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## SOME EVIDENCE FOR THE WINDBORNE SPREAD OF FOWL PEST

By C. V. SMITH

**Introduction.**—Fowl pest is a respiratory disease initiated by a virus. Although a virus may exist outside of a body cell, the processes necessary for the growth and reproduction of the virus only occur after it has penetrated a cell. The factors which determine whether virus or host cell will dominate are the subject of current research. If the virus enslaves the cell, the cell then lends itself to the multiplication of the virus at the expense of its own growth and economy. The cell may suffer deterioration or its genetic pattern may be dramatically altered. If the host cell dominates, the viral invader may take up residence within the cell without affecting the cell adversely.

With infectious diseases, the inoculation of one individual by another may commonly be by an airborne route. This article examines whether meteorological conditions were suitable for such a route in the widespread outbreaks of fowl pest in Bedfordshire and neighbouring counties in the early part of 1960 and 1962.

Whilst the diameters of virus particles are of the order 0.01 microns, they are commonly found, in the free atmosphere, to be associated with particulate matter (such as dust and dried saliva) having a diameter of a few microns. Broadly speaking, we can expect such fine particles suspended in the air to follow the movement of the air. Their movement is also affected to some extent by Brownian and turbulent diffusion and by the existence of local temperature, vapour pressure and electrical gradients. However, these smaller-scale processes, together with those of impaction and direct condensation, are only likely to be of importance when removal of the particles from the atmosphere is under consideration.

An exposed surface in a broiler house will show a visible dust collection in a matter of hours. Modern intensive units may have a through-put of one to two million cubic feet of air per hour. If the houses in which the initial outbreaks occurred may be regarded as continuous point sources of infectious dust particles, then Pasquill<sup>1</sup> has given a method for estimating the dispersion of this windborne material for distances of up to 100 kilometres.

**The technique and criteria adopted.**—A schematic diagram of a plume from a source at ground level is shown in Figure 1. The angle AOB gives a measure of the lateral spread and is defined by the arc APB, the points A and B

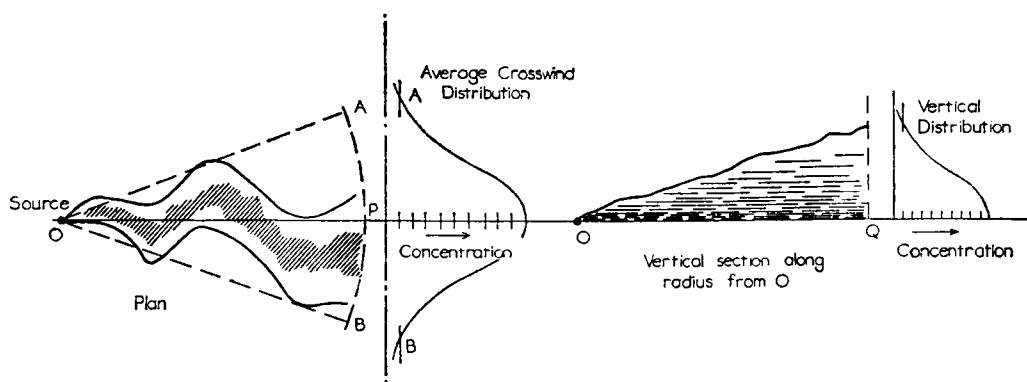


FIGURE 1—SCHEMATIC DIAGRAM OF A PLUME FROM A SOURCE AT GROUND LEVEL

being chosen to locate concentrations of one-tenth of the axial (or peak) concentration. The vertical spread is similarly defined as the height at which one-tenth of the ground concentration is reached.

Relationships are available to determine the concentrations at various distances and heights downstream, provided the rate of release of material at the source is available. Since the source strengths in question must be regarded as unknowns, and since even a single virus can multiply rapidly given the right environment, attention has been confined to locating the axes and lateral spread of the dust plumes. The information necessary to do this comes from weather maps and from the fine structure shown by routine records of wind speed and direction.

Information supplied on the outbreaks stated simply the sites and the dates on which confirmation of the disease was obtained. The data were perhaps biased towards occurrences within counties, with Bedfordshire as the main centre of interest.

The earliest date of confirmation within the information presented was taken to indicate the primary source of infection. In general, it was assumed that the source was destroyed on the day following the date of confirmation of the disease. A period of 8 days (including the date of confirmation) was taken as the interval during which windborne infection could spread from a primary source. For subsequent outbreaks, it was necessary to allow for an incubation period after the arrival of the infection and for a rather more variable period before the outbreak was confirmed by laboratory tests. (The date of confirmation depended upon how quickly the disease became obvious, how quickly it was then reported and how soon laboratory tests could confirm.) Only at sites where fowl pest was confirmed within 6 to 14 days of the arrival of air from a source of infection was the new outbreak taken as attributable to that source. Subsequent (secondary) sites of the disease were themselves additional sources of infection. Such sources were considered as operative from the fourth day after the arrival of a 'trajectory' from an earlier source up to the date of confirmation.

The wind record at Cardington was taken as representative of the areas of interest and the orientation and lateral spread from sources were only obtained for one hour (1200 to 1300 GMT) of each day.

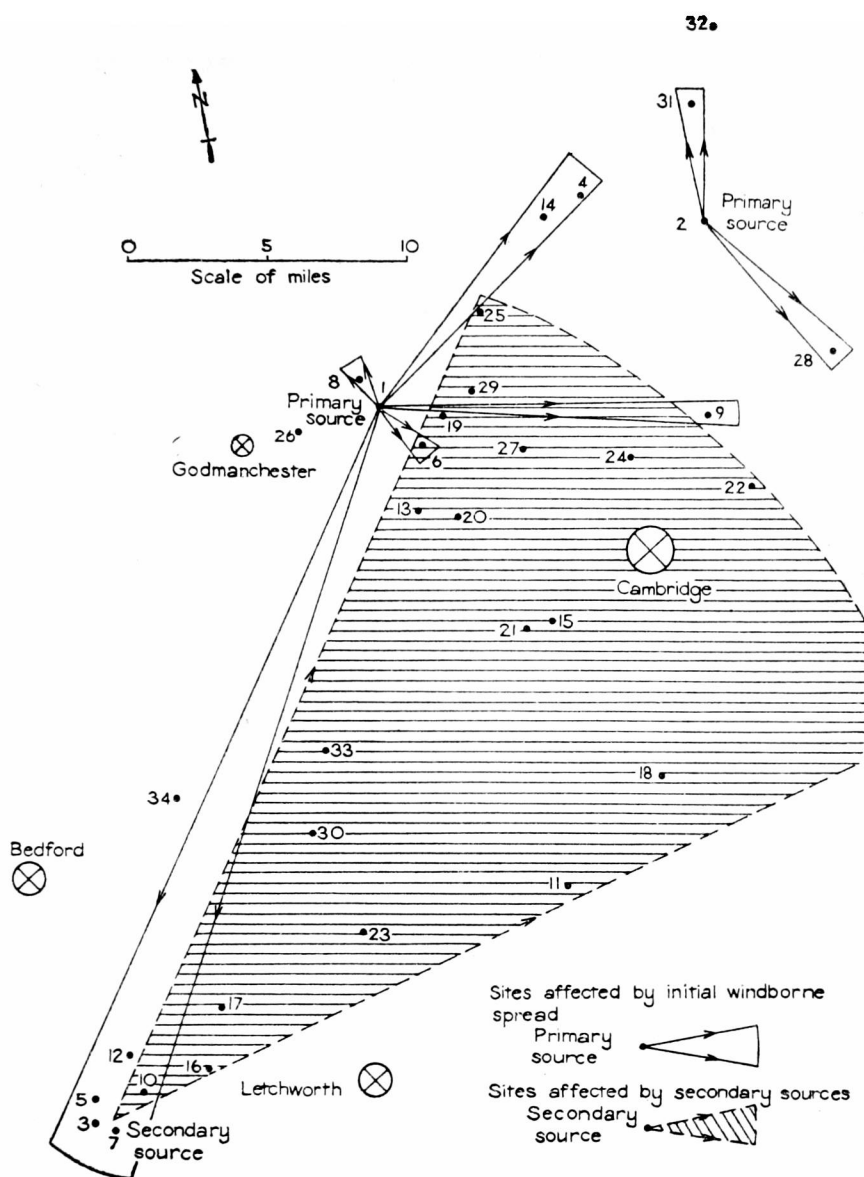


FIGURE 2—SITES AND EXAMPLES OF THE SPREAD OF FOWL PEST IN THE SPRING OF 1962

For identification of site numbers see Table I.

### The outbreaks.—

(i) *March and April 1962.*—Figure 2 is a map of the area showing sites of the outbreaks. Table I lists the locations and dates of confirmation of the outbreaks. In addition, Table I lists the outbreaks (indicated by an asterisk) attributable to various sources.

A primary source in the vicinity of St. Ives over the period 15 to 23 March only 'explains' the outbreak at Fen Drayton, but a primary source near St. Ives over the period 21 to 29 March (6 to 14 days before the outbreaks at Little Thetford and Greenfield) accommodates a far greater number of subsequent occurrences. The result of treating secondary sources is also shown in Table I.

TABLE I—SOURCES OF INFECTION AND SITES OF SUBSEQUENT OUTBREAKS ATTRIBUTABLE TO A WINDBORNE SPREAD

Sources and dates on which the location was acting as a source															
Site number	Location	Date of confirmation of outbreak	Primary sources			Secondary sources							Site number		
			St. Ives 15.3.62 to 23.3.62 Source	St. Ives 21.3.62 to 29.3.62 Source	Little Thelford 27.3.62 to 4.4.62 Source	Greenfield 28.3.62 to 4.4.62 Source	Witcham 29.3.62 to 4.4.62 Source	Flitton 28.3.62 to 5.4.62 Source	Pen Drayton 31.3.62 to 5.4.62 Source	Pulloxhill 28.3.62 to 6.4.62 Source	Needingworth 1.4.62 to 6.4.62 Source	Water-beach 31.3.62 to 6.4.62 Source		Silsoe 28.3.62 to 7.4.62 Source	Sutton 2.4.62 to 10.4.62 Source
1	St. Ives	23.3.62													1
2	Little Thelford	4.4.62													2
3	Greenfield	4.4.62		*											3
4	Witcham	4.4.62		*											4
5	Flitton	5.4.62		*											5
6	Fen Drayton	5.4.62	*												6
7	Pulloxhill	6.4.62	*	*											7
8	Needingworth	6.4.62	*	*											8
9	Waterbeach	6.4.62	*	*											9
10	Silsoe	7.4.62		*				*						*	10
11	Roydon	8.4.62		*				*						*	11
12	Clophill	8.4.62		*				*						*	12
13	Boxworth	8.4.62		*				*						*	13
14	Sutton	10.4.62	*					*	*					*	14
15	Comberton	10.4.62		*				*	*					*	15
16	Gravenhurst	11.4.62		*				*	*					*	16
17	Shefford	12.1.62		*				*	*					*	17
18	Fowlmere	12.1.62		*				*	*					*	18
19	Swavesey	12.4.62		*				*	*					*	19
20	Lolworth	12.4.62		*				*	*			*		*	20
21	Tot	13.1.62		*				*	*			*		*	21
22	Stow-Cum-Quay	13.4.62		*				*	*			*		*	22
23	Hinxworth	14.4.62		*				*	*			*		*	23
24	Histon	14.1.62		*				*	*			*		*	24
25	Earith	15.4.62		*				*	*			*		*	25
26	Hemingford	16.4.62		*				*	*			*		*	26
27	Long Stanton	16.4.62		*				*	*			*		*	27
28	Burwell	16.1.62		*				*	*			*	*	*	28
29	Over	16.4.62		*				*	*			*	*	*	29
30	Wrestlingworth	17.4.62		*				*	*			*	*	*	30
31	Chittisham	17.4.62		*				*	*			*	*	*	31
32	Littleport	17.4.62		*				*	*			*	*	*	32
33	Gamlingay	20.4.62		*				*	*			*	*	*	33
34	Great Barford	21.4.62		*				*	*			*	*	*	34

An asterisk indicates that an outbreak occurred at the location shown on the left.

(ii) *March and April 1960.*—As before, a map of the area is shown (Figure 3) and the locations and dates of confirmation of the outbreaks are listed (Table II). In addition, the subsequent outbreaks attributable to various sources are shown.

