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FIRST CONGRESS OF THE WORLD METEOROLOGICAL ORGANIZATION

By E. G. BILHAM, B.Sc., D.I.C.

The First Congress of the World Meteorological Organization (W.M.O.) was held at the Hotel du Palais d'Orsay in Paris from March 19 to April 28, 1951. It was attended by delegates and advisers representing 58 members of the Organization, and by observers representing the International Union of Geodesy and Geophysics, the United Nations Organization and many of the specialized agencies having interests in meteorology. The total number of persons present in one or other of these capacities was about 150.

The International Meteorological Organization, which has now ceased to exist, was formed in 1878 to facilitate the international exchange of meteorological information. It was a semi-official association of the directors of national and territorial meteorological services, who attended its conferences in that capacity and not as representatives of governments. Following upon earlier discussions at which the need for an international body, representative of governments, to replace the International Meteorological Organization was agreed in principle, a Convention was drawn up at the 12th Conference of Directors, held in Washington in 1947, to establish a World Meteorological Organization. The Convention, which has been published by H.M. Stationery Office (Cmd. 7427), establishes the World Meteorological Congress as the supreme body of the Organization and provides that Congress should meet at intervals not exceeding four years. Other organs established by the Convention are the Executive Committee, Regional Associations, Technical Commissions and the Secretariat.

The deed of transfer of the assets, functions and responsibilities of the International Meteorological Organization to the World Meteorological Organization was signed on April 4, 1951. From that date the International Meteorological Organization ceased to exist and the World Meteorological Organization came effectively into being. The task before the First Congress was thus a very onerous one. It had to create, *ab initio*, a new organization and to agree upon the measures necessary to ensure its smooth functioning within the broad framework of the Convention. Much of this work was of administrative, legal or financial character and the larger delegations included experts in these fields.

At the first session Congress elected Sir Nelson Johnson, principal delegate of the United Kingdom and outgoing President of the International Meteorological Organization, as Chairman of the First Congress. Other representatives of the United Kingdom were Mr. H. T. Smith (Air Ministry Secretariat), Mr. E. G. Bilham (Meteorological Office), Capt. R. F. Nichols, R.N. (Director of the Naval Weather Service), Inst. Capt. P. Bracelin (Naval Weather Service), Mr. J. Price (British Embassy), Mr. J. Riley (Ministry of Civil Aviation) and Mr. A. W. Ireland (A.-E. Sudan). Cdr. C. E. N. Frankcom, R.N.R. (retd.), was present for part of the time in his capacity as outgoing President of the International Meteorological Organization Commission for Maritime Meteorology.

The meetings in plenary session were much facilitated by the use of the simultaneous interpretation system. Each participant was provided with a pair of head-phones and a switch so that the English, French, Spanish or Russian version of everything spoken could be heard at will.

It would be impossible to set out all the results achieved at the Congress within the compass of a short article. We shall therefore confine attention to those items of the agenda likely to be of most interest to readers of this Magazine.

Officers of the Organization.—The following were elected to hold office until the end of the Second Congress: President, Dr. Reichelderfer (United States); First Vice-President, M. Viaut (France); Second Vice-President, Mr. Sellick (Rhodesia).

Executive Committee.—The Executive Committee consists of the Officers, the Presidents of the six Regional Associations (see below) and six additional elected members. The following were elected: Johnson (United Kingdom), Zolotukhin (U.S.S.R.), Hesselberg (Norway), Azcarraga (Spain), Ferreira (Portugal), Aslam (Pakistan).

Regional Associations.—Congress established six Regional Associations to continue the work of the six Regional Commissions set up by the International Meteorological Organization in 1946. An important change now introduced is to include the oceans as well as the land areas in the regions. Thus Region VI (Europe) includes not only Europe but also the eastern half of the North Atlantic Ocean. The Regional Associations, membership of which is confined to directors of services having networks extending into the regions concerned, met during the Congress and elected the following presidents and vice-presidents:—

