Region of ICAO held a special meeting in Montreal from 23 February to 20 March to discuss long-term plans for Air Traffic Control and Related Services within the Region. Mr D. G. Harley (Met.O.17) was a member of the United Kingdom delegation.

South Pacific Air Transport Council

The 17th Meeting of the South Pacific Air Transport Council was held in Fiji from 1 to 10 November. Mr D. G. Harley (Met.O.17) attended as a member of the United Kingdom delegation to discuss matters concerning meteorological services in the south-west Pacific.

North Atlantic Treaty Organization

The 22nd Meeting of the Standing Group Meteorological Committee was held in London from 22 to 24 June with Dr A. C. Best, Director of Services, as Chairman. Mr P. J. Meade, then Deputy Director (Outstation Services), Mr L. H. Starr, Assistant Director (Observations and Communications), and Mr R. A. Buchanan (Met.O.17), were also members of the United Kingdom delegation. Language interpretation and secretarial services were provided by the Meteorological Office.

The two Working Groups of the Standing Group Meteorological Committee, on Weather Plans and Weather Communications, met twice during the year, in Istanbul from 23 to 31 March and in Ottawa from 12 to 20 October. Mr L. H. Starr and Mr R. A. Buchanan represented the United Kingdom at both meetings. At the Ottawa meeting Mr Starr resigned as Chairman of the Working Group on Weather Communications and was replaced by the U.S.A. member of the Group; Mr Buchanan was elected Chairman of the Working Group on Weather Plans in place of the French member.

At the 14th Meeting of the SHAPE Meteorological Committee, held near Paris from 24 to 26 May, Mr R. A. Buchanan represented the Meteorological Office.

Mr A. G. Matthewman (Met.O.7) attended a meeting of the Armaments Committee's External Ballistics Group in Paris from 26 to 30 April as a member of the United Kingdom delegation. He was also present at meetings of Sub-Group II of the External Ballistics Group in Athens from 26 to 29 January and in Paris from 30 November to 3 December.

At a meeting in Paris on 22 and 23 November to consider the tasks of a proposed group of experts on Meteorological Measuring Techniques and Equipment under the Armaments Committee, Mr A. G. Matthewman headed the United Kingdom delegation which included Dr N. E. Rider (Met.O.16), Mr R. A. Buchanan and representatives of the Navy and Army Departments. Mr Buchanan also represented the Standing Group Meteorological Committee.

Other WMO Meetings or Joint WMO Meetings with other international bodies in which Meteorological Office Staff took part were as follows :

Subject	Place and Date	Attended by
WMO Advisory Committee on scientific questions, policy and plans on training and education	Geneva February	Dr R. C. Sutcliffe (Director of Research until 31 August 1965)
Symposium on the design of Hydrological Networks	Quebec June	Mr A. Bleasdale (Met.O.3)
Symposium on Meteorological Results of the International Indian Ocean Expedition	Bombay June	Mr D. H. Johnson, Chief Meteorological Officer, Far East
Symposium on Scientific Aspects of Global Weather Processes	Moscow June	Mr E. Knighting and Mr G. A. Corby, Assistant Directors (Forecasting Research and Dynamical Climatology)
Symposium on Atmospheric Chemistry	Visby (Sweden) August	Mr R. F. Zobel, Chief Meteorological Officer, Met. Research Flight
WMO Working Group on Meteorological Telecommunications	Geneva September	Mr L. H. Starr, Assistant Director (Observations and Communications). Mr E. J. Bell (Met.O.5c)
WMO Working Group on Codes	Geneva September	Mr C. J. M. Aanensen (Met.O.6)
Seminar on Meteorology and the Desert Locust	Asmara (Eritrea) September	Mr W. G. Harper, Chief Meteorological Officer, Middle East

WMO Working Group on Climatological Data Aspects of the World Weather Watch	Geneva November	Mr R. H. Clements, Assistant Director (Climatological Services)
Seminar on Numerical Weather Prediction	Moscow Nov–Dec	Mr E. Knighting as Consultant and Lecturer

Attendances at international meetings sponsored by bodies other than WMO, or WMO in conjunction with other UN Agencies or ICSU were as follows :

Subject	Place and Date	Attended by
Symposium on Air Pollution (International Journal of Air and Water Pollution)	Utrecht November	Dr F. Pasquill (Met.O.14) and Dr A. G. Forsdyke, Assistant Director (Special Investigations)
Symposium on Ecosystems (UNESCO)	Copenhagen July	Mr L. P. Smith (Met.O.7) and Mr M. J. Blackwell (Met.O.14)
IQSY Assembly	Madrid March–April	Dr R. Frith, Assistant Director (High Atmosphere)
Committee for Space Research (ICSU)	Rio de Janiero May	Dr R. Frith and Dr K. H. Stewart (Met.O.19)
Symposium on the Mesosphere and Stratosphere	Paris March	Dr R. J. Murgatroyd (Met.O.20), Dr K. H. Stewart (Met.O.19) and Mr D. E. Miller (Met.O.19)
Cloud Physics and Severe Local Storms (American Meteorological Society)	Reno, Nevada, U.S.A. October	Mr D. R. Grant (Met.O.15)
Sub-Committee on Maritime Safety (IMCO)	London April–May	Cdr C. E. N. Frankcom, Marine Superintendent
Seminar on Air/Sea Search and Rescue	New York May	Cdr C. E. N. Frankcom, Marine Superintendent
Advisory Committee of European Operating States on North Atlantic Ocean Stations (ICAO)	Greenock May	Cdr C. E. N. Frankcom, Marine Superintendent
Conference on Micrometeorology (University of Toronto and Canadian Department of Transport)	Toronto April	Dr F. Pasquill (Met.O.14)
Committee on Atmospheric Electricity (IAMAP/IAGA)	Paris May	Mr L. Jacobs, Assistant Director (Observatories and Micrometeorology)

There were several international meetings during the year on operational and research meteorological questions relating to the development of a supersonic civil aircraft. These took place in London, Paris and Washington and were attended by Mr R. F. Jones, Assistant Director (Atmospheric Physics) and Mr A. A. Worthington (Met.O.6) as appropriate.

Mr T. W. Harrold (Met.O.15) was detached from 21 April to 20 June to Norman, Oklahoma, U.S.A., for participation in work on the U.S.A. National Severe Storms Project.

The following members of the staff were released during the year to take up appointments under arrangements made by the Ministry of Overseas Development :

Mr J. W. Bush for service at Kano Airport, Nigeria.

Mr P. G. Rackliff for service at Nandi Airport, Fiji.

Messrs M. J. Batstone and K. J. Smith for services in Trinidad.