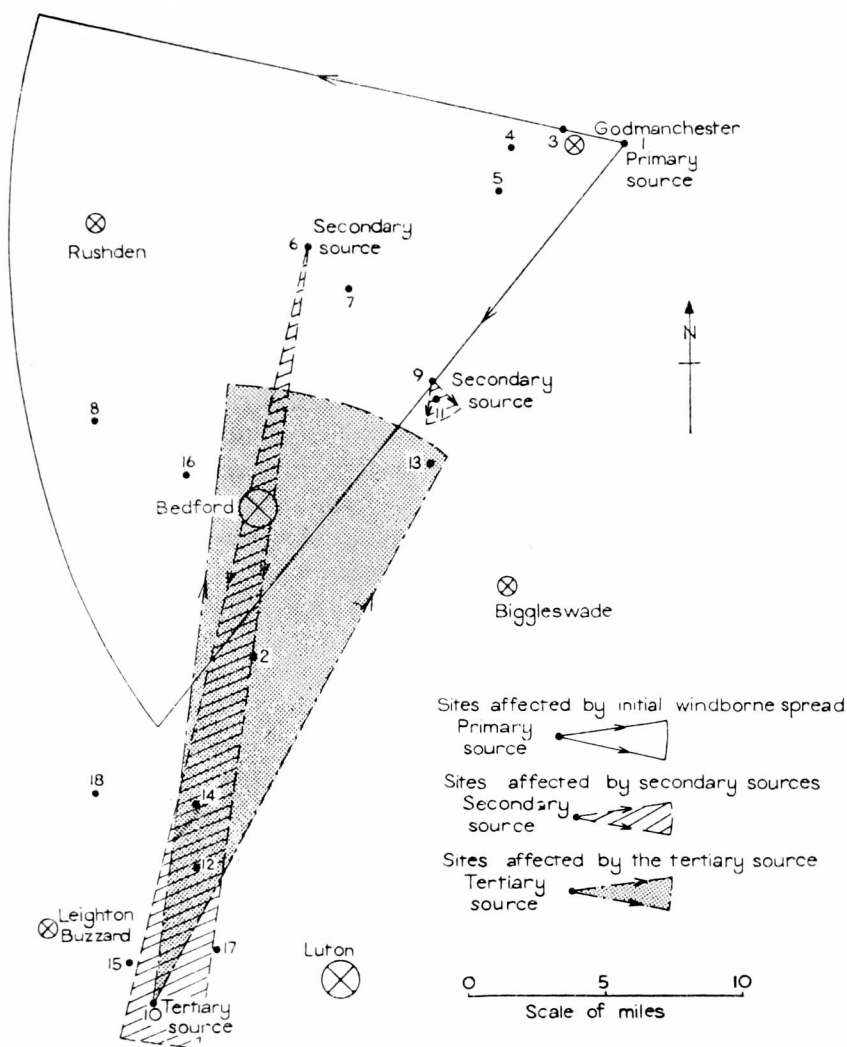


FIGURE 3—SITES AND EXAMPLES OF THE SPREAD OF FOWL PEST IN THE SPRING OF 1960

For identification of site numbers see Table II.

### Discussion.—

(i) *The results.*—The windborne spread of infection is obviously a possibility. The mechanical transport of infectious dust particles by people and vehicles moving between sources and subsequent seats of infection cannot be ignored. Another possibility is that fowl-pest carriers are likely to be present in any large flock and that their presence remains hidden until such times as the biological resistance of the birds becomes lowered, perhaps by diet deficiencies, perhaps by environmental stress associated with inadequate ventilation systems, i.e. with draughty or dusty and ammoniacal atmospheres.

TABLE II—SOURCES OF INFECTION AND SITES OF SUBSEQUENT OUTBREAKS ATTRIBUTABLE TO A WINDBORNE SPREAD

Site number	Location	Date of confirmation of outbreak	Sources and dates on which the location was acting as a source										Site number
			Primary source	Secondary sources						Tertiary sources			
			Hemingtonford	Huntingdon	Brampton	Buckden	Portenhall	Chawston	Eaton Bray	Tingrith	Houghton Regis		
1	Hemingtonford	25.3.60	17.3.60 to 25.3.60	23.3.60 to 2.4.60	24.3.60 to 2.4.60	20.3.60 to 2.4.60	26.3.60 to 4.4.60	29.3.60 to 4.4.60	30.3.60 to 8.4.60	9.4.60 to 17.4.60	20.4.60 to 23.4.60	1	
2	Houghton Conquest	2.4.60	*	Source			*					2	
3	Huntingdon	2.4.60	*	*	Source							3	
4	Brampton	2.4.60	*	*								4	
5	Buckden	2.4.60	*	*	Source	Source						5	
6	Portenhall	4.4.60	*	*	*	*	Source					6	
7	Little Stoughton	4.4.60	*	*	*	*						7	
8	Carlton	4.4.60	*	*	*	*						8	
9	Chawston	4.4.60	*	*				Source				9	
10	Eaton Bray	8.4.60					*	*	Source			10	
11	Wyboston	12.4.60						*				11	
12	Toddington	15.4.60						*	*			12	
13	Great Barford	16.4.60						*	*			13	
14	Tingrith	17.4.60							*	*		14	
15	Stanbridge	22.4.60							*	Source		15	
16	Stanbridge	4.5.60									*	16	
17	Bromham	22.4.60										17	
17	Houghton Regis	23.4.60								*	Source	17	
18	Houghton Regis	3.5.60										18	
18	Woburn	28.5.60										18	

An asterisk indicates that an outbreak occurred at the location shown on the left.

If in 1962, a source of infection is assumed in the St. Ives area over the period 21 to 29 March (6 to 14 days before the first outbreak in Bedfordshire), then a total of 29 of the 33 later outbreaks can be 'explained' with the restrictive criteria and with examination of the situation for only one hour of each day. Any one site is commonly affected by more than one source.

In 1960, with Hemingford as the primary source, the outbreaks up to the 12 April are fairly adequately covered. Thereafter the linkage is a little tenuous but, if pursued, then some 15 out of 19 later outbreaks are 'explained' by the airborne route. Taking both years together, the windborne dispersion of infectious material can account for some 85 per cent of all outbreaks.

(ii) *Preventive measures.*—A uniformly high standard of hygiene and animal husbandry would help and vaccines are now generally available. An alternative is to remove the virus particles from the atmosphere, but to do this would require a change in the ventilation systems of most of our present poultry houses.

Much depends on the particle size. Little elimination of particles of virus dimensions is likely to be achieved by conventional filtration or scrubbing techniques. Once inhaled, the particles, because of their dimensions, are unlikely to escape from the lungs and if 'soluble' they will have rapid access to the blood-stream. In the free atmosphere, the removal of such particles may be slow, being primarily dependent upon the processes of direct condensation, Brownian movement and impaction. Since, however, the viruses are more usually associated with larger dust particles, complete sterilization is likely to be obtained by an efficient air filtration system of the type employed in operating theatres and other places where airborne organisms are unwanted. Such an arrangement would imply a plenum ventilation system.

Sterilization of the incoming air by means of radio-active sources might also be considered.

The use of prophylactic aerosol sprays within the house does not appear to recommend itself. The capture of dust particles by the droplets from such a spray is probably only obtained by impaction, i.e. direct collision, and this process is not likely to be efficient. An evaporating droplet, in fact, repels dust particles.

**Acknowledgement.**—The author would like to thank Mr. G. Duncan, Veterinary Officer of the Ministry of Agriculture, Fisheries and Food, Bedford, for supplying information on the outbreaks.

#### REFERENCE

1. PASQUILL, F.; The estimation of the dispersion of windborne material. *Met. Mag., London*, 90, 1961, p. 33.

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## SIXTEENTH SESSION OF THE EXECUTIVE COMMITTEE OF THE WORLD METEOROLOGICAL ORGANIZATION

By C. W. G. DAKING, B.Sc.

The sixteenth session of the Executive Committee, the first full session since Fourth Congress in April 1963, took place in the beautifully appointed Headquarters of the World Meteorological Organization (WMO) in Geneva from 26 May to 12 June, 1964. The President of the Organization, Dr. A. Nyberg of Sweden, in opening the session paid tribute to Dr. F. W. Reichelderfer, a past

President of WMO, and to Dr. P. D. McTaggart-Cowan both of whom had relinquished their membership of the Executive Committee since the previous session. The President then welcomed Dr. R. M. White, Dr. Reichelderfer's successor as Chief of the U.S. Weather Bureau and Mr. Elliot Coen, acting President of Regional Association IV, both of whom were now interim members of the Executive Committee. There was thus a full attendance of members, now 21, as approved by Fourth Congress and in addition, the Committee had the benefit of the presence of the Chairman (also the President of the Commission for Aerology (CAe)) of the WMO Advisory Committee, Dr. G. P. Cressman and Mr. A. Silva de Sousa, outgoing President of the Commission for Aeronautical Meteorology (CAeM). Representatives of the United Nations Educational, Scientific and Cultural Organization (UNESCO) were present for the discussion on the International Hydrological Decade.

Every effort had been made by the Secretary-General to reduce the agenda on this occasion and this enabled the Committee to complete its tasks in 16 days. In doing this it was helped considerably by the provision of interpretation and translation facilities, in the four working languages of WMO, i.e. English, French, Russian and Spanish as approved at Fourth Congress.

The highlights of the session were the detailed and prolonged work on the World Weather Watch and the New Development Fund, subjects which are closely interrelated. Discussions on these subjects lasted over several days and involved the study of many documents. They indicated an urgent need for work to be begun by the WMO Planning Unit on such questions as the location and functions of World and Regional Centres, global communications networks and observational systems. In this connexion a schedule for completion of the various phases of planning was drawn up which provides for completion of planning by February 1967 in time for the complete World Weather Watch implementation plan to be submitted to Fifth Congress. Resolutions on the subject of World Weather Watch covered such matters as the need to extend the use of the Automatic Picture Transmission system for satellite data, the desirability of obtaining data especially from sparse data areas through increased provision of aircraft reports, upper air observations from mobile ships and the use of horizontal sounding balloons tracked from the surface or by satellite. Both France and U.S.A. intend to carry out pilot projects in the southern hemisphere using horizontal sounding balloons for obtaining upper air data. WMO is to appeal to the International Air Transport Association and the International Civil Aviation Organization (ICAO) to make greater efforts to provide Members with aircraft reports particularly over oceanic and uninhabited areas now that aircraft are equipped with automatic navigation devices and have the ability to determine upper winds more accurately than in the past.

With regard to the New Fund, discussion centred on the plan for utilization and operation of the fund which had been approved in principle by Fourth Congress, for the development of meteorological organization leading to improved networks and communications ultimately benefitting all who depend on meteorological data for their work be it operational or research. A tentative programme for the Fourth Financial Period was drawn up which provisionally allocates the funds available as follows—one-half to improving facilities, i.e. networks and communications, one-tenth to education and training not qualifying for assistance under the United Nations (UN) programmes and



four-tenths to surveys and studies in connexion with the World Weather Watch, e.g. new observation techniques and global telecommunication systems. A great deal of the detailed work on this complex subject was done by a working group whose membership included the President, the Secretary-General, and Dr. White and Sir Graham Sutton. A Panel of the Executive Committee (EC) is scheduled to meet in October 1964 to examine proposals submitted for projects to be approved for 1965. All Regions are represented on this Panel whose membership includes the President and the two Vice-Presidents and M. André Viaut (France), Mr. W. J. Gibbs (Australia) and Sir Graham Sutton. The composite plan for operation of the New Fund as finally agreed by the EC (only one member dissenting) is to be forwarded to Members for their approval by postal ballot after which, it being assumed that a two-thirds majority in favour will be obtained, the Panel can get to work and set the machinery in motion for projects to be carried out in 1965.

Quite unexpectedly the subject of sessions of Technical Commissions and Regional Associations gave rise to fierce controversy. It having been agreed that as a host country for the Commission for Maritime Meteorology (CMM)-IV was not forthcoming, the Commission should meet in Geneva, the question of working languages was immediately raised and some argued that interpretation and documentation should be provided in all four working languages. Fourth Congress Abridged Report was quoted from freely both in Working Committees and at Plenary meetings but certain members remained unconvinced that Congress had provided funds for the use of the four working languages only at Congress and at sessions of the EC. In the end, it was agreed that the Secretary-General should take all possible steps with host countries and Members concerned to find means of alleviating the situation and should attempt to prepare a general scheme with regard to the use of four working languages taking into account budgetary implications and assessing the consequences both for WMO and for Members. The cost at the WMO Headquarters of interpretation and translation of all documents in four languages for a session of CMM lasting 15 days was estimated by the Secretary-General to be about £7500. It was therefore decided that at CMM-IV interpretation will be in two languages only, but that draft decisions and final decisions would be made available in four languages if required, all other documents being in two languages.

Considerable attention was devoted to clarification of certain of the General Regulations and during the discussion on this matter a most unfortunate discrepancy between the English and French texts in Article 13(a) of the Convention came to light. The English text includes the words "to conduct the activities of the Organization in accordance with *the intention of* such decisions"—that is, the decisions of Congress. The words in italics have been omitted from the French text. Various methods of remedying the situation were discussed but eventually it was decided to consult the legal expert who had assisted WMO in the revision of the Convention before Fourth Congress, and request him to consider the matter and report to the EC at its 17th session. The Working Group on the Convention set up by Congress is also to be informed of the matter and of the expert's opinion.

The Committee noted with great appreciation the first report of the WMO Advisory Committee established by Fourth Congress. Various parts of the

report were considered under relevant agenda items. The Committee endorsed the list of principal research projects which should be undertaken and prepared an 'action list' allocating follow-up action by Members, Technical Commissions, the Secretary-General and so on, as considered appropriate. This report contained a statement about the modification of weather and climate, to the effect that before large-scale modifications are attempted, the consequences must be predicted. This was endorsed by the EC and the President of CAe was requested to prepare a report on this subject. It transpired that recent events at a session of the Committee on Space Research (COSPAR) had emphasized the need for close co-ordination between WMO and other organizations concerned with the science of meteorology and a Resolution was passed which authorized the President to discuss with the President of the International Council of Scientific Unions (ICSU) arrangements for the co-ordination of the relevant programmes of WMO and ICSU. In order to achieve the objective desired it is probable that joint meetings between the WMO Advisory Committee and the relevant body or bodies of ICSU will be arranged.