Miss J. H. Winscom was appointed to a post in the Secretariat of WMO at its Headquarters in Geneva in March.

Dr G. B. Tucker was appointed to the post of Assistant Director (Research) in the Commonwealth Bureau of Meteorology, Australia in April.

List of Abbreviations used in this Section

IAGA —International Association of Geomagnetism and Aeronomy
IAMAP —International Association of Meteorology and Atmospheric Physics
ICAO —International Civil Aviation Organization
ICSU —International Council of Scientific Unions
IMCO —Inter-Governmental Maritime Consultative Organization
IQSY —International Years of the Quiet Sun
SHAPE —Supreme Headquarters Allied Powers Europe
UNESCO—United Nations Educational, Scientific and Cultural Organization
WMO —World Meteorological Organization

STAFF

GENERAL

The Meteorological Office organization is shown in the diagram on page x and the names of the principal officers are listed on page xi. At the end of the year 1965, the total number of posts of all grades was 3740. The actual strength at the end of the year was made up as follows :

Scientific Officer Class	
Chief Scientific Officers	3
Deputy Chief Scientific Officers	4
Senior Principal Scientific Officers	27
Principal Scientific Officers	76
Senior Scientific Officers	23
Scientific Officers	22
Administrative Class	
Assistant Secretary	1
Experimental Officer Class	
Chief Experimental Officers	19
Senior Experimental Officers	237
Experimental Officers	394
Assistant Experimental Officers	197
Scientific Assistant Class	
Senior Scientific Assistants	268
Scientific Assistants	1267
Marine Staff	
Marine Superintendent	1
Nautical Officer Class	8
Ocean Weather Ships and Base	
Officers	71
Crew	122
Technical and Signals Grades	251
Executive and Clerical Grades	162
Typing and miscellaneous non-industrial grades	128
Industrial employees	102
Locally entered staff and employees overseas	207

The recruitment of honours graduates into the Scientific Officer Class improved during the year and reduced the overall deficiency. Increased complements in the Experimental Officer and Scientific Assistant Classes, resulting mainly from the reduction in conditioned hours, caused manning problems. The autumn recruitment of Scientific Assistants was good but resignations rose. Recruitment of Radio Meteorological Technicians improved but demands for this grade of staff are increasing. Applications for Civil Service Research Fellowships with the Meteorological Office increased towards the end of the year.

Eight Assistant Experimental Officers from the Office, who were taking Sandwich Courses leading to the Diploma in Technology, shared the year between the Office and the Northampton College of Advanced Technology. Four college-based Sandwich Course students spent their extra-college periods with the Office. Study concessions were granted to 318 members of the staff. Eighteen university undergraduates were selected from among many applicants to work in the Office as Vacation Students.

CHANGES IN SENIOR STAFF

Dr B. J. Mason, F.R.S., lately Professor of Cloud Physics at Imperial College, was appointed Director-General of the Meteorological Office on the retirement of Sir Graham Sutton, C.B.E., F.R.S.

Mr J. S. Sawyer, F.R.S., was appointed Director of Research on the retirement of Dr R. C. Sutcliffe, C.B., O.B.E., F.R.S.

Mr E. Knighting, B.Sc., succeeded Mr Sawyer as Deputy Director (Dynamical Research).

Mr B. C. V. Oddie, C.B.E., B.Sc., was appointed as Deputy Director (Outstations Services) and Mr P. J. Meade, O.B.E., B.Sc., A.R.C.S., as Deputy Director (Central Services).

There were three promotions to Senior Principal Scientific Officer, including two to Assistant Director posts and one Special Merit promotion (Dr K. H. Stewart).

HONOURS AND DISTINCTIONS

Mr B. C. V. Oddie was awarded the C.B.E., Mr C. W. G. Daking the I.S.O. and Mr H. D. Henley the B.E.M. An auxiliary observer, Mr F. J. Parsons, received the M.B.E.

The L. G. Groves Memorial Prizes were awarded to Mr L. P. Smith (for Meteorology) and Mr A. A. Sandland (Observer's Prize).

Mr E. W. E. Reid was awarded the Imperial Service Medal.

APPENDIX I

BOOKS OR PAPERS BY MEMBERS OF THE STAFF

The following books or papers by members of the staff were noted during the year ending 31 December 1965:

AANENSEN, C. J. M., see RITCHIE, W. G. and AANENSEN, C. J. M.

ALEXANDER, L. L.; Easterly winds and low stratus at Leuchars. *Met. Mag., London,* **94,** 1965, pp. 292–298.

ALMOND, R., B.Sc.; Techniques of temperature and wind sounding with the SKUA meteorological rocket. *Met. Mag., London,* **94,** 1965, pp. 327–331.

ATKINS, N. J.; Forecasting fog clearance at Wittering. *Met. Mag., London,* **94,** 1965, pp. 298–300.

BAILEY, M. with PERKINS, E. J. and WILLIAMS, B. R. H.; The biology of the Solway Firth in relation to the movement and accumulation of radioactive materials. VI General hydrography, with an appendix on meteorological observations. Rep. U.K. atom. Energy Auth. Prod. Gp., Risley, 1964.

BAILEY, M. with PERKINS, E. J. and WILLIAMS, B. R. H.; The biology of the Solway Firth in relation to the movement and accumulation of radioactive materials. VII Sea-bed and sea-surface drifter releases.—A. Solway Firth, 1962. Rep. U.K. atom. Energy Auth. Prod. Gp., Risley, 1964.

BAILEY, M. with PERKINS, E. J. and WILLIAMS, B. R. H.; The biology of the Solway Firth in relation to the movement and accumulation of radioactive materials. VIII Sea-bed and sea-surface drifter releases.—B. Solway Firth, 1963. Rep. U.K. atom. Energy Auth. Prod. Gp., Risley, 1964.

BAILEY, M. with PERKINS, E. J. and WILLIAMS, B. R. H.; The biology of the Solway Firth in relation to the movement and accumulation of radioactive materials. IX Sea-bed and sea-surface drifter releases.—C. N.E. Irish Sea and Solway Firth, 1963. Rep. U.K. atom. Energy Auth. Prod. Gp., Risley, 1964.

BAILEY, M. with PERKINS, E. J. and WILLIAMS, B. R. H.; The biology of the Solway Firth in relation to the movement and accumulation of radioactive materials. X Weather—May 1962 to April 1963. Rep. U.K. atom. Energy Auth. Prod. Gp., Risley, 1963.

BAILEY, M. with PERKINS, E. J. and WILLIAMS, B. R. H.; Some effects of the cold winter of 1962–63 on the flora and fauna of the Solway Firth. *Trans. Dumfriesshire and Galloway nat. Hist. antiq. Soc., Edinburgh,* **41,** 1963, pp. 30–44.