Under the Technical Programme of the WMO the Committee discussed such matters as the plan for use of the WMO projects funds for the rest of the Fourth Financial Period, symposia to be supported during 1965, the financing of sessions of working groups in 1965 and scientific problems to be discussed at EC-XVII. With regard to symposia to be supported in 1965 the Secretary-General was requested to endeavour to organize a symposium on meteorological data processing and the Committee agreed to give substantial support to symposia on:

(a) Meteorological results of the International Indian Ocean Expedition (with UNESCO)—Bombay;

(b) Hydrological network design (with the International Association of Scientific Hydrology)—Canada;

(c) Polar meteorology (with the International Association of Meteorology and Atmospheric Physics);

and to various other projects, e.g. agrometeorology, comparison of instruments, and network and communications surveys.

The Committee considered that the scientific discussion held during its 16th session had been most beneficial—Numerical Weather Prediction and prospects for the future presented by Dr. Döös of the Swedish Meteorological Service—and agreed that further scientific subjects should be discussed at future sessions. The following two subjects were selected for the 17th session—

(a) the use of radar for assessments of areal rainfall

and (b) the synoptic use of meteorological satellite data and prospects for the future.

Fourth Congress approved the use of the International Meteorological Organization (IMO) Funds to pay an honorarium for a lecture to be delivered at each session of Congress. The EC having taken into account the fact that WMO is planning to have a global observation system, decided that the IMO lecture to be delivered at Fifth Congress should be devoted to the general circulation of the atmosphere. A list of three scientists who were to be invited, in order of priority, to prepare and present the lecture was drawn up by a Working Group and accepted by the Committee. The IMO Prize for 1964

was awarded to Dr. F. W. Reichelderfer, until October 1963, Chief of the U.S. Weather Bureau. Readers will recall that the 1963 recipient was Dr. R. C. Sutcliffe, Director of Research in the Meteorological Office.

With regard to the collection and processing of marine climatological data the Committee supported a Japanese proposal that each Responsible Member as defined in Resolution 35(Cg-IV) should publish the summaries relating to its area of responsibility at its own expense. The Secretary-General was requested to ask the Members concerned whether they would be willing to accept this task and provide the necessary funds.

The EC studied with interest the steps which have been taken since Fourth Congress towards the expansion of the training activities of the Organization. The Committee noted that in certain respects the implementation of the WMO plan for training of meteorological personnel in the developing countries of Africa had encountered difficulties which originated mainly from the lack of students with adequate qualifications who wished to take up meteorology as a profession. The Committee agreed that the question of meteorological training in Africa could be studied again at the next session of Regional Association I (Lagos, February 1965), in the light of the progress achieved, the difficulties encountered and the experience gained so far. The Secretary-General was therefore directed to submit to the fourth session of Regional Association I a full report on this question. The Committee considered that the immediate requirements of the developing countries should be met by training personnel at Class II level rather than persons of a high scientific standard (University graduates). It was mentioned that, as an interim measure, the training of Class II and III meteorologists should be carried out on a regional basis and within the region, while the training of Class I meteorologists could be provided by the countries having adequate facilities.

The Committee noted with appreciation the report of the Secretary-General on the action taken to implement the decision of Fourth Congress regarding the International Year of the Quiet Sun (IQSY) meteorological programme. It was decided that the WMO/IQSY Fund should be used for the publication of IQSY meteorological data which would not otherwise be published. The Secretary-General was requested to examine this matter and to bring forward specific proposals to a future session of the EC. The International Union of Geodesy and Geophysics (IUGG) representative spoke with appreciation of the speedy action taken by WMO in developing and introducing the STRAT-WARM scheme. He considered it very likely that scientists would wish to continue this scheme after the end of IQSY and suggested that a decision to this effect might be taken by the EC at its 17th session. The Committee decided to refer this suggestion to the President of CAe for consideration.

With regard to the International Hydrological Decade beginning in 1965, it was noted that the Intergovernmental Meeting of Experts convened by UNESCO in April 1964 had fully recognized that WMO would play an important role in the implementation of the Decade Programme. It was decided that WMO should concentrate on the following activities:

- (i) Preparation and distribution of guidance material on hydrometeorological practices including questions of standardization of instruments and methods of observation;

- (ii) Assistance to Members in the establishment and expansion of basic hydrometeorological networks and related services;
- (iii) Training of manpower required to meet the expansion of national hydrometeorological data gathering and other services;
- (iv) Promotion of research and widespread dissemination of hydrometeorological knowledge;

and that an EC Panel of Experts should be formed to consider and promote the programme of WMO participation in the Decade and to maintain, through the Secretary-General, close collaboration with the Co-ordinating Council of UNESCO for the Decade and with appropriate bodies of ICSU, so that WMO would be fully informed on developments of the whole project of the International Hydrological Decade.

Some attention was paid to questions concerning the structure and operation of WMO. The EC noted the report presented by the Standing Advisory Committee on Technical Matters on steps to improve the structure and operation of the Organization regarding scientific and technical matters. The Committee agreed that there was a need for speeding up the technical work of the Organization and that this question should be further studied with the following two purposes in view: (*a*) to improve the present machinery within the existing regulations and the WMO Convention; and (*b*) to prepare proposals for consideration by Fifth Congress. With regard to the immediate problem of improving the technical and scientific activities of WMO the EC agreed that there was a particular need for the preparation of guidance material in the following two fields: (*a*) planning and carrying out of symposia supported by WMO, and (*b*) establishment and activities of working groups of Regional Associations and Technical Commissions.

The EC examined separately the two volumes of the provisional final report of the Third Session of CAeM, and its decisions on the recommendations of the simultaneous meetings with the MET/OPS Divisions of ICAO have been included in three separate EC Resolutions. These contain a mass of detail but also some important questions of policy. Among the latter are approval by the EC for the setting up of a CAeM Working Group to consider procedures for compiling aviation forecasting techniques and practices and for highlighting subjects on which research is urgently needed, so that Members may consider subjects for their research programmes which have especial importance for aviation. The President of CAeM is to consider the research aspects in consultation with the President of CAe and to submit detailed terms of reference of the Working Group to the President of WMO for consideration prior to their approval. The joint meeting with ICAO had recommended that the exchange of upper air data up to 10 mb now in progress during the IQSY period should be continued after the IQSY ends so that data may accumulate for high levels for the purpose of carrying out preparatory studies necessary for the planning of supersonic operations. This proposal was supported and endorsed in a separate Resolution which is to be brought to the attention of all Members. The Committee supported the wish of the CAeM to meet in sessions, quite separate from, and as an additional feature to, the simultaneous meetings with the appropriate technical bodies of ICAO, as provided by the WMO/ICAO working arrangements. These separate sessions should not be split up in individual short meetings convened while the simultaneous meetings are in

progress. The separate sessions should be held immediately before or immediately after the simultaneous meetings, preferably after, and their duration could be of the order of one week. Their purpose would be to consider technical and scientific matters in the field of aeronautical meteorology, as distinct from procedural and organizational matters.

There was a disappointing development regarding Antarctic Meteorology. Fourth Congress had provided for the setting up of a Standing Committee on the Antarctic to deal with operational matters in that area. This Committee was to have acted as a Regional Association for the Antarctic. At the request of certain delegations at Congress, the relevant Resolution contained a clause which prevented the setting up of the Standing Committee until all Members of WMO which are signatories of the Antarctic Treaty had signified their approval. Unfortunately, at the meeting of the Antarctic Treaty Powers held in Brussels at the same time as EC-XVI, one delegation declined to give approval for the formation of a WMO Standing Committee for reasons which remain shrouded in mystery to the writer. It was decided that, in these circumstances, the EC should set up a Working Group whose terms of reference were virtually the same as agreed for the Standing Committee at Fourth Congress and that it should report to the EC with its recommendations on operational and research questions and that it should be composed of members nominated by the Permanent Representatives of countries which are signatories of the Antarctic Treaty.

This session of the EC was particularly arduous and heavy burdens fell on those members whose services are amongst the leading ones in the world, notably on Sir Graham Sutton who is one of the few 'elder statesmen' left on the Committee. His experience and knowledge of legal and administrative niceties pertaining to WMO enabled the Committee to extricate itself from some awkward situations. Towards the end of the session the weather became warm and very humid—conditions which were trying indeed for the Bracknell contingent, and also for some others used to high temperatures coupled with low dew-points. The Secretary-General and his staff worked with their customary skill in preparing the 118 documents for the session (in four languages). Somehow the translators, typists and duplicator operators managed to keep up to date—a commendable performance. Relaxation was provided on several occasions in the evenings thus enabling members and their advisers to reduce the tensions built up during some of the meetings. All the same it was good to touch down at London (Heathrow) Airport on the return journey after a quick and comfortable flight.

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## **NOTE ON WEATHER OBSERVATIONS AT EFFORD, LYMINGTON, HAMPSHIRE**

By O. S. WELFORD

One of the chain of Ministry of Agriculture, Fisheries and Food experimental horticulture stations is at Efford which is situated 2 miles north of the western end of the Solent, halfway between Southampton and Bournemouth. The site was chosen for its high light intensity which is of benefit to the culture of early tomatoes. However, a wide variety of vegetable crops is also grown, as well as the main types of soft fruits—strawberries, black currants, and raspberries. There

is also an area of apples and pears. Other crops such as chrysanthemums and lettuce are grown in glasshouses or in unheated Dutch-light structures and frames.

It can thus readily be appreciated that much depends on weather conditions, especially in the spring when the land is prepared for outdoor crops and also in midsummer when good weather is vital for soft fruit picking. Again, winter sunshine is important for the production of early tomatoes.

Weather observations have been taken daily at Efford since March 1953 thus giving continuous data for 11 years. General observation suggested that a study of the measurements might produce evidence of some interesting variations from long-term averages. Such departures if they persist may be of great importance to growers and also be of interest to meteorologists studying climate and to agricultural scientists and advisory officers of the National Agricultural Advisory Service.<sup>1</sup>

The Efford observations under review are those for January 1954 to December 1963, and the long-term averages used for comparison are the provisional rainfall averages for 1916–50 and the provisional averages of bright sunshine (for simplification referred to as sunshine) for 1931–60 for Efford, and provisional temperature averages for Bournemouth (Hurn) for 1921–50 as supplied by the Meteorological Office.

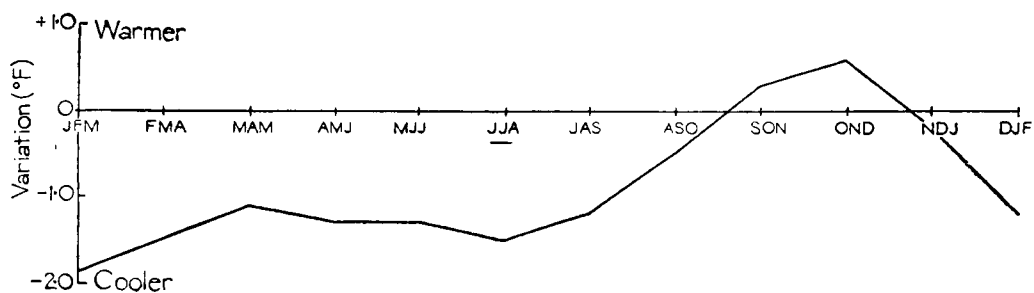
Table I shows for each month the mean daily temperature, the mean monthly rainfall and the mean daily hours of sunshine for the period 1954–63 compared with their respective long-term averages.

TABLE I—AVERAGES FOR EACH MONTH OF TEMPERATURE, RAINFALL AND SUNSHINE AT EFFORD COMPARED WITH THE LONG-TERM AVERAGES

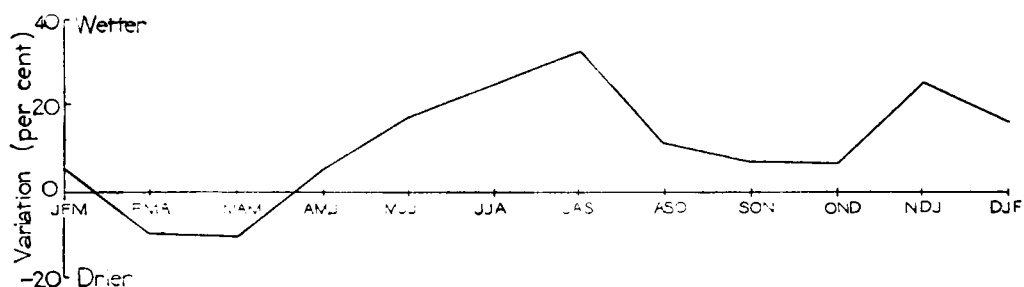
	Period	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	Year
Mean daily temperature (°F)	1921–50	40.9	41.1	44.5	48.5	53.4	59.0	62.5	62.4	58.8	52.1	45.5	41.5	50.9
	1954–63	39.0	38.8	43.3	47.5	52.3	57.8	61.0	60.7	58.2	52.9	46.0	42.0	50.0
Mean monthly rainfall (inches)	1916–50	2.3	2.1	2.1	1.7	1.8	1.8	1.9	2.3	2.2	4.0	3.0	3.0	28.2
	1954–63	3.3	1.8	1.9	1.6	1.7	2.3	2.2	3.0	3.1	3.2	3.6	3.7	31.3
Mean daily sunshine (hours)	1931–60	2.13	2.95	4.45	6.50	7.32	7.83	6.99	6.89	5.32	3.89	2.36	1.80	4.88
	1954–63	2.15	2.93	4.45	5.97	7.47	7.70	7.14	6.39	5.36	3.99	2.34	1.84	4.82

**Daily temperatures.**—In Figure 1(a) the 3-monthly moving averages of the Efford 10-year means are compared with those of the period 1921–50. This curve confirms the comparisons shown in Table I which show that the months January to September are cooler than expected. Once October comes into the reckoning the picture changes to show that the late autumn and early winter are warmer than average. The months showing the largest deviation from normal are February (2.3°F lower), July (1.5°F lower) and August (1.7°F lower). These serve to keep the January–March and February–April periods in the spring much cooler, by 1.9°F and 1.5°F, and in midsummer the June–August period is 1.5°F cooler. In contrast October shows an upward trend (0.8°F higher) as does November (0.5°F higher) and December (0.5°F higher). The periods from September to November and from October to December are therefore warmer than expected by 0.3°F and 0.6°F, respectively.

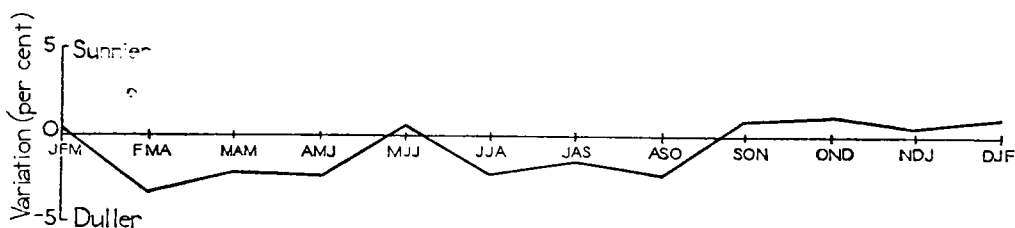
Extreme screen temperatures recorded over the 10-year period were 86°F maximum and 12°F minimum, with 10°F as the lowest grass minimum. These



(a) Temperature: variation in °F based on 3-monthly moving averages of mean daily temperature.



(b) Rainfall: percentage variation based on 3-monthly moving averages of mean monthly rainfall in inches.



(c) Sunshine: percentage variation based on 3-monthly moving averages of mean daily hours of sunshine.

FIGURE 1—VARIATION OF EFFORD 1954-63 AVERAGES FROM THE LONG-TERM AVERAGES

The long-term average is used as the zero line in each case. The months are identified by their initial letters.

minimum temperatures occurred on 26 January 1963, the grass minimum being over 4 inches of snow. The average frequencies of air and ground frost for each month are given in Table II. (On 1 January 1963 the definition of air frost was changed from a screen reading of '32°F or below' to 'below 32.0°F, and the definition of ground frost was changed on 1 January 1961 from a grass minimum reading of '30.4°F or below' to '32°F or below' and on 1 January 1963 to below 32°F'.)

TABLE II—AVERAGE MONTHLY FREQUENCY OF AIR AND GROUND FROST AT EFFORD (1954-63)

	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	Year
	<i>average number of occasions</i>												
Air frost	14	11	7	2	0	0	0	0	0	1	4	8	47
Ground frost	17	14	12	7	2	0	0	0	0	2	7	12	73

Air frosts in May have occurred on two occasions only; in September air and ground frosts have been recorded once only during the 10 years.

Soil temperatures are recorded daily at depths of 4 inches, 8 inches and 2 feet, and Table III shows the monthly means at these depths. There are no long-term averages for comparison.

TABLE III—MEAN SOIL TEMPERATURES AT 0900 GMT AT EFFORD (1954-63)

Depth	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.
	<i>degrees Fahrenheit</i>											
4 inches	37.6	37.5	41.3	47.5	54.3	60.5	63.3	62.0	57.8	52.3	44.6	40.5
8 inches	38.7	38.4	42.2	47.6	54.2	59.5	62.6	61.6	58.3	52.7	45.8	41.6
2 feet	41.8	41.8	43.6	48.3	53.4	58.3	61.5	61.9	60.0	55.5	49.7	44.9

Extreme soil temperatures reached during the 10-year period were 22.9°F in January 1963 and 71.8°F in July 1959, both at the 4-inch depth. A study of the soil temperature figures shows that those at the 8-inch depth follow closely the average daily temperatures for each month at Efford (cf. Table I).

**Monthly rainfall.**—In Figure 1(*b*) an attempt has been made to express the variation of the 1954-63 average monthly rainfall from the long-term average as a percentage of the 1916-50 average. Using the 3-monthly moving averages of the latter period as a base, those of the Efford 10-year means are plotted as a percentage. The resulting curve confirms the impression given by the figures in Table I of a drier spring and a wetter summer than the long-term average.

The annual average increase of the Efford 10-year figure over that of 1916-50 is 11.1 per cent. The range of the Efford rainfall lies between 25.7 inches in 1962 to 46.2 inches in 1960. These extremes were spread over 141 days of rain (0.01 inches or more) in 1962 and 199 days in 1960. The average number of rain days per year is 151. The average number per month does not vary greatly from month to month. Even for the driest months February to May the average number is 11, while for the wettest ones, August to January, it does not exceed 15. Heavy falls occur generally in late autumn, but some may do so during thundery conditions in midsummer. Since 1954 the heaviest daily falls recorded were 2.46 inches on 19 October 1955 and 2.42 inches on 23 June 1960.

**Sunshine.**—Mean daily hours of sunshine in each month are shown in Table I. In Figure 1(*c*) the 3-monthly moving averages of the Efford monthly means have again been used for comparison with those of the 1931-60 long-term ones. Using the latter as the base the former are expressed as a percentage, giving a curve similar in general shape to the rainfall one of Figure 1(*b*) but with a less pronounced deviation from the long-term average. But, even so, it may be seen that though the spring months are drier than expected they are surprisingly duller, a result which is probably related to the tendency to dry easterly winds at this season. A further interesting trend is for the winter months, though wetter than average, to be sunnier than expected. This latter fact is very important for glasshouse crops where light intensity is a limiting factor, for example in the production of early tomatoes. Experience at Efford has also shown that the drier, cooler and duller than average springs have created conditions for land preparation for seed sowing which have proved more difficult than expected.

This short review of the weather data at Efford Experimental Horticulture Station seeks to show trends which may or may not persist. It is hoped that it may provide a basis for further study.

**Acknowledgements.**—The author is indebted to Mr. W. H. Hogg, Senior Meteorological Officer of the National Agricultural Advisory Service, Bristol, for his advice on the presentation of the data and to the observers at Efford, Messrs. Bullock, Cheston, Slater and Lewis for their assistance.

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1. SMITH, L. P.; Progress report on agricultural meteorology. *N.A.A.S. Quart. Rev.*, London, No. 62, 1963, p. 81.

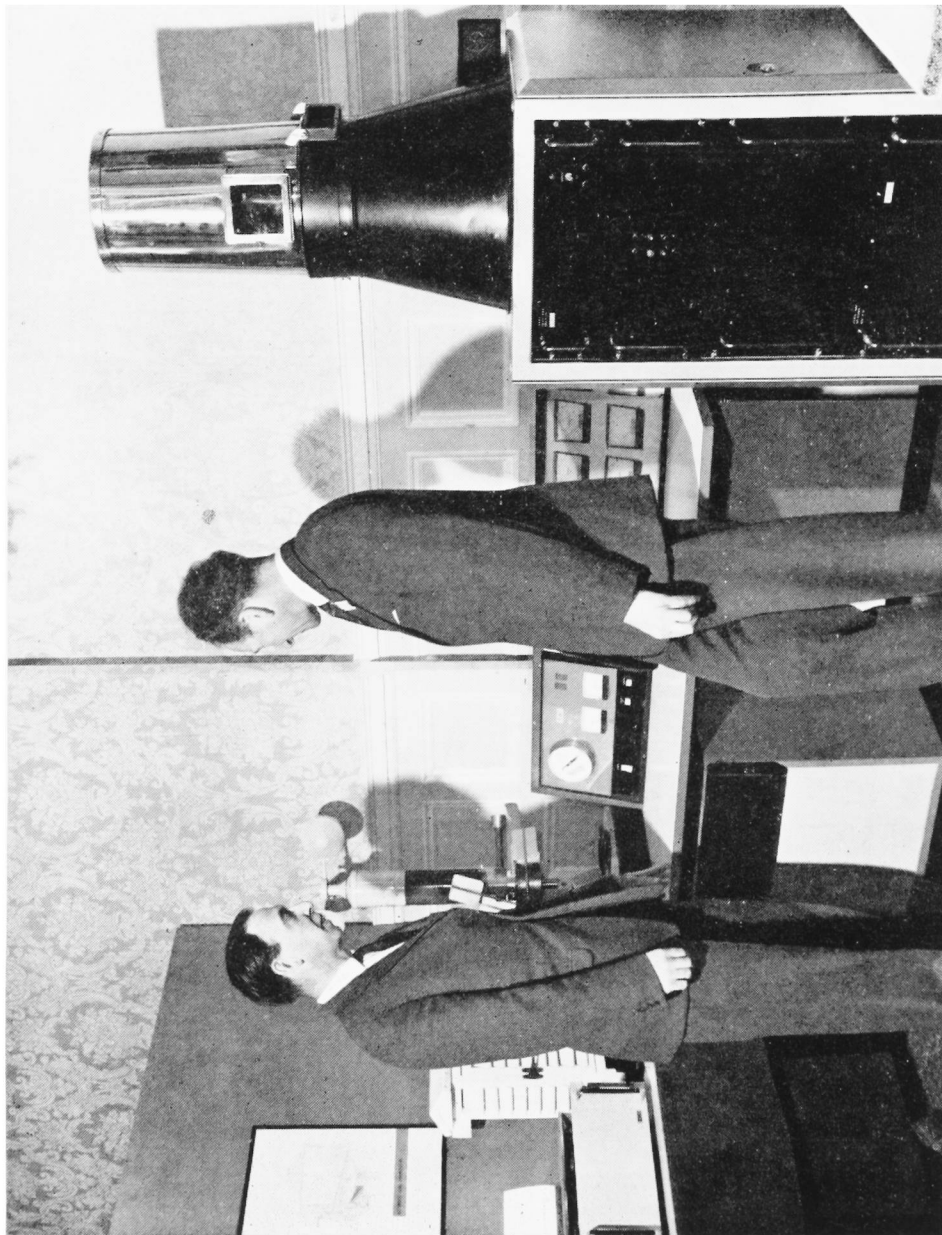




*Photograph by R. K. Pilsbury*

**PLATE I—THE AUXILIARY REPORTING STATION AND KEY CLIMATOLOGICAL STATION  
OF ROSS-ON-WYE WHICH BEGAN REPORTING IN 1859**

Pictured above is Mr. Parsons to whom we send our congratulations on completion this year of 50 years of observing work and our thanks for the excellent contribution he has made to our meteorological records.



*Photograph by courtesy of EMI Electronics Ltd.*

**PLATE II—THE AUTOMATIC WEATHER STATION AT EMI ELECTRONICS' SYMPOSIUM  
AND EXHIBITION IN LONDON, 26-28 MAY 1964**

Dr. N. E. Rider (left) of the Meteorological Office, Bracknell, and Dr. Karl Newman of EMI Electronics Ltd's telemetry division discussing the automatic weather station which attracted so much interest at the exhibition.



*Photograph by J. Paton*

PLATE III—TURBULENCE AT 80 KM SHOWN BY NOCTILUCENT CLOUD, 0214 GMT,  
25 JULY 1950

Previously a brilliant aurora accompanied the cloud which remained stable until about 0206 GMT when this 'fuming' began.

*To face p. 273*



*Photograph by courtesy of BEA*

**PLATE IV—PRESENTATION OF METEOROLOGICAL OFFICE AWARDS AT THE HEAD-  
QUARTERS OF THE GUILD OF AIR PILOTS AND AIR NAVIGATORS ON 15 JULY 1964**

Dr. A. C. Best, C.B.E., Director of Services of the Meteorological Office presenting a brief case to Captain R. P. Ellis of BEA (see page 285).

## FORECASTING DRY SPELLS OF THREE DAYS OR MORE IN SOUTH-EAST ENGLAND FROM NOVEMBER TO APRIL

By C. A. S. LOWNDES

**Introduction.**—In a recent paper<sup>1</sup> it was shown that the highest proportion of the dry spells at London which occur in the months November to April is associated with a spread of high pressure from the south-west or west of the British Isles and that many of the longer spells are associated with a spread of high pressure from the north-east or east, particularly in the five months November to March. In an earlier paper<sup>2</sup> the synoptic types associated with dry spells at London were classified into Types I to IX and for the months May to October rules were described<sup>3</sup> for forecasting dry spells at London and in south-east England associated with a spread of high pressure from the south-west of the British Isles (Type V). The basic predictors were a mobile upper trough between  $60^{\circ}\text{W}$  and  $50^{\circ}\text{W}$  and surface pressure above normal at the Azores. It was decided, in the first instance, to determine whether similar predictors were applicable in the winter months. It became clear from a study of 500-millibar troughs between  $70^{\circ}\text{W}$  and  $40^{\circ}\text{W}$  that, as in the summer months, many of the Type V spells began one or two days after a trough became situated between  $60^{\circ}\text{W}$  and  $50^{\circ}\text{W}$ . Many of the spells associated with a spread of high pressure from the north-east of the British Isles (Type I) also began one or two days after an upper trough became situated between  $60^{\circ}\text{W}$  and  $50^{\circ}\text{W}$ . The two synoptic evolutions were as follows:

*Model SW.*—The upper trough between  $60^{\circ}\text{W}$  and  $50^{\circ}\text{W}$  generally progressed across the Atlantic at about 10 degrees of longitude per day and weakened. At the same time, a surface high moved from south-west of the British Isles to the region of the British Isles.