BENWELL, G. R. R., B.A.; The estimation and variability of precipitable water. *Met. Mag., London,* **94,** 1965, pp. 319–327.

BINDING, A. A.; Association of clear-air turbulence with 300 mb contour patterns. *Met. Mag., London,* **94,** 1965, pp. 11–19.

BIRD, L. G., see GOODISON, C. E. and BIRD, L. G.

BLEASDALE, A., B.A., B.Sc.; Improvement of rain-gauge networks. *Met. Mag., London,* **94,** 1965, pp. 137–142.

BLEASDALE, A., B.A., B.Sc., and FARRAR, A. B.; The processing of rainfall data by computer. *Met. Mag., London,* **94,** 1965, pp. 98–109.

BRADBURY, T. A. M.; Wave clouds over Berkshire. *Weather, London,* **20,** 1965, p. 16.

BULMER, B. F., M.A., B.Sc.; The climate and weather of the North Sea with special reference to the region between latitudes 53° and 56° N, and longitudes 1° and 3°E. *Mar. Obsr, London,* **35,** 1965, pp. 180–188.

BUSHBY, F. H., B.Sc.; Automation in analysis. *Q. Jl R. met. Soc., London,* **91,** 1965, pp. 527–528.

CHUTER, I. H., see HOWKINS, G. A. and CHUTER, I. H.

CLARK, D. D., M.A.; A meteorological rocket sonde. *J. scient. Instrum., London,* **42,** 1965, pp. 733–736.

COLES, V. R., M.Sc.; Short-range weather forecasting. *Adv. Sci., London,* **22,** 1965, pp. 123–124.

CORNFORD, S. G., B.Sc.; Fall speeds of precipitation elements. *Q. Jl R. met. Soc., London,* **91,** 1965, pp. 91–94.

COTTIS, J. G., B.Sc.; Symposium on the biological significance of climatic changes in Britain. *Met. Mag., London,* **94,** 1965, pp. 59–61.

Cox, W. J.; Meteorological observations aboard R.R.S. *Discovery*. International Indian Ocean Expedition. *Mar. Obsr, London*, **35**, 1965, pp. 21–26.
Craddock, J. M., M.A.; The analysis of meteorological time series for use in forecasting. *The Statistician, London*, **15**, 1965, pp. 167–190.
Craddock, J. M., M.A.; Aspects of planning problems. Part I. Temperature statistics relevant to gas consumption in London. London, Inst. Gas Engng., 102nd Ann. Gen. Meetg, 24–28 May 1965, Solihull, 1965, pp. 1–8.
Craddock, J. M., M.A.; Domestic fuel consumption and winter temperatures in London. *Weather, London*, **20**, 1965, pp. 257–258.
Craddock, J. M., M.A.; A meteorological application of principal component analysis. *The Statistician, London*, **15**, 1965, pp. 143–156.
Craddock, J. M., M.A.; More rainfall statistics. *Weather, London*, **20**, 1965, pp. 44–50.
Craddock, J. M., M.A.; Statistics and weather forecasting. *The Statistician, London*, **15**, 1965, pp. 101–109.
Croxall, H. E. and Smith, L. P., B.A.; Sowing dates for winter wheat. *N.A.A.S. q. Rev., London*, **68**, 1965, pp. 147–149.
Dibden, P. C., B.Sc., A heat-balance study on Sørbreen, Jan Mayen. *J. Glaciol., Cambridge*, **5**, 1965, pp. 793–803.
Dight, F. H., O.B.E., B.Sc.; Climatological extremes. *Weather, London*, **20**, 1965, p. 266.
Dight, F. H., O.B.E., B.Sc.; 'Windiness' in Shetland. *Met. Mag., London*, **94**, 1965, pp. 231–236.
Ebdon, R. A.; 100-mb temperature and contour patterns. January to April 1962 and 1964. *Weather, London*, **20**, 1965, pp. 91–96.
Edmond, Geraldine E.; An analysis of tropical stratospheric winds by means of a band pass filter technique. *Met. Mag., London*, **94**, 1965, pp. 304–308.
Ellis, N.; A colloquium on television weather forecasting. *Met. Mag., London*, **94**, 1965, pp. 118–120.
Farmer, S. F. G., B.A.; Results from the SKUA meteorological rocket programme. *Met. Mag., London*, **94**, 1965, pp. 332–337.
Farrar, A. B., see Bleasdale, A. and Farrar, A. B.
Frankcom, C. E. N., O.B.E.; Meteorology and the International Convention on Safety of Life at Sea (1960). *Mar. Obsr, London*, **35**, 1965, pp. 197–199.
Freeman, M. H., O.B.E., M.Sc.; A statistically based graphical technique of objective forecasting. *The Statistician, London*, **15**, 1965, pp. 157–165.
Freeman, M. H., O.B.E., M.Sc.; Long range weather forecasting. *Mar. Obsr, London*, **35**, 1965, pp. 27–29.
Frith, R., O.B.E., Ph.D.; The high atmosphere. *Met. Mag., London*, **94**, 1965, pp. 19–23.
Frith, R., O.B.E., Ph.D.; The Sixth International Space Science Symposium, May 1965. *Met. Mag., London*, **94**, 1965, pp. 302–303.
Frith, R., O.B.E., Ph.D.; Third Assembly of the Special Committee for the International Years of the Quiet Sun, Madrid, 1965. *Met. Mag., London*, **94**, 1965, pp. 220–221.
Frost, R., B.A. and Stephenson, P. M., M.Sc.; Mean streamlines and isotachs at standard pressure levels over the Indian and West Pacific Oceans and adjacent land areas. *Geophys. Mem., London*, **14**, No. 109, 1965.
Frost, R., B.A. and Stephenson, P. M., M.Sc.; Mean streamlines for standard pressure levels over the Indian Ocean and adjacent land areas. Proc. of the WMO/IUGG Symp. trop. Met., Rotorua, N.Z., 5–13 Nov. 1963, Wellington, N.Z., 1964, pp. 96–106.
Froude, G. and Simmonds, J., M.A.; Phenomenal temperature oscillation in Aden. *Met. Mag., London*, **94**, 1965, pp. 184–187.
George, J.; London Weather Centre moves to High Holborn. *Met. Mag., London*, **94**, 1965, pp. 187–189.
Giles, B. L., see Jennings, T. D. D., Macey, C. J. and Giles, B. L.
Gloyne, R. W., Ph.D.; Climate and the blackface sheep industry. *J. blackface sheep breeders' Assoc., Edinburgh*, **17**, 1964, pp. 29–33.
Gloyne, R. W., Ph.D.; Some characteristics of the natural wind and their modification by natural and artificial obstructions. *Scient. Hort., Wye*, **17**, 1964–65, pp. 7–19.
Gloyne, R. W., Ph.D.; The 'standard' climate—its measurement and significance for vegetation. *Scient. Hort., Wye*, **17**, 1964–65, pp. 137–150.