*Model SW-NE.*—The upper trough between  $60^{\circ}\text{W}$  and  $50^{\circ}\text{W}$  generally progressed at 10 to 20 degrees of longitude per day and rapidly weakened. At the same time, a surface high moved from the Azores region towards the British Isles, losing its identity as it linked across the British Isles with a high over Scandinavia. The high over Scandinavia then moved to a position to the east or south-east of the British Isles with a ridge persisting over the British Isles.

In forecasting either model, the surface pressure level at the Azores was not a sufficiently precise predictor and the position and central pressure of the surface high were used. It was found necessary to invoke further predictors, in particular a measure of the zonal flow across the Atlantic (zonal index).

**Data extracted.**—For the 14 years 1949 to 1962, all occasions when a 500 mb trough was situated between  $60^{\circ}\text{W}$  and  $50^{\circ}\text{W}$  were noted and the following data extracted. All upper air data were obtained from 500 mb charts.

(i) *Upper air data.*—

- (a) The maximum negative height anomaly at  $45^{\circ}\text{N}$  on the trough axis between  $60^{\circ}\text{W}$  and  $50^{\circ}\text{W}$ .
- (b) The latitude of the centre of the belt of flow around the base of the trough.
- (c) The latitude at which the flow on the eastern flank of the trough changed from a south-westerly to a south-easterly (if applicable).
- (d) The spacing from the trough between  $60^{\circ}\text{W}$  and  $50^{\circ}\text{W}$  to the next upwind trough.

(e) The 500 mb height at Lajes (Azores) minus that at Keflavik (Iceland) (a measure of the zonal index).

(ii) *Surface data.*—(a) The position and central pressure of all surface highs with a central pressure of 1020 mb or more in the Atlantic–European sector between longitudes 50°W and 50°E and from latitude 20°N to 70°N. (The central pressure of the high was taken to be that of the closed isobar nearest the centre with isobars at 4 mb intervals).

(b) The dates of the beginning and end of all dry spells of three days or more in south-east England. A dry spell was defined as a period when none of a group of 11 stations in south-east England, for which 12-hour totals of precipitation are given in the *Daily Weather Report*, had more than a trace of precipitation. The 7 stations, Kew, London Airport, Felixstowe, Gorleston, Mildenhall, West Raynham, and Boscombe Down were available throughout the 14-year period. The other 4 varied but came from the following group of 9 stations: Thorney Island, Hurn, Lympne, Tangmere, Calshot, Cranfield, Gatwick, Cardington and Wittering. On a few occasions, when it was clearly illogical to split a dry spell, a small amount of precipitation over a short period was allowed. This usually involved up to 0.2 millimetres provided by moist airstreams from the sea affecting coastal stations or by wet fog at night.

**Model SW: the critical values of the predictors.**—For Model SW, a study was made of occasions when a 500 mb trough was situated between 60°W and 50°W and at the same time a surface high was situated in an area between longitudes 50°W and 5°W and latitudes 20°N to 70°N (see Figure 5).

*The intensity of the trough between 60°W and 50°W.*—The intensity of the trough between 60°W and 50°W was not critical. Dry spells which began within three days were associated with troughs with negative anomalies at 45°N ranging from 3 decametres in April to 37 decametres in January. However, some very flat troughs were not associated with dry spells. On these occasions, as in the summer months, the flow around the base of the upper trough was centred north of 46°N. For troughs associated with dry spells, the flow around the base of the trough was centred south of 47°N for the months November to March and south of 49°N for April.

*The flow on the eastern flank of the trough.*—The flow ahead of troughs which were associated with dry spells was usually south-westerly or south-south-westerly. On occasions when the flow became south-easterly, south of latitude 53°N, no dry spell followed. Examples of this type of trough are shown in Figures 1 and 2. The 500 mb chart for 1200 GMT on 3 January 1959 (Figure 1) shows the trough associated with a classic blocking system and the flow ahead of the trough becoming south-easterly at 50°N. On this occasion, the block persisted in much the same position for several days. An intense surface high persisted over Greenland, a surface high south-west of the British Isles moved to Spain, and the British Isles remained under the influence of a cyclonic northerly type. The 500 mb chart for 1500 GMT on 22 January 1952 (Figure 2) shows the flow ahead of the trough becoming south-easterly at 49°N. On this occasion, an intense surface high rapidly developed over southern Greenland and a surface high north of the Azores made no progress towards the British Isles, which remained under the influence of a northerly cyclonic type.

*The spacing to the next upwind trough.*—On occasions when a dry spell followed within three days, the spacing from the trough between 60°W and 50°W to the

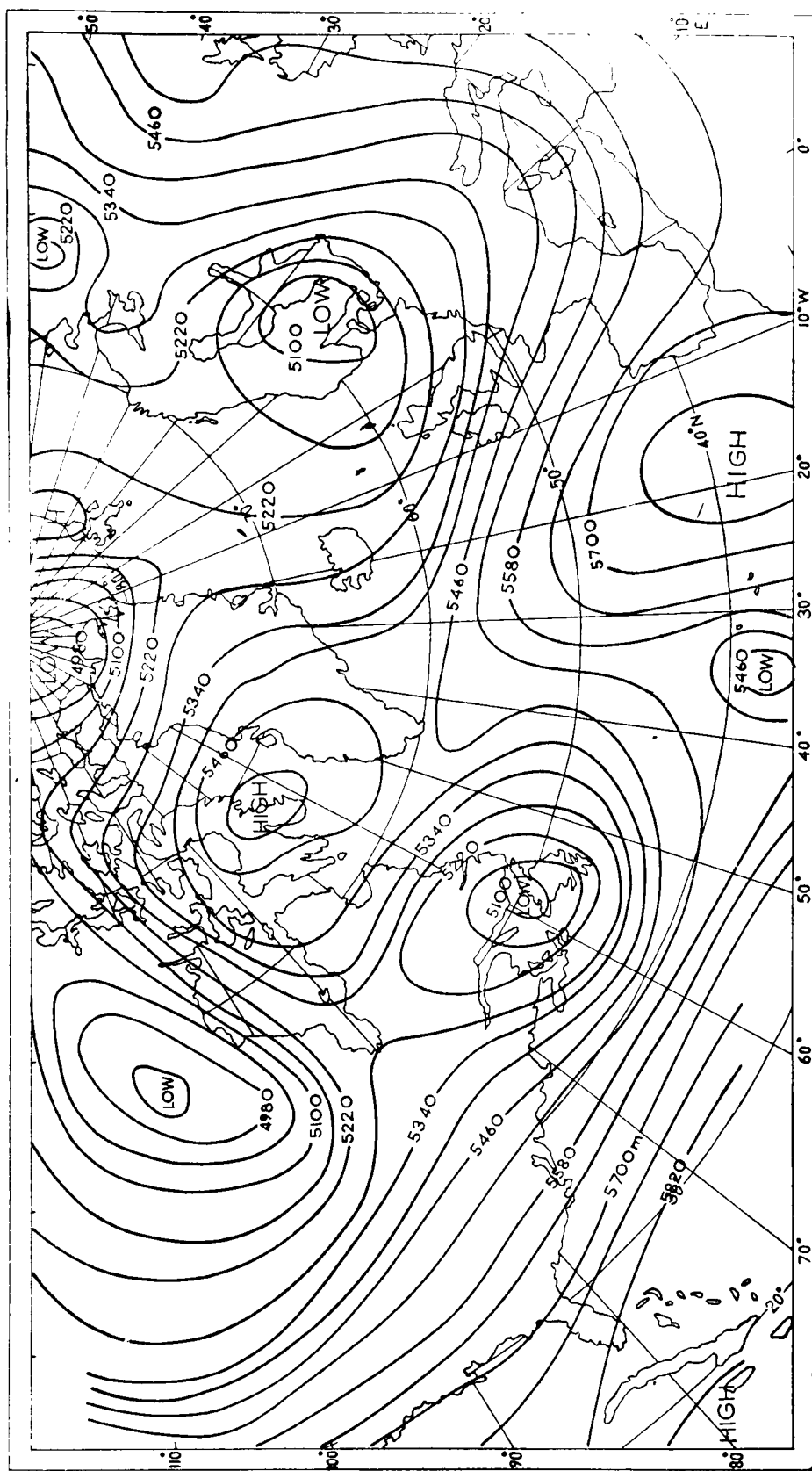


FIGURE 1—THE FLOW ON THE EASTERN FLANK OF THE TROUGH  
500 mb contours at 1200 GMT on 3 January 1959

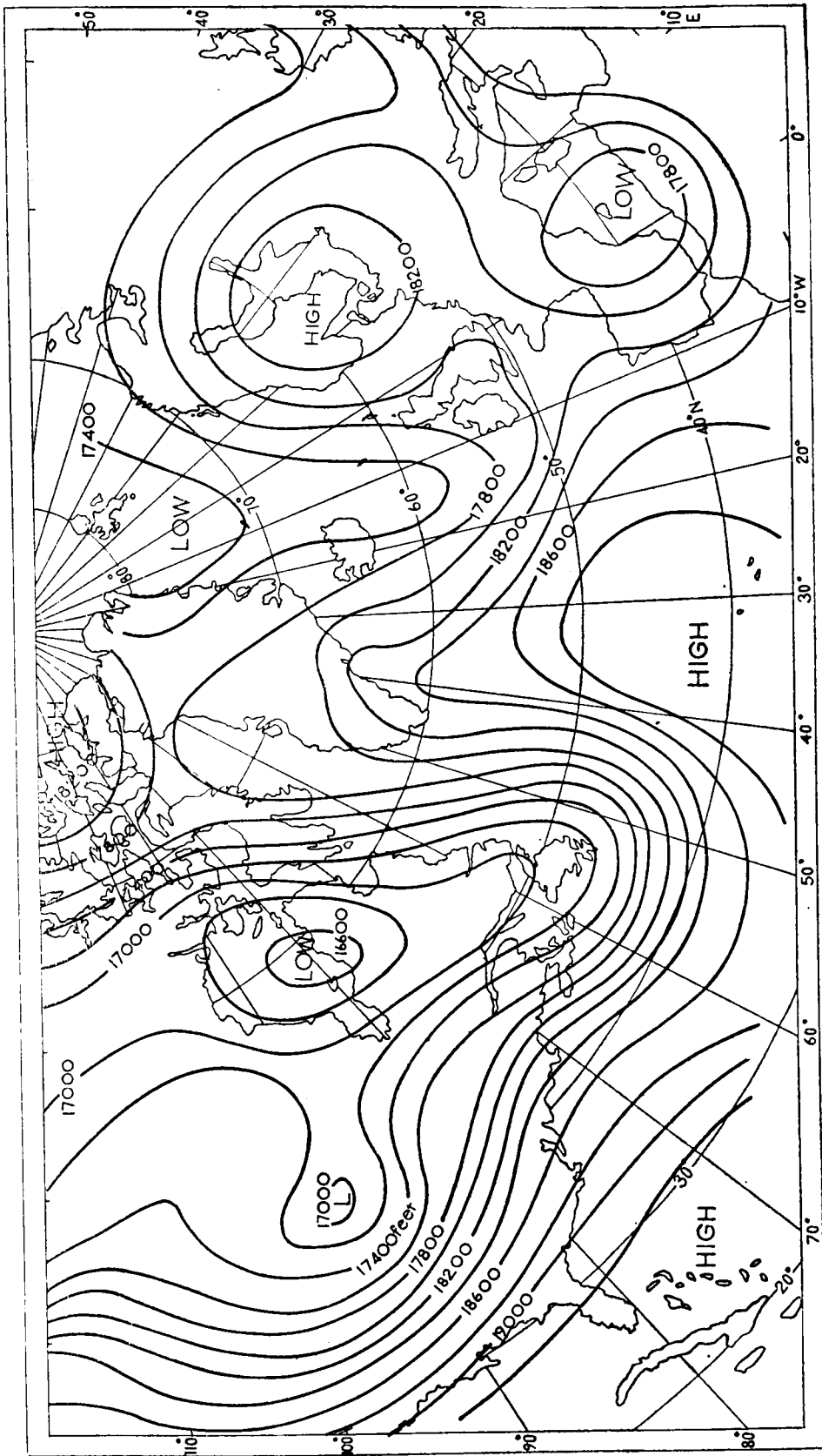


FIGURE 2—THE FLOW ON THE EASTERN FLANK OF THE TROUGH  
500 mb contours (feet) at 1500 GMT on 22 January 1952