GLOYNE, R. W., PH.D. and MACSWEEN, N.; Weather of recent seasons in the blackface sheep areas. *J. blackface sheep breeders' Assoc., Edinburgh*, **17**, 1964, pp. 1–4.
GOLDING, B., see LEWIS, R. P. W. and GOLDING, B.
GOODISON, C. E.; Prototype telemetry set for airfield meteorological observations. *Wld Aerospace Syst., London*, **1**, 1965, pp. 309–312.
GOODISON, C. E. and BIRD, L. G.; Telephone interrogation of rain-gauges. *Met. Mag., London*, **94**, 1965, pp. 144–147.
GORDON, J. C., M.A.; Mediterranean synoptic weather and the associated 1000–500 mb thickness pattern. *Tech. Notes Wld met. Org., Geneva*, No. 69, 1965, pp. 199–204.
GRANT, D. R., B.SC.; Some aspects of convection as measured from aircraft. *Q. Jl R. met. Soc., London*, **91**, 1965, pp. 268–281.
GRANT, D. R., B.SC.; Waves in an inversion layer. *Met. Mag., London*, **94**, 1965, pp. 34–37.
GRAY, A. and STEWART, W. J.; Orographic effects at Acklington. *Met. Mag., London*, **94**, 1965, pp. 8–11.
GRINDLEY, J., B.A.; Rainfall over Great Britain and Northern Ireland during 1964. *Wat. and Wat. Engng, London*, **69**, 1965, pp. 100–104.
HAMILTON, R. A., O.B.E., B.A.; Secular and other changes of atmospheric electrical potential gradient at Lerwick. *Q. Jl R. met. Soc., London*, **91**, 1965, pp. 348–352.
HARROLD, T. W., B.SC.; Estimation of rainfall using radar—a critical review. *Scient. Pap. met. Off., London*, No. 21, 1965.
HEFFER, D. J.; A test of Kennington's method of forecasting the time of clearance of radiation fog. *Met. Mag., London*, **94**, 1965, pp. 259–264.
HOGG, W. H., M.SC.; Climatic factors and choice of site, with special reference to horticulture. Institute of Biology, Symposia No. 14. The biological significance of climatic changes in Britain. London and New York, Academic Press, 1965, pp. 141–155.
HOGG, W. H., M.SC.; Measurements of the shelter effect of land-forms and other topographical features, and of artificial wind-breaks. *Scient. Hort., Wye*, **17**, 1964–65, pp. 20–30.
HOGG, W. H., M.SC.; Report on work at experimental horticulture stations with shelter screens. *Scient. Hort., Wye*, **17**, 1964–65, pp. 61–66.
HOUGHTON, D. M., M.SC.; Current forecasting practice. *Q. Jl R. met. Soc., London*, **91**, 1965, pp. 524–526.
HOWKINS, G. A., M.B.E., B.SC. and CHUTER, I. H., B.SC.; The effects on equivalent headwinds and flight times of errors in forecasting wind direction and wind speed. *Met. Mag., London*, **94**, 1965, pp. 341–346.
HURST, G. W., B.SC.; Forecasting the severity of sugar beet yellows. *Pl. Path., London*, **14**, 1965, pp. 47–53.
HURST, G. W., B.SC.; Grass growing days. Univ. Coll. Aberyst., Memo. No. 6, (1963), 1964, pp. 25–29.
HURST, G. W., B.SC.; Laphygma Exigua immigrations into the British Isles, 1947–1963. *Inst. J. Biomet., London*, **9**, 1965, pp. 21–28.
HURST, G. W., B.SC.; Services to the agricultural community. *Met. Mag., London*, **94**, 1965, pp. 121–126.
JACOBS, L., M.A., M.SC.; The Leningrad Radiation Symposium, 1964. *Met. Mag., London*, **94**, 1965, pp. 308–313.
JACOBS, L., M.A., M.SC.; The Russian research ship *Zarya. Mar. Obsr, London*, **35**, 1965, pp. 75–77.
JAMES, D. G., PH.D. with HILLEARY, D. T. and WARK, D. Q.; An experimental determination of the atmospheric temperature profile by indirect means. *Nature, London*, **205**, 1965, pp. 489–491.
JAMES, D. G., PH.D. and POTHECARY, I. J. W., B.SC.; Some aspects of satellite meteorology. *Met. Mag., London*, **94**, 1965, pp. 193–202.
JEFFERSON, G. J., M.SC.; Unusual convection cloud. *Met. Mag., London*, **94**, 1965, pp. 23–25.
JENNINGS, T. D. D., MACEY, C. J. and GILES, B. L.; Forecasting fog clearance at Gaydon, Cottesmore and Watton. *Met. Mag., London*, **94**, 1965, pp. 301–302.
JOHNSON, D. H., M.SC.; African synoptic meteorology. *Tech. Notes Wld met. Org., Geneva*, No. 69, 1965, pp. 48–90.
JOHNSON, D. H., M.SC.; Climatological aids. *Tech. Notes Wld met. Org., Geneva*, No. 64, 1964, Vol. I, pp. 116–126.

JOHNSON, D. H., M.Sc.; Commentary on the analysis work relating to tropical Africa (Series B charts). *Tech. Notes Wld met. Org., Geneva*, No. 64, 1964, Vol. II, pp. 21–31.

JOHNSON, D. H., M.Sc.; Forecasting weather in East Africa. *Tech. Notes Wld met. Org., Geneva*, No. 64, 1964, Vol. I, pp. 83–94.

JOHNSON, D. H., M.Sc.; Forecasting weather in West Africa. *Tech. Notes Wld met. Org., Geneva*, No. 64, 1964, Vol. I, pp. 95–103.

JOHNSON, D. H., M.Sc.; High-level charts and jet streams. *Tech. Notes Wld met. Org., Geneva*, No. 64, 1964, Vol. I, pp. 104–115.

JOHNSON, D. H., M.Sc.; Methods of analysis: Part 1: Flow analysis. Part 2: Contour analysis. *Tech. Notes Wld met. Org., Geneva*, No. 64, 1964, Vol. I, pp. 71–75; 76–82.

JOHNSON, D. H., M.Sc.; The meteorological implications of downwind movement. *Tech. Notes Wld met. Org., Geneva*, No. 69, 1965, pp. 6–19.

JOHNSON, D. H., M.Sc.; Weather systems of West and Central Africa. Proc. of the WMO/UGGI Symp. trop. Met., Rotorua, N.Z., 5–13 Nov. 1963, Wellington, N.Z., 1964, pp. 339–346.

KIRK, T. H., B.Sc.; Commentary on the analysis work relating to North Africa and Middle East areas (series A charts). *Tech. Notes Wld met. Org., Geneva*, No. 64, 1964, Vol. II, pp. 7–19.

KIRK, T. H., B.Sc.; Discontinuities with reference to Mediterranean and North African meteorology. *Tech. Notes Wld met. Org., Geneva*, No. 64, 1964, Vol. I, pp. 35–48.

KIRK, T. H., B.Sc.; A note on aerodrome forecasting with reference to objective methods. *Tech. Notes Wld met. Org., Geneva*, No. 64, 1964, Vol. I, pp. 65–70.

KIRK, T. H., B.Sc.; A useful synoptic representation of moisture. *Met. Mag., London*, **94**, 1965, pp. 214–218.

LAMB, H. H., M.A.; Britain's changing climate. Institute of Biology, Symposia No. 14. The biological significance of climatic changes in Britain. London and New York, Academic Press, 1965, pp. 3–31.

LAMB, H. H., M.A.; Circulation of the atmosphere. Priestley, R., Adie, R. J. and Robin, G. de Q. (editors), Antarctic Research, London, Butterworths, 1964, pp. 265–277.

LAMB. H. H., M.A.; The climate. Priestley, R., Adie, R. J. and Robin, G. de Q. (editors), Antarctic Research, London, Butterworths, 1964, pp. 278–291.

LAMB, H. H., M.A.; Climatic changes and variations in the atmospheric and ocean circulations. *Geol. Rdsch., Stuttgart*, **54**, 1964, pp. 486–504.

LAMB, H. H., M.A.; The early Medieval warm epoch and its sequel. *Palaeogeog., Palaeoclim., Palaeoecol., Amsterdam*, **1**, 1965, pp. 13–37.

LAMB, H. H., M.A.; Frequency of weather types. *Weather, London*, **20**, 1965, pp. 9–12.

LAMB, H. H., M.A.; The history of our climate: Univ. Coll., Aberyst., Memo. No. 8 (1965), 1965, pp. 1–18.

LAMB, H. H., M.A.; Trees and climatic history in Scotland. *Q. Jl R. met. Soc., London*, **91**, 1965, pp. 542–550.

LAWRENCE, E. N., B.Sc.; A climatic singularity in June 1964 in south-east England. *Met. Mag., London*, **94**, 1965, pp. 290–292.

LAWRENCE, E. N., B.Sc.; Terrestrial climate and the solar cycle. *Weather, London*, **20**, 1965, pp. 334–343.

LEWIS, R. P. W., M.A., M.Sc.; Objective pattern matching in long range forecasting. *The Statistician, London*, **15**, 1965, pp. 239–245.

LEWIS, R. P. W., M.A., M.Sc. and GOLDING, B.; Errors in the traditional method of computing general values of monthly and annual rainfall over large areas. *Met. Mag., London*, **94**, 1965, pp. 109–113.

LOWNDES, C. A. S.; Forecasting dry spells of three days or more in south-east England from May to October: a revised model. *Met. Mag., London*, **94**, 1965, pp. 241–251.

LOWNDES, C. A. S.; The forecasting of shower activity in airstreams from the north-west quarter over south-east England in summertime. *Met. Mag., London*, **94**, 1965, pp. 264–280.

MCCAFFERY, W. D. S., B.Sc.; The effect of contaminated muslins and wicks on wet-bulb temperature readings. *Met. Mag., London*, **94**, 1965, pp. 225–231.

MCGAIN, R. E. S.; A note on equivalent tailwinds on the great-circle route Prestwick to Montreal. *Met. Mag., London*, **94**, 1965, pp. 69–76.

McLeod, C. N.; An index of comfort for Gan. *Met. Mag., London*, **94**, 1965, pp. 166–171.
McLeod, C. N., see Stephenson, P. M. and McLeod, C. N.
Macsween, N., see Gloyne, R. W. and Macsween, N.
Macey, C. J., see Jennings, T. D. D., Macey, C. J. and Giles, B. L.
Maidens, A. L., B.Sc.; New Meteorological Office wind-finding radar. *Met. Mag., London*, **94**, 1965, pp. 95–96.
Maidens, A. L., B.Sc.; A standard heater for recording rain-gauges. *Met. Mag., London*, **94**, 1965, pp. 280–281.
Miller, D. E., B.A. and Stewart, K. H., Ph.D.; Observations of atmospheric ozone from an artificial Earth satellite. *Proc. R. Soc., London*, **288**, 1965, pp. 540–544.
Murgatroyd, R. J., Ph.D., A.M.I.E.E.; Tracers and transfer problems in the lower stratosphere. *Q. Jl R. met. Soc,. London*, **91**, 1965, pp. 421–424.
Murgatroyd, R. J., Ph.D., A.M.I.E.E.; Winds in the mesophere and lower thermosphere. *Proc. R. Soc., London*, **288**, 1965, pp. 575–589.
Murray, R., M.A. and Miles, M. K., M.Sc.; Simple measures of the raininess of a month. *Met. Mag., London*, **94**, 1965, pp. 1–7.
Oddie, B. C. V., C.B.E., B.Sc.; The hail cannon. An early attempt at weather control. *Weather, London*, **20**, 1965, pp. 154–156.
Pasquill, F., D.Sc.; Meteorological aspects of the spread of windborne contaminants. WHO, Protection of the public in the event of radiation accidents. Geneva, 1965, pp. 43–53.
Pedgley, D. E., B.Sc.; The sea breeze front and movement of locust swarms. *Tech. Notes Wld met. Org., Geneva*, No. 69, 1960, pp. 274–276.
Pilsbury, R. K.; Halo display at Bracknell, Berkshire, on 11 May 1965. *Met. Mag., London.* **94**, 1965, pp. 315–316.
Pothecary, I. J. W., B.Sc.; The atmosphere in action. London, Macmillan, 1965.
Pothecary, I. J. W., see James, D. G. and Pothecary, I. J. W.
Rackliff, P. G.; Summer and winter indices at Armagh. *Weather, London*, **20**, 1965, pp. 38–44.
Ramsey, B.; Summer sea surface temperatures at Gibraltar. *Mar. Obsr, London*, **35**, 1965, pp. 33–35.
Ride, D. J.; Convection from burning cornfields. *Weather, London*, **20**, 1965, pp. 238–241.
Ride, D. J.; A discontinuity in surface wind arising from differential heating. *Weather, London*, **20**, 1965, pp. 212–215.
Ritchie, W. G., M.A., and Aanensen, C. J. M., M.Sc.; The annual variation in the jet stream across the Greenwich meridian. *Met. Mag., London*, **94**, 1965, pp. 337–341.
Robinson, D. G., Ph.D., F.Inst.P.; 1964 World conference on radio meteorology, incorporating the 11th Weather Radar Conference, Boulder, Colorado. *Met. Mag., London*, **94**, 1965, pp. 114–116.
Sawyer, J. S., M.A., F.R.S.; The dynamical problems of the lower stratosphere. *Q. Jl R. met. Soc., London*, **91**, 1965, pp. 407–416.
Sawyer, J. S., M.A., F.R.S.; Symposium on meteorological data processing, Brussels, 1965. *Met. Mag., London*, **94**, 1965, pp. 346–347.
Shaw, D. B., B.Sc.; Address by Professor E. H. Palmén. 'The atmospheric heat budget and general circulation.' *Met. Mag., London*, **94**, 1965, pp. 283–285.
Shellard, H. C., B.Sc.; Microclimate and housing. 1. Topographical effects. 2. Effects of orientation. *Architects' J. London*, **141**, 1965, pp. 21–26 and 81–84.
Simmonds, J., see Froude, G. and Simmonds, J.
Smith, F. B., Ph.D.; The role of wind shear in horizontal diffusion of ambient particles. *Q. Jl R. met. Soc., London*, **91**, 1965, pp. 318–329.
Smith, L. P., B.A.; Possible changes in seasonal weather. Institute of Biology, Symposia No. 14. The biological significance of climatic changes in Britain. London and New York, Academic Press, 1965, pp. 187–191.
Smith, L. P., B.A.; The weather factor in agriculture. Dublin, Irish Maltsters' Conf., Proc. Irish Maltsters' tech. Meetg, 26–28 May 1964, Dublin, Arthur Guinness, 1964, pp. 17–21.
Smith, L. P., see Croxall, H. E. and Smith, L.P.
Stacey, F. D., see Westcott, P. and Stacey, F. D.
Sparks, W. R.; The measurement of atmospheric pressure at sea. *Mar. Obsr, London*, **35**, 1965, pp. 29–32.