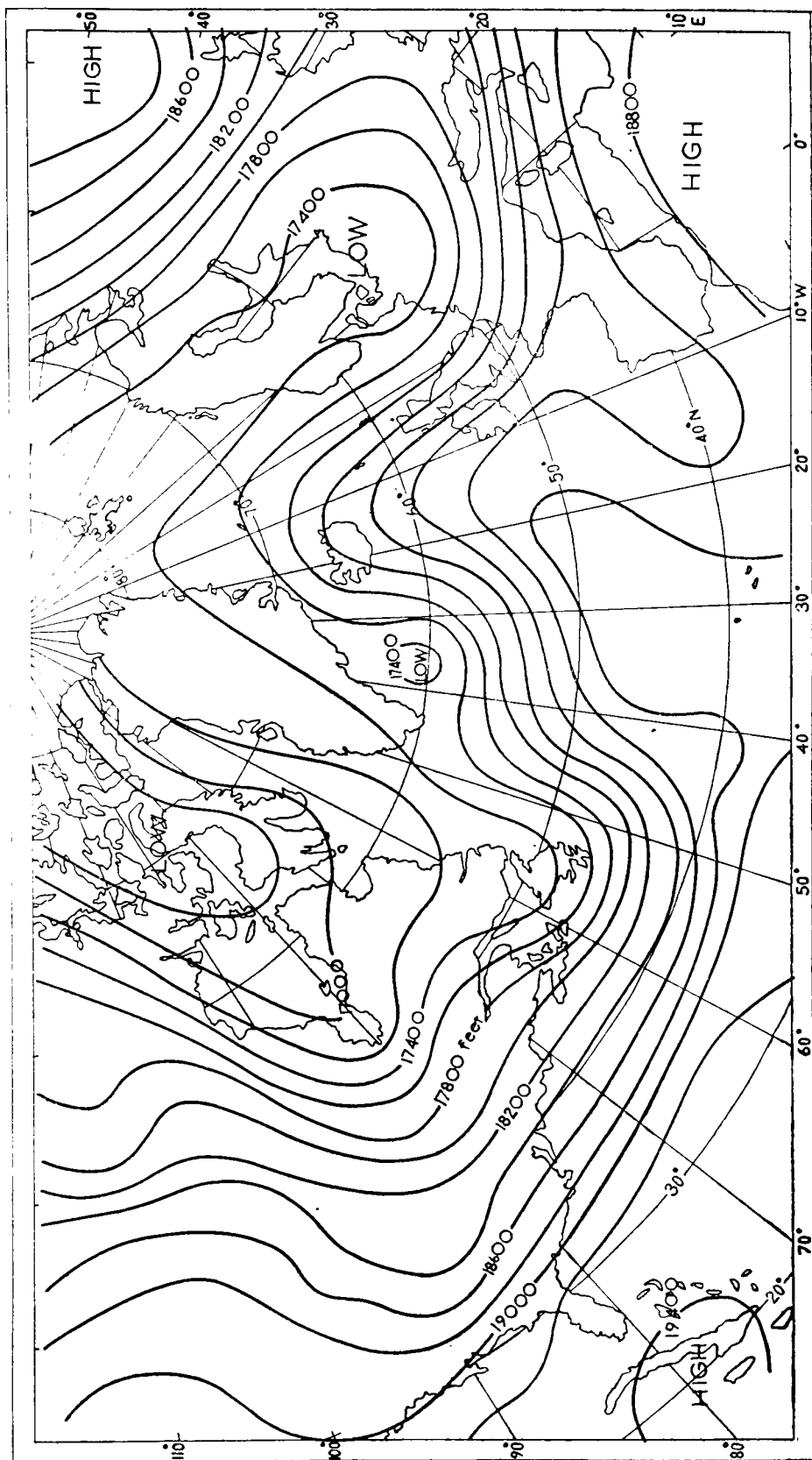


FIGURE 3--THE SPACING TO THE NEXT UPWIND TROUGH  
500 mb contours (feet) at 1500 GMT on 11 November 1952

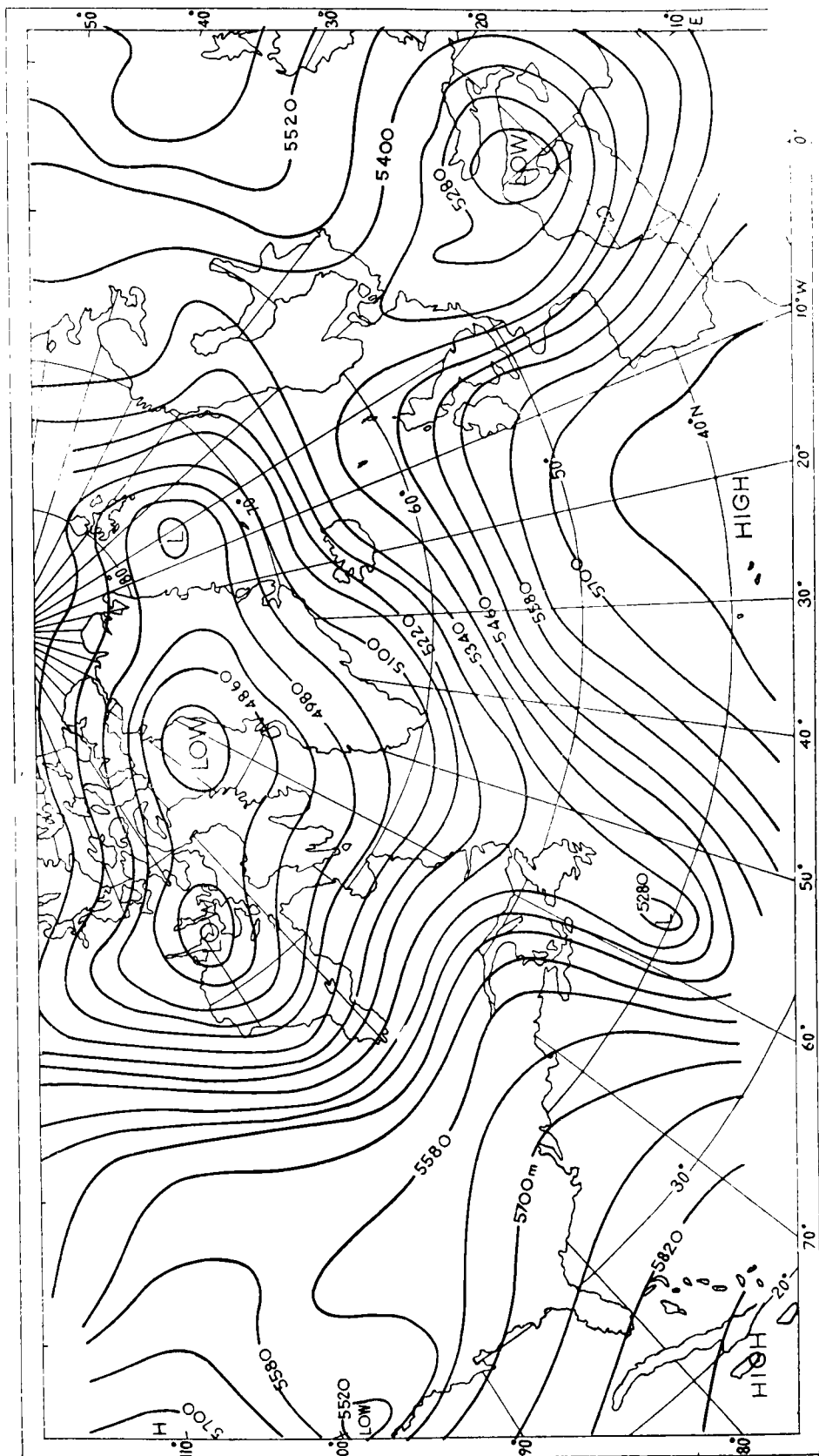


FIGURE 4—THE SPACING TO THE NEXT UPWIND TROUGH  
500 mb contours at 0000 GMT on 13 January 1958

next upwind trough was  $32^\circ$  of longitude or more. On many occasions when no dry spell followed, the spacing was less than  $30^\circ$ . Examples of this type of situation are shown in Figures 3 and 4. The 500 mb chart for 1500 GMT on 11 November 1952 (Figure 3) shows the trough between  $60^\circ\text{W}$  and  $50^\circ\text{W}$  closely followed by another trough less than  $30^\circ$  upwind. During the following 48 hours, the trough between  $60^\circ\text{W}$  and  $50^\circ\text{W}$  ran forward quickly as a weak feature to north of Iceland and the following trough replaced it between  $60^\circ\text{W}$  and  $50^\circ\text{W}$ . A surface high north of the Azores was stationary and fronts associated with a depression near Iceland crossed the British Isles bringing rain. The 500 mb chart for 0000 GMT on 13 January 1958 (Figure 4) again shows a second trough less than  $30^\circ$  upwind with the trough between  $60^\circ\text{W}$  and  $50^\circ\text{W}$  partially cut off. Within 36 hours, the trough had almost completely cut off in low latitudes with the main flow around a shallow trough at  $50^\circ\text{W}$  in high latitudes. A surface high moved from the Azores to a position south-west of the British Isles, intensifying from 1028 to 1040 mb, but fronts associated with depressions which moved across Iceland to Spitsbergen swung south-eastwards across the British Isles bringing some rain to most districts.

*The zonal flow across the Atlantic (zonal index).*—A measure of the zonal flow across the Atlantic, when the trough was situated between  $60^\circ\text{W}$  and  $50^\circ\text{W}$ , was found to be a useful predictor. The index used was the 500 mb height at Lajes in the Azores minus that at Keflavik in Iceland. On nearly all occasions when a dry spell occurred, the zonal index was less than 60 decametres. On occasions when the index was 60 or more, the surface high to the south-west of the British Isles often extended a ridge over France or Spain with cyclonic westerlies bringing rain to the British Isles.

*The orientation of the surface high.*—On five occasions when other factors were favourable and no dry spell occurred, the surface high to the south-west of the British Isles was elongated in a north-south direction.

**Model SW: a summary of the critical values of the predictors.—**

- (i) The flow around the base of the trough between  $60^\circ\text{W}$  and  $50^\circ\text{W}$  must be centred south of  $47^\circ\text{N}$  ( $49^\circ\text{N}$  for April).
- (ii) The flow ahead of the trough must not become south-easterly, south of latitude  $53^\circ\text{N}$ .
- (iii) The spacing to the next upwind trough must not be less than  $30^\circ$  of longitude.
- (iv) The zonal index must be less than 60 decametres.
- (v) The surface high must not be elongated in a north-south direction.

Including only those occasions when the above conditions were satisfied, a diagram was plotted (Figure 5) showing the positions of surface highs with a central pressure of 1020 mb or more. If a dry spell of three days or more began within three days, a dot was plotted. A dry spell of two days was indicated by a dot within a circle. If no dry spell began within three days, a cross was plotted. The numbers next to the plots are the last two figures of the central pressure of the high in millibars. Occasions when a dry spell was associated with Model SW-NE are not included. An area enclosing many of the dry-spell plots is shown to the south-west of the British Isles. All of the highs within the area which were associated with dry spells of three days or more had a central pressure of 1028 mb or more. Of the 30 dry spells of three days or more associated with the highs within the area, 3 began on the same day that the trough

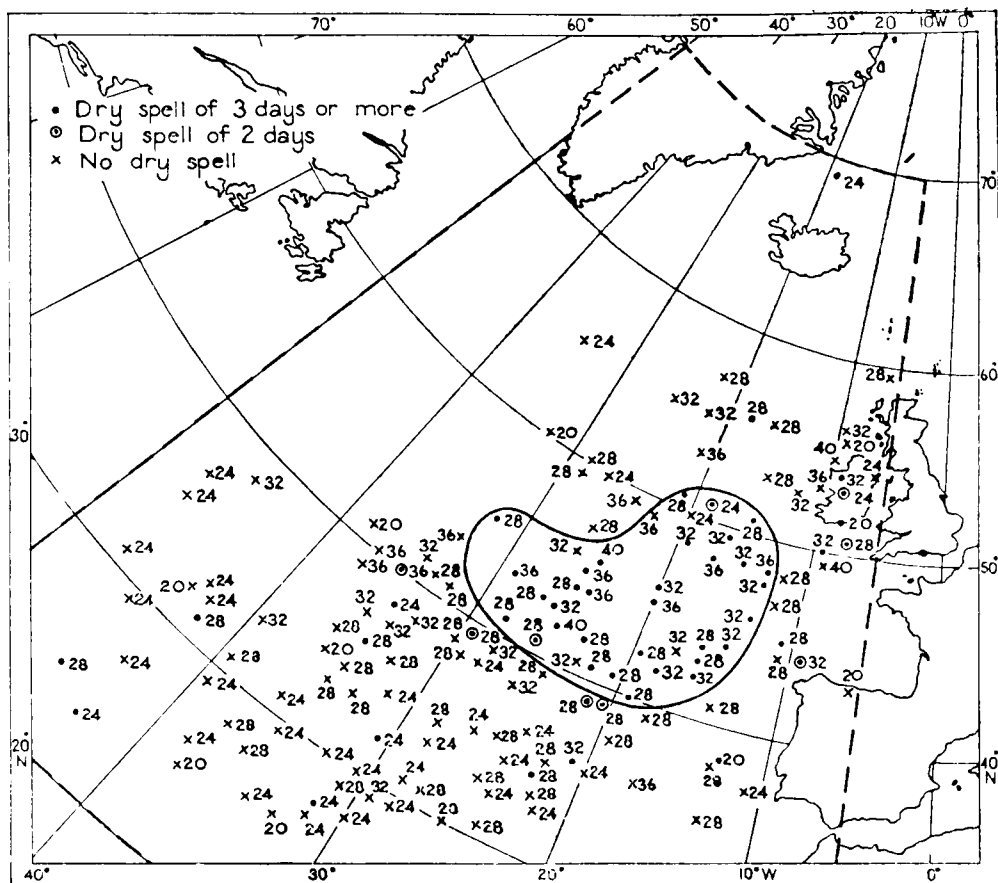


FIGURE 5—MODEL SW: POSITION AND INTENSITY OF SURFACE HIGHS  
The central pressures of the surface highs are given in mb omitting the first two figures.

reached longitudes  $60^{\circ}\text{W}$  to  $50^{\circ}\text{W}$ , 12 began one day later, 12 began two days later and 1 began three days later. Two spells had begun already and continued for a further three days. One high was associated with a continuation for a further three days of 1 of the 30 spells. There were four occasions when a high of 1028 mb or more within the area was not associated with a dry spell, two of which were in December. As none of the occasions when a dry spell followed was in December, there is no evidence that Model SW is of use in this month.