STEPHENSON, P. M., M.Sc., and MCLEOD, C. N.; Note on the errors involved in computing mean comfort indices from mean values of dry-bulb and wet-bulb temperatures and wind speed. *Met. Mag., London*, **94**, 1965, pp. 171–173.
STEPHENSON, P. M., M.Sc., and STEMMLER, A.; Heavy thunderstorm with hail at Kuching (Sarawak). *Met. Mag., London*, **94**, 1965, pp. 236–240.
STEPHENSON, P. M., see FROST, R. and STEPHENSON, P. M.
STEMMLER, A., see STEPHENSON, P. M. and STEMMLER, A.
STEWART, K. H., see MILLER, D. E. and STEWART, K. H.
STEWART, W. J. see GRAY, A. and STEWART, W. J.
STUBBS, M. W., B.Sc.; The standard error of a sea surface temperature as measured using a canvas bucket. *Met. Mag., London*, **94**, 1965, pp. 66–69.
SUTTON, SIR GRAHAM, C.B.E., D.Sc., LL.D., F.R.S.; Admiral FitzRoy and the storm glass. *Weather, London*, **20**, 1965, pp. 270–271.
SUTTON, SIR GRAHAM, C.B.E., D.Sc., LL.D., F.R.S.; Micrometeorology. *Scient. Am., New York*, **211**, 1964, pp. 62–70.
SUTTON, SIR GRAHAM, C.B.E., D.Sc., LL.D., F.R.S.; The Natural Environment Research Council. *Nature, London*, **207**, 1965, pp. 567–568.
SUTTON, SIR GRAHAM, C.B.E., D.Sc., LL.D., F.R.S.; Reorganization of Assistant Directorates. *Met. Mag., London*, **94**, 1965, pp. 33–34.
THOMPSON, N., B.Sc.; Short-range vertical diffusion in stable conditions. *Q. Jl R. met. Soc., London*, **91**, 1965, pp. 175–183.
TUCKER, G. B., PH.D.; The distribution and annual cycle of local heating rate throughout the troposphere in the northern hemisphere. *Met. Mag., London*, **94**, 1965, pp. 205–214.
TUCKER, G. B., PH.D.; The divergence of horizontal eddy flux of momentum in the lower equatorial stratosphere. *Q. Jl R. met. Soc., London*, **91**, 1965, pp. 356–359.
TUCKER, G. B., PH.D.; The equatorial tropospheric wind regime. *Q. Jl R. met. Soc., London*, **91**, 1965, pp. 140–150.
TYLDESLEY, J. B., B.A.; The solution of atmospheric diffusion equations by electrical analogue methods. *Scient. Pap. met. Off., London*, No. 22, 1965.
TYLDESLEY, J. B., B.A. and WALLINGTON, C. E., M.Sc.; The effect of wind shear and vertical diffusion on horizontal dispersion. *Q. Jl R. met. Soc., London*, **91**, 1965, pp. 158–174.
WALKER, Judith M.; Distribution of crops with respect to mean potential soil moisture deficits at the end of August. *Met. Mag., London*, **94**, 1965, pp. 47–51.
WALLINGTON, C. E., M.Sc.; Forecasting for gliding. *Schweizer Aerorevue, Zürich*, **40**, 1965, pp. 147–149.
WALLINGTON, C. E., M.Sc.; Gliding through a sea-breeze front. *Weather, London*, **20**, 1965, pp. 140–144.
WALLINGTON, C. E., M.Sc.; Meteorology at the 1965 World Gliding Championships. *Met. Mag., London*, **94**, 1965, pp. 281–282.
WALLINGTON, C. E., M.Sc.; Meteorology at South Cerney. *Sailpl. Gliding, London*, **16**, 1965, pp. 291–292.
WALLINGTON, C. E., M.Sc.; Weather in court. *Weather, London*, **20**, 1965, pp. 290–293.
WALLINGTON, C. E., see TYLDESLEY, J. B. and WALLINGTON, C. E.
WESTCOTT, P. and STACEY, F. D., PH.D.; The record of a vector proton magnetometer after the March 1964 Alaskan earthquake. *J. Geophys. Res., Richmond, Va*, **70**, 1965, pp. 3321–3323.
WILLIAMS, R. F.; Tynemouth Priory Round Table balloon race. *Weather, London*, **20**, 1965, pp. 246–249.
ZOBEL, R. F., O.B.E., B.Sc.; An example of ventilation error in the dry-bulb and wet-bulb psychrometer. *Met. Mag., London*, **94**, 1965, pp. 161–166.
ZOBEL, R. F., O.B.E., B.Sc.; Wind strength and rainfall—are they related? *Weather, London*, **20**, 1965, pp. 13–16.

APPENDIX II

A SELECTION OF THE LECTURES AND BROADCASTS GIVEN BY MEMBERS OF THE STAFF

F. H. BUSHBY, B.SC.; Mathematics in dynamical meteorology. *Institute of Mathematics and its applications, Newcastle.* 21 October.

P. G. F. CATON, PH.D.; The use of Doppler radar in meteorological research. *The Institution of Electronic and Radio Engineers, London.* 17 November.

G. A. CORBY, B.SC.; The ultra-long planetary waves in the atmosphere and their dependence on topography. *Department of Applied Mathematics and Theoretical Physics, Cambridge.* 2 March.

G. A. CORBY, B.SC.; Extended integrations with the equivalent barotropic model. *IAMAP/WMO symposium, Moscow.* 24 June.

S. G. CORNFORD, B.SC.; The physics of rain. *The Physical Society, Glasgow University.* 27 January.

J. M. CRADDOCK, M.A.; Temperature statistics and gas consumption. *Institution of Gas Engineers, Solihull.* 26 May.

J. M. CRADDOCK, M.A.; Temperature statistics and gas consumption. *BBC sound broadcast 'Today'.* 27 May.

J. M. CRADDOCK, M.A.; Forecast for next 30 days. *BBC television broadcast.* 16 July.

J. M. CRADDOCK, M.A.; Statistical problems in long-range forecasting. *Royal Statistical Society, University of Nottingham.* 14 October.

J. M. CRADDOCK, M.A.; Statistical problems in long-range forecasting. *Statistical Laboratory, University of Cambridge.* 29 October.

M. H. FREEMAN, O.B.E., M.SC.; Long-range forecasting. *Royal Meteorological Society, Manchester.* 5 March.

M. H. FREEMAN, O.B.E., M.SC.; Long-range forecasting. *Institute of Physics and the Physical Society, University of Sheffield.* 12 March.

M. H. FREEMAN, O.B.E., M.SC.; Accuracy of long-range forecasts. *BBC sound broadcast 'South East'.* 14 April.

M. H. FREEMAN, O.B.E., M.SC.; Long-range forecasting. *United Kingdom Atomic Energy Authority, Capenhurst.* 7 September.

M. H. FREEMAN, O.B.E., M.SC.; Evening discourse on long-range forecasting. *Royal Meteorological Society, London,* 3 November.

M. H. FREEMAN, O.B.E., M.SC.; Long-range forecasting. *University of Bristol, Physical Society.* 5 November.

R. FRITH, O.B.E., PH.D.; Skua results. *COSPAR 8th Plenary meeting Mar del Plata, Argentina.* 16 May.

R. FRITH, O.B.E., PH.D.; The higher atmosphere. *London Chapter of the American Meteorological Society.* 19 November.

R. FRITH, O.B.E., PH.D.; The upper atmosphere. *Bristol University, 3rd year physics course.* 22 November.

R. FRITH, O.B.E., PH.D.; Exploring the atmosphere. *Series of lectures to undergraduates at Reading University.*

A. GILCHRIST, M.A.; General circulation and world climatology. *Series of lectures to undergraduates at Reading University.*

D. R. GRANT, B.SC.; Some measurements of convection from aircraft. *Organisation Scientifique et Technique Internationale du Vol à Voile congress, South Cerney.* 10–11 June.

G. W. HURST, B.SC., D.I.C.; Meteorology and agriculture. *Reading University.* 18 February.

D. G. JAMES, PH.D.; Small-scale disturbances as observed by TIROS satellite. *Organisation Scientifique et Technique Internationale du Vol à Voile, South Cerney.* 11 June.

D. G. JAMES, PH.D.; Satellite meteorology. *British Association, Cambridge.* 3 September.

D. G. JAMES, PH.D.; Meteorological uses of satellite observations. *Popular lecture, Royal Meteorological Society.* 23–24 November.

E. KNIGHTING, B.Sc.; Planetary waves. *Department of Applied Mathematics and Theoretical Physics, Cambridge.* 2 March.

E. KNIGHTING, B.Sc.; An address to the applied mathematics seminar. *University College of Wales, Aberystwyth.* 11 March.

E. KNIGHTING, B.Sc.; Dynamics of large-scale processes in the atmosphere. *IAMAP/ WMO symposium, Moscow.* 23–30 June.

E. KNIGHTING, B.Sc.; Dynamics of large-scale processes in the atmosphere. *Moscow radio.* 26 June.

E. KNIGHTING, B.Sc.; Press conference with others, conducted by the editorial board of the Literature Gazette. *Moscow.* 28 June.

E. KNIGHTING, B.Sc.; Meteorological forecasting by computer. *National Physical Laboratory, Teddington, Middx.* 27–29 September.

E. KNIGHTING, B.Sc.; Numerical weather prediction. *WMO training seminar, Moscow.* 24 November–6 December.

H. H. LAMB, M.A.; Climatic variation. *University College of Wales, Aberystwyth.* 10 March.

H. H. LAMB, M.A.; Climatic change. *BBC television broadcast 'Tonight'.* 10 June.

H. H. LAMB, M.A.; Forecast for next 30 days. *BBC television broadcast.* 16 July.

H. H. LAMB, M.A.; Climatic change. *BBC sound broadcast 'Science Survey'.* 2 December.

B. J. MASON, D.Sc., F.R.S.; Meteorology today and tomorrow. *BBC sound broadcast 'Science Survey'.* 2 October.

B. J. MASON, D.Sc., F.R.S.; The formation of raindrops and hailstones. *Inaugural meeting of British Association Area Committee, Edinburgh.* 26 October.

B. J. MASON, D.Sc., F.R.S.; Interviews on use of COMET computer in routine forecasting. *BBC sound and television broadcasts.* 2 November.

B. J. MASON, D.Sc., F.R.S.; Guest of the week in 'Woman's Hour'. *BBC sound broadcast.* 24 November.

B. J. MASON, D.Sc., F.R.S.; *BBC sound broadcast 'Who Knows?'* 9, 23 and 30 December.

D. E. MILLER, B.A.; A spectrophotometer for the measurement of solar ultra-violet radiation by ozone, flown in the ARIEL II satellite. *Optics in Space Conference, Institute of Physics, Southampton.* 29 September.