**Model SW: the tracks taken by the surface highs.**—Figure 6 shows the tracks taken by the surface highs from their initial positions within the specified area to their positions three days later. The highs generally moved in a north-easterly direction over or to the south of the British Isles. After three days, most of the highs were positioned east or south-east of the British Isles, some over the British Isles and a few to the south or south-west. The tracks of two highs are not shown. On one occasion in April after a small depression had moved south-eastwards across the British Isles, a high formed to the north-west and moved over the British Isles linking with the high which had persisted to the south-west. On the other occasion, also in April, the high to the south-west moved towards the British Isles and weakened as a new high formed to the north of the British Isles.

**Model SW: the effect of a second surface high in the Atlantic-European sector.**—On 18 of the 30 occasions there was no other surface high in the Atlantic-European sector. On 4 occasions another high was situated

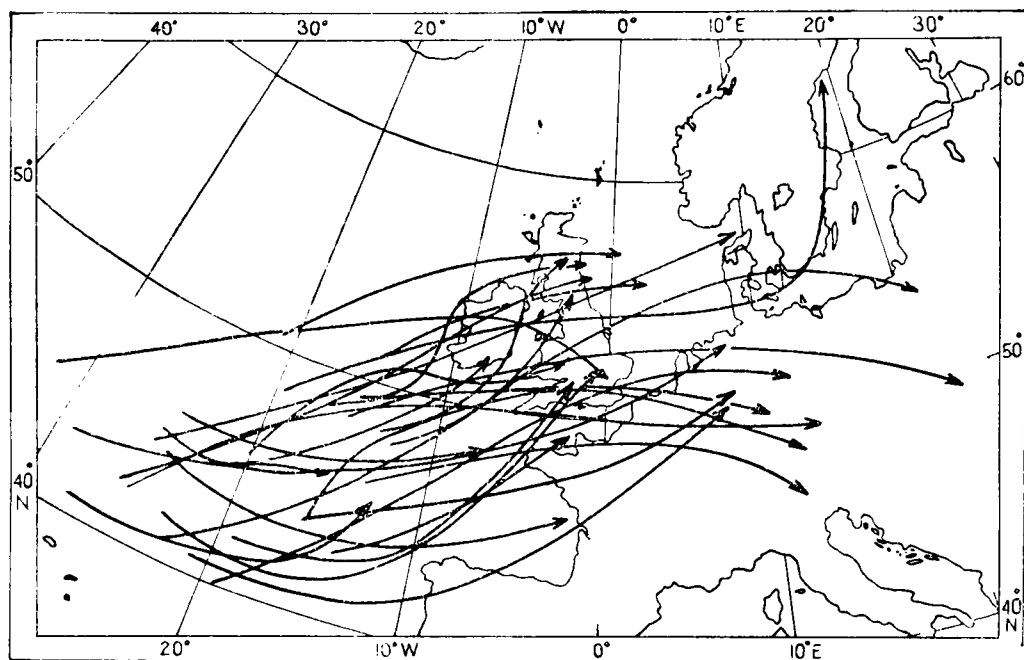


FIGURE 6—MODEL SW: TRACKS OF SURFACE HIGHS OVER THREE DAYS

over Russia, on 2 occasions over France and on 1 occasion over Scandinavia, the Baltic states, the Balkans, Italy, to the north of the British Isles and to the west of the British Isles. The high to the south-west of the British Isles lost its identity by linking with the other high on only 2 occasions. On 1 occasion the high to the south-west linked with a high over Scandinavia, transferring the centre of high pressure to the British Isles and on the other occasion merged with a high to the west before moving across the British Isles.

On 1 occasion when other factors were favourable and no dry spell occurred, a second high was centred near Iceland.

**Model SW: rules for forecasting dry spells in south-east England in November and from January to April.—**

(i) Take note of each chart on which a 500 mb trough is situated between  $60^{\circ}\text{W}$  and  $50^{\circ}\text{W}$ .

(ii) If a surface high with a central pressure of 1028 mb or more is situated within the specified area to the south-west of the British Isles (see Figure 5) a dry spell is likely to begin in south-east England within one or two days. Occasionally, the dry spell may have begun already and a continuation for a further three days is likely. This procedure applies provided that (a) the flow around the base of the trough is centred south of  $47^{\circ}\text{N}$  ( $49^{\circ}\text{N}$  for April), (b) the flow ahead of the trough does not become south-easterly in a latitude south of  $53^{\circ}\text{N}$ , (c) the spacing to the next upwind trough is not less than  $30^{\circ}$  of longitude, (d) the zonal index is less than 60 decametres, (e) the surface high is not elongated in a north-south direction and (f) another high is not situated in the region of Iceland. Another high may be situated in any other part of the Atlantic-European sector.

**Model SW-NE: the critical values of the predictors.—**For Model SW-NE, a study was made of occasions when a 500 mb trough was situated between  $60^{\circ}\text{W}$  and  $50^{\circ}\text{W}$  and at the same time a surface high was positioned

in an area between longitudes  $50^{\circ}\text{W}$  and  $5^{\circ}\text{W}$  and latitudes  $20^{\circ}\text{N}$  to  $50^{\circ}\text{N}$  and another high in an area between longitudes  $5^{\circ}\text{W}$  and  $50^{\circ}\text{E}$  and latitudes  $50^{\circ}\text{N}$  to  $70^{\circ}\text{N}$  (see Figure 7).

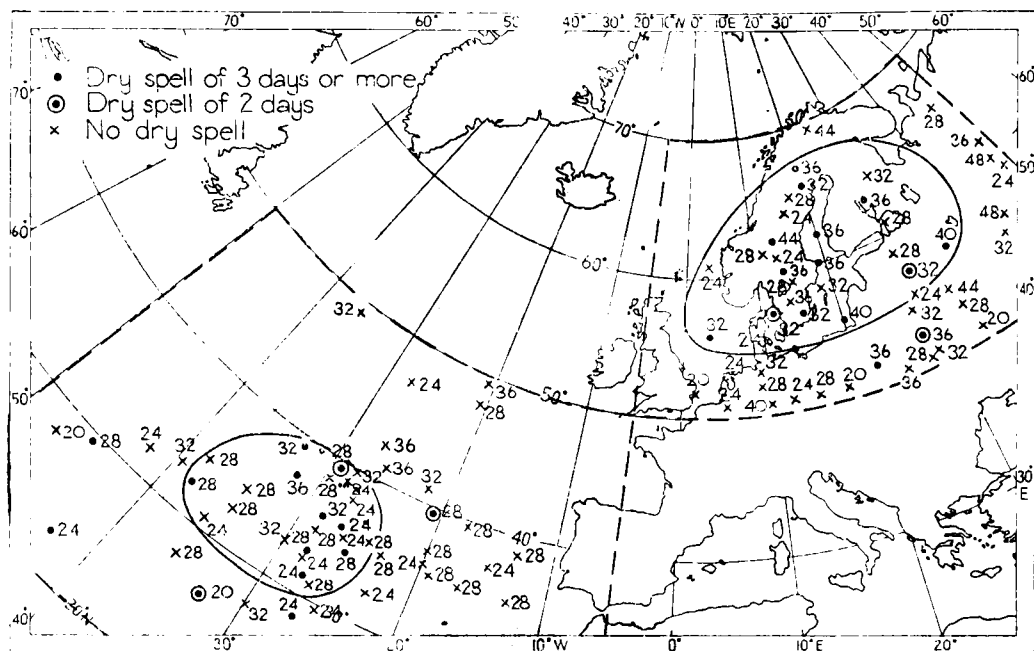


FIGURE 7—MODEL SW-NE: POSITION AND INTENSITY OF SURFACE HIGHS  
The central pressures of the surface highs are given in mb omitting the first two figures.

*The intensity of the trough between  $60^{\circ}\text{W}$  and  $50^{\circ}\text{W}$ .*—The intensity of the trough was not very critical. Dry spells were associated with troughs with negative anomalies at  $45^{\circ}\text{N}$  ranging from 9 decametres for April to 31 decametres for January. However, some flat troughs were not associated with dry spells. On these occasions, the flow around the base of the trough was centred between  $44^{\circ}\text{N}$  and  $52^{\circ}\text{N}$ . For troughs associated with dry spells, the flow was centred between  $36^{\circ}\text{N}$  and  $43^{\circ}\text{N}$ .

*The east-west spacing between the surface highs.*—On occasions when a dry spell followed, the east-west spacing between the high to the south-west of the British Isles and the high to the north-east varied between  $32^{\circ}$  and  $68^{\circ}$  of longitude. On 4 occasions when no dry spell occurred, the spacing was  $74^{\circ}$  or more.

#### **Model SW-NE: a summary of the critical values of the predictors.—**

(i) The flow around the base of the trough between  $60^{\circ}\text{W}$  and  $50^{\circ}\text{W}$  must be centred south of  $44^{\circ}\text{N}$ .

(ii) The east-west spacing between the surface highs to the south-west and north-east of the British Isles must be less than  $70^{\circ}$  of longitude. Including only those occasions when the above conditions were satisfied, a diagram was plotted (Figure 7) showing the positions of surface highs with a central pressure of 1020 mb or more.

Occasions when a dry spell associated with Model SW followed are not included. Most dry-spell plots fall within the smaller areas indicated. Figure 8 shows the areas modified to include only those occasions when one high was

situated in one area and one in the other. The dry spells of three days or more were associated with a high of 1032 mb or more in the north-east area and a high of 1024 mb or more in the south-west area. Of the 7 dry spells of three days or more associated with the highs, 2 had already begun and continued for a further three days after the trough reached longitude  $60^{\circ}\text{W}$  to  $50^{\circ}\text{W}$ , 3 began one day later and 2 began two days later. One occasion was associated with a continuation for a further three days of one of the 7 spells. On one occasion in December when a high of 1032 mb was situated in each area, no dry spell followed. As none of the occasions when a dry spell followed was in December, there is no evidence that Model SW-NE is of use in this month.

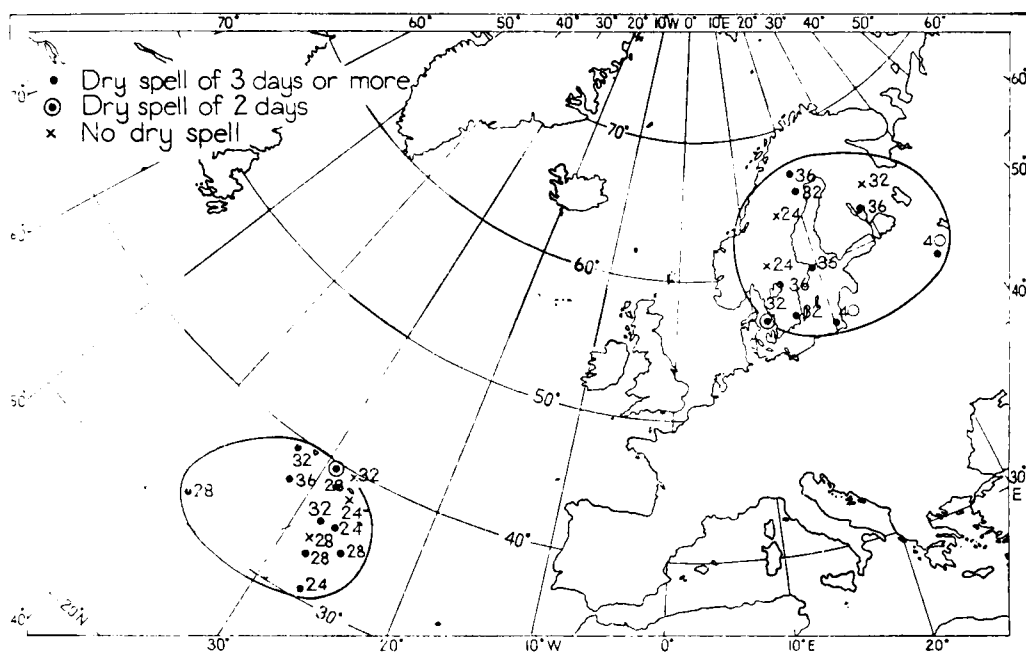


FIGURE 8—MODEL SW-NE: POSITION AND INTENSITY OF SURFACE HIGHS ON OCCASIONS WHEN A HIGH WAS SITUATED IN EACH AREA AT THE SAME TIME

The central pressures of the surface highs are given in mb omitting the first two figures.

**Model SW-NE: the effect of a third surface high in the Atlantic-European sector.**—On all occasions associated with a dry spell of three days or more, there was no third surface high in the Atlantic-European sector. On one occasion, associated with a dry spell of only two days, there was a complex high to the east of the British Isles with a small surface high cell over Scandinavia and the main cell of the same intensity over the Balkans.