R. J. MURGATROYD, O.B.E., PH.D., A.M.I.E.E.; Radiation sources and sinks in the stratosphere and mesosphere. *International meeting at the Centre National d'études Spatiales, Paris.* 10 March.

R. J. MURGATROYD, O.B.E., PH.D., A.M.I.E.E.; The circulation of the stratosphere, mesosphere and lower thermosphere. *Fourth session of the Commission for Aerology, Brussels.* 15 July.

R. MURRAY, M.A.; Forecast for next 30 days. *BBC television broadcast.* 16 July.

F. PASQUILL, D.Sc.; A 20-lecture course on fundamental aspects of atmospheric diffusion. *Department of Meteorology, Pennsylvania State University.* 29 March–3 June.

F. PASQUILL, D.Sc.; A 4-lecture course on air pollution meteorology. *The Center for Air Environment Studies, Pennsylvania State University.* 29 March–3 June.

F. PASQUILL, D.Sc.; A review lecture opening the sessions on atmospheric diffusion. *First Canadian Conference on Micrometeorology, Toronto.* 12–14 April.

F. PASQUILL, D.Sc.; A 6-lecture version of the course on atmospheric diffusion. *The Robert A. Taft Sanitary Engineering Institute, Cincinnati, Ohio,* 14–18 June.

F. PASQUILL, D.Sc.; The effect of air movements on the dispersal of gases. *Civil Defence Scientific Intelligence Officers attending a study weekend, Cranfield.* 25 July.

W. T. ROACH, PH.D., D.I.C.; Directed a field study course in meteorology at the request of the Royal Meteorological Society and Field Studies Council. *Preston Montford.* 7–14 April.

G. D. ROBINSON, PH.D., F.INST.P.; Some aspects of the meteorology of the near-surface layer. *International Association of Geodesy—symposium on electromagnetic distance measurement, Oxford.* 7 September.

J. S. SAWYER, M.A., F.R.S.; The dynamical problems of the lower atmosphere. *Presidential address, Royal Meteorological Society, London.* 28 April.

J. S. SAWYER, M.A., F.R.S.; Mathematics applied to the large-scale dynamics of the atmosphere. *Institute of Mathematics and its Applications, Coventry.* 20 May. *London* 23 June. *Leeds* 4 November.

J. S. SAWYER, M.A., F.R.S.; Long-term weather anomalies and their possible causes. *Scottish and Manchester centres of the Royal Meteorological Society.* 29 October, 19 November.

F. B. SMITH, PH.D.; Mean meridional circulation in the lower stratosphere. *Geophysical Fluid Dynamics study group at Buxton.* 3–7 January.

F. B. SMITH, PH.D.; Derivation of tracer flux in terms of the fundamental parameters of two-dimensional turbulence. *Applied Mathematics group at University College of North Wales, Bangor.* 18 November.

F. B. SMITH, PH.D.; Introduction to atmospheric physics. *Series of lectures to undergraduates at Reading University.*

L. P. SMITH, B.A.; Effective transpiration as a climate parameter. *Nottingham University.* 17 February.

L. P. SMITH, B.A.; Recent developments in agrometeorology. *Rothamsted Experimental Station.* 3 May.

K. H. STEWART, PH.D.; Meteorological Office experiments in the ARIEL II satellite. *British Interplanetary Society, London.* 5 January.

K. H. STEWART, PH.D.; Measurements of ozone from the ARIEL II satellite. *Atmospheric physics colloquium, Oxford University.* 11 February.

K. H. STEWART, PH.D.; Talk on UK-2 results. *COSPAR 8th Plenary meeting, Mar del Plata, Argentina.* 17 May.

K. H. STEWART, PH.D.; Measurements of ozone from the ARIEL II satellite. *Physics colloquium, Southampton University.* 28 October.

R. C. SUTCLIFFE, C.B., O.B.E., PH.D., F.R.S.; Weather prediction and weather control. *Twenty-first Pearson lecture, Whitcliffe Mount Grammar School, Cleckheaton, Yorkshire.* 6 March.

SIR GRAHAM SUTTON, C.B.E., D.SC., LL.D., F.R.S.; *BBC sound broadcast 'Who Knows'.* 22 March, 10 May.

SIR GRAHAM SUTTON, C.B.E., D.SC., LL.D., F.R.S.; Recent developments in the Meteorological Office and plans for the Natural Environment Research Council. *Parliamentary and Scientific Committees at the House of Commons.* 11 May.

A. WOODROFFE, B.SC.; Computers in weather forecasting. *Sixth form lectures for the Royal Meteorological Society.* 26–28 October.

APPENDIX III

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 20 December 1965).

Daily Weather Report, containing weather maps for the northern hemisphere, British Isles, etc. and data (to 31 December 1965).

Daily Weather Report, Overseas Supplement, containing surface and upper air data (to 6 August 1965).

Meteorological Magazine (to December 1965).

Monthly Weather Report (to August 1965).

Seismological Bulletin. A diary of seismological disturbances recorded on the Galitzin aperiodic seismographs at Kew Observatory, Richmond (to January 1965, when operation of the Galitzins ceased). From July 1964, the Bulletin included a diary of disturbances recorded at Eskdalemuir Observatory, Dumfriesshire, on the standard American World-Wide Seismograph system (to March 1965).

Marine Observer (quarterly) (to October 1965).

The Observatories' Year Book, comprising the geophysical results obtained from autographic records and eye observations at Lerwick, Eskdalemuir and Kew Observatories (1963).

Monthly Weather Survey and Prospects, a 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 (to December 1965).

British Rainfall (1960/1961).

SERIAL

Geophysical Memoirs:

108. Gales in Yorkshire in February 1962, by C. J. M. Aanensen, M.Sc.

109. Mean streamlines and isotachs at standard pressure levels over the Indian and West Pacific Oceans and adjacent land areas, by R. Frost, B.A. and P. M. Stephenson, M.Sc.

Scientific Papers:

21. Estimation of Rainfall using Radar—a critical review, by T. W. Harrold, B.Sc., D.I.C.

22. The Solution of Atmospheric Diffusion Equations by Electrical Analogue Methods, by J. B. Tyldesley, B.A.

OCCASIONAL

Hygrometric Tables—Stevenson Screen readings in degrees Fahrenheit, Part I, 6th Edition.

Instructions for the Preparation of Weather Maps (4th Edition).

Weather in Home Fleet Waters—Vol. 1, Part 2—Northern Seas (Norwegian and Barents Seas and East Atlantic north of 60°N).

Ice Accretion on Aircraft.

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