On one occasion when other factors were favourable and no dry spell occurred, a third high was situated to the west of the British Isles.

**Model SW-NE: rules for forecasting dry spells in south-east England in November and from January to April.**—

- (i) Take note of each chart on which a 500 mb trough is situated between  $60^{\circ}\text{W}$  and  $50^{\circ}\text{W}$ .
- (ii) If a surface high with a central pressure of 1024 mb or more is situated in the south-west area and a high with a central pressure of 1032 mb or more is situated in the north-east area (Figure 8) a dry spell of three

days or more is likely to begin in south-east England within one or two days. On other occasions, the dry spell may have begun already and a continuation of at least three days is likely.

This procedure applies provided that (a) the flow around the base of the trough is centred south of 44°N, (b) the east-west spacing between the surface high to the south-west and the high to the north-east is less than 70° of longitude, (c) the high in the north-east area is not part of a complex high with the main cell to the south of the area and (d) a third high is not situated to the west of the British Isles.

**The proportion of dry spells forecast.**—Table I shows the number of spells of three days or more which actually occurred during the period 1949 to 1962 with figures in brackets indicating the number which would have been forecast by the two models.

TABLE I—THE NUMBER OF DRY SPELLS WHICH OCCURRED AND THE NUMBER

Synoptic type	FORECAST (1949 TO 1962)								Total
	I(NE)	II(E)	III(SE)	IV(S)	V(SW)	VI(W)	VII(NW)	VIII(N)	
	<i>number of spells</i>								
November	1(1)	2(0)	1(0)	—	4(4)	5(0)	—	—	13(5)
December	2(0)	1(0)	1(0)	2(0)	1(0)	2(0)	—	—	9(0)
January	2(1)	3(1)	1(0)	1(0)	4(4)	2(1)	1(0)	1(0)	15(7)
February	2(0)	1(1)	3(0)	1(0)	3(2)	1(0)	2(0)	—	13(3)
March	3(2)	2(0)	—	2(0)	6(4)	2(1)	2(0)	2(0)	19(7)
April	2(2)	1(0)	1(0)	—	13(12)	1(0)	4(1)	—	22(15)
Total	12(6)	10(2)	7(0)	6(0)	31(26)	13(2)	9(1)	3(0)	91(37)

Figures in brackets indicate the number of spells which would have been forecast by the two models.

The rules would have forecast 26 of the 31 Type V dry spells of three days or more which actually occurred and 6 of the 12 Type I spells. They would also have forecast 2 of the 10 Type II spells, 2 of the 13 Type VI spells and 1 of the 9 Type VII spells. Of the 91 spells of all types 37 would have been forecast. A forecast of a dry spell of three days would have been wrong on four occasions though on two of them the weather was dry for two days.

Table II shows the number of spells of three days or more which actually occurred in each individual year with figures in brackets indicating the number which would have been forecast.

TABLE II—THE NUMBER OF DRY SPELLS WHICH OCCURRED AND THE NUMBER

Synoptic type	FORECAST IN INDIVIDUAL YEARS								Total
	I(NE)	II(E)	III(SE)	IV(S)	V(SW)	VI(W)	VII(NW)	VIII(N)	
	<i>number of spells</i>								
1949	1(0)	—	2(0)	—	4(4)	—	1(0)	—	8(4)
1950	—	1(0)	1(0)	—	4(3)	—	1(0)	—	7(3)
1951	—	2(1)	—	—	—	1(0)	—	—	3(1)
1952	—	—	—	1(0)	1(1)	2(0)	1(0)	—	5(1)
1953	1(1)	1(0)	3(0)	—	2(2)	1(0)	—	—	8(3)
1954	1(1)	1(0)	—	1(0)	3(2)	—	—	2(0)	8(3)
1955	1(0)	1(0)	—	—	1(1)	2(1)	1(0)	—	6(2)
1956	1(1)	—	—	—	4(4)	1(0)	1(0)	—	7(5)
1957	2(1)	2(0)	—	1(0)	—	1(0)	1(0)	—	7(1)
1958	2(2)	—	—	—	3(3)	—	1(0)	1(0)	7(5)
1959	—	2(1)	—	—	4(3)	2(1)	—	—	8(5)
1960	1(0)	—	—	1(0)	—	—	1(1)	—	3(1)
1961	2(0)	—	1(0)	—	2(2)	2(0)	—	—	8(2)
1962	—	—	—	1(0)	3(1)	1(0)	1(0)	—	6(1)
Total	12(6)	10(2)	7(0)	6(0)	31(26)	13(2)	9(1)	3(0)	91(37)

Figures in brackets indicate the number of spells which would have been forecast.



The two models would have been of most use in 1956, 1958 and 1959 when 5 spells in each year would have been forecast. They would have been of least use in 1951, 1952, 1957, 1960 and 1962 when only 1 spell a year would have been forecast.

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#### NOTES AND NEWS

##### **Meteorological Office awards to captains and navigators of civil aircraft**

At the headquarters of the Guild of Air Pilots and Air Navigators in South Street, Mayfair on Wednesday 15 July, two senior pilots received presentation briefcases for their long and meritorious service in the provision of weather reports from aircraft. The awards go to Captain T. M. Bulloch, D.S.O., D.F.C., commander of Boeing 707 flights with BOAC, and Captain R. P. Ellis, of the BEA Vanguard fleet (see Plate IV).

Both Captain Bulloch and Captain Ellis started their air careers with the Royal Air Force. Ulster-born Captain Bulloch, aged 48 and living at Burnham, Bucks, is a Master Air Pilot of almost 30 years' flying experience. He served with Coastal Command on U-boat hunting over the Atlantic and had five confirmed sinkings to his credit before joining BOAC in 1945.

Captain Ellis, also a Master Air Pilot, is 49 and lives at Ruislip, Middlesex. He joined BEA in 1946 after six years' war service and is today a Senior Captain 1st Class of the Vanguard fleet flying the Line's domestic trunk routes. He is an Upper Freeman of the Guild of Air Pilots and Air Navigators.

Dr. A. C. Best, C.B.E., Director of Services, Meteorological Office, presented the briefcases on behalf of the Director-General of the Meteorological Office, and emphasized how the demands of aviation stimulated the development of techniques of forecasting for longer routes, for greater heights and with greater precision.

The first-hand knowledge of upper weather conditions that pilots and navigators meet along their scheduled flight routes is most valuable when reported back to the Meteorological Office and enables the official forecasters to build up more accurate meteorological maps for following flights, and it is on such accurate weather patterns that the safety and economic operation of civil aircraft is dependent.

For their valuable weather reporting services and for the best series of weather reports in the past year, the following captains and navigators have been awarded books by the Director-General, Meteorological Office: Captains J. R. Payne, J. R. Affleck, P. Bray and T. M. Mackenzie of BEA; Captains L. H. Levene and P. Seigel of British United Airways; and Captains S. T. R. Beal, S. W. Gooch, J. C. O. Granett and J. E. Sayce of BOAC. Similar awards go to BOAC navigators M. T. Rogers, D. E. Campbell, G. S. Turner, and G. T. Leggett, and to D. A. Barbour of British United Airways.

## REVIEW

*Wind-driven ocean circulation*, edited by Allan R. Robinson. 9½ in × 6½ in, pp. 161, *illus.*, Blaisdell Publishing Company, New York, 1963. Price: \$3.75.

Since the atmosphere and the oceans are both fluids moving on the surface of the rotating earth, it is hardly surprising that the meteorologist is often on familiar ground in considering the general circulation of the oceans. The fundamental equations are those he knows; ideas on scale of motion, vorticity and geostrophic balance apply equally to both. There are differences, of course. The motions of the atmosphere are more complex than those of the oceans, and exhibit turbulence of a kind and on a scale that defies precise enough description for incorporation into a satisfactory theory of the general circulation. On the other hand, oceanic circulations present their own particular problems, notably perhaps, the awkward boundary conditions which must be applied in any mathematical solution.

This book brings together eight previously published original papers on the theory of the general circulation of the oceans, and ends with notes by the editor which in effect review the subject. The first paper was written in 1947 by Sverdrup who computed the strength of equatorial counter-currents in a baroclinic ocean from the known wind stress, while the last dates from 1961 when Carrier and Robinson described a relatively sophisticated model that accounted for many of the observed features of the large-scale oceanic circulations. Despite this span of 14 years and although eight authors are represented, the papers are remarkably coherent, developing logically from one another so as to constitute a compelling account of the growth of ideas in a difficult field of geophysical study. The meteorologist may well be surprised to find what strides were made, and this without the use of the electronic computer which dominates atmospheric studies. He will be encouraged to look again at some of his own apparently intractable problems.

The idea of publishing together papers by various authors which are already available elsewhere can be good, but obviously the material must be carefully chosen if a useful purpose is to be served. The choice here will please meteorologists at least; they will be happy to have these important papers in a field closely allied to their own in such a convenient volume.

A. GILCHRIST

## METEOROLOGICAL OFFICE NEWS

**Retirement.**—The Director-General records his appreciation of the services of:

*Mr. Leonard Dods*, Principal Scientific Officer, who retired from the Meteorological Office on 22 June 1964 after 38 years service.

This bare statement will but poorly express feelings of regret in all who knew Mr. Dods, on the departure of a well-loved colleague.

Leonard Dods joined the Meteorological Office in 1926 and spent the first six months of his career in the World Climatology Division, then at South Kensington. He was then posted to the Forecast Division, M.O.2, and, like several of his colleagues who joined the Office in the late twenties, made his first acquaintance with synoptic meteorology through the rather mundane duties which fell to the lot of a Junior Professional Assistant in those days. However he was soon promoted to Senior Professional Assistant with some

forecasting responsibilities. Short spells of duty at Cardington (in the former Airship Services Division), Larkhill, and longer ones at Eskdalemuir and Malta followed, but in 1939 he returned to what came to be regarded as his home ground, the Forecast Division at Headquarters, as a Senior Forecaster. Here he stayed throughout the war years, a difficult period when data were scarce and often unreliable, the demands for forecasts increased enormously and the responsibility attaching to a senior forecasting post was heavy and fraught with anxiety. Night duties for forecasters were introduced in the early wartime days at Dunstable and on one of these Mr. Dods, by his prompt action at considerable personal risk and some injury, saved the wooden building then occupied from almost certain destruction by fire which had started unobserved. His colleagues of those days remember with gratitude his level-headedness in difficult situations, his unfailing cheerfulness and his willingness to take more than his share of the burden of duties. He never spared himself, and it came as no surprise that his health suffered; in 1947 he was taken off shift duties and posted as Head of the Special Investigations Branch, M.O.9, at the Kingsway Headquarters. Since then Assistant Directors in charge of M.O.9 have come and gone but Leonard Dods has remained so that to many minds he and M.O.9 have been one and the same.

In M.O.9 he has shown the same kind, helpful and self-effacing spirit. He will be missed, not only for his personal qualities but because in appealing to precedent for guidance in the now Met.O.9 his colleagues will in future have to search through thick files and dusty papers instead of simply asking 'Doddie'.

A. G. F.

## RESEARCH METEOROLOGIST

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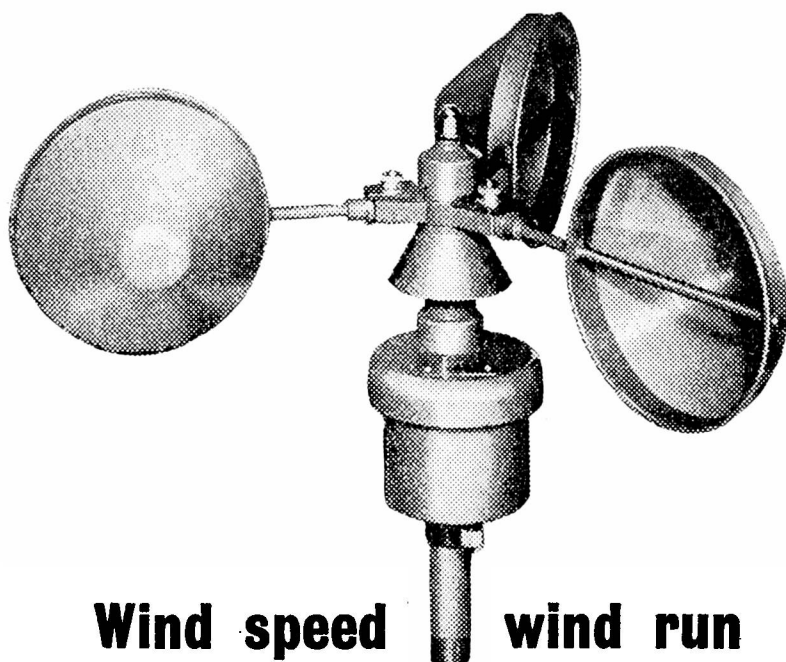
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quoting RC 283/383/04 and giving full name, age and qualifications.



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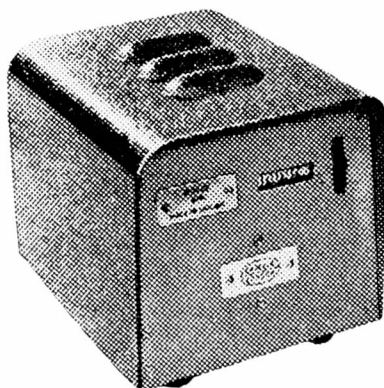
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