ASSOCIATION	PRESIDENT	VICE-PRESIDENT
Region I (Africa)	Davies (British East Africa)	Fahmy (Egypt)
Region II (Asia)	Sohoni (India)	Zolotukhin (U.S.S.R.)
Region III (South America)	de Souza (Brazil)	Monasterio (Argentine)
Region IV (North and Central America)	Thomson (Canada)	Peña-Aguirre (Mexico)
Region V (South-west Pacific)	Barnett (New Zealand)	del Rosario (Philippines)
Region VI (Europe)	Lugeon (Switzerland)	Lambor (Poland)

Technical Commissions.—Congress had to consider what Technical Commissions should be established (the general aim being to keep the number to a minimum) and to determine their terms of reference. At a later stage, after decisions had been reached on these questions, Congress "went into

Commission " and elected presidents to hold office until the first full meeting of each Commission. Eight Commissions covering the following fields of responsibility were established as listed below, with their presidents:—

COMMISSION	PRESIDENT
Bibliography and Publications	Mézin (France)
Instruments and Methods of Observation	Patterson (Canada)
Aerology	van Mieghem (Belgium)
Climatology	Thornthwaite (United States)
Agricultural Meteorology	Burgos (Argentine)
Maritime Meteorology	Frankcom (United Kingdom)
Synoptic Meteorology	Bleeker (Netherlands)
Aeronautical Meteorology	Nagle (United States)

The Synoptic and Climatological Commissions also elected as Vice-Presidents, Dr. Björkdal (Sweden) and Dr. Basu (India) respectively.

Secretariat.—The Secretariat will be established at Geneva and will include both an Administrative Division and a Technical Division. Congress appointed Dr. G. Swoboda to the post of Secretary-General. In the newly created Technical Division individual officers will be nominated to act as permanent secretaries of each Technical Commission.

Technical regulations.—Immediate steps will be taken to prepare and publish technical regulations covering meteorological practices and procedures. These will be arranged under subject headings and will provide members for the first time with a succinct and complete statement of the technical practices with which they are expected to conform.

Cloud atlas.—Work is well advanced on the preparation of a new " International cloud atlas " and provision has been made in the World Meteorological Organization budget for its publication before the next meeting of Congress.

Technical assistance.—Congress resolved that the World Meteorological Organization should participate in the United Nations Expanded Program of Technical Assistance for Economic Development of Under-Developed Countries.

Networks.—The World Meteorological Organization will take all appropriate measures to ensure adequacy in the world network of meteorological stations. In the event of a serious gap, it will examine ways of bridging it either by means of collective aid, financing out of special funds, or by agreement with one or more countries.

Publications.—The Secretariat will produce a periodical bulletin for the purpose of keeping members informed of international meteorological activities. Consideration will also be given to the publication of condensed statistics of basic meteorological data either in tabular or chart form.

Social.—Our French hosts arranged a number of pleasant social functions, including some specially planned for the entertainment of the wives of delegates. On April 19 delegates attended a reception by the President of the French Republic at the Palais de l'Elysée. A reception given by the American Delegation at the Hotel du Palais d'Orsay made a pleasant conclusion to the Congress.

ZONAL AND OTHER INDICES

By A. G. FORSDYKE, Ph. D.

The "zonal index" has attained some prominence in meteorological literature during recent years, largely owing to the part which it has played with other indices of atmospheric circulation in American extended-forecasting technique. To see it in proper perspective however it is desirable first to give a little consideration to indices in general.

In meteorology an index is a number, usually derived by a process of averaging, which expresses some large-scale property or process in the atmosphere. Indices were first used by a number of early workers in statistical investigations connected with long-range forecasting. Among the indices used by Walker, for example, was the " North-Atlantic oscillation ", a linear combination of mean values of pressure and/or temperature taken over a specified period at selected stations in the North Atlantic. He correlated this quantity with numerous others expressing seasonal weather characteristics for particular and often remote regions. Similar statistical work with indices was described by Exner, Defant, Baur and Brooks in many original papers, references to which will be found in Sir Napier Shaw's " Manual of meteorology ", Vol. II, Chapter VII.

Circulation indices.—The main emphasis with regard to indices in recent years has been on their use as measures of the strength of the atmospheric circulation, and as possible indicators of large-scale weather types. Goldie[1], for example, used the annual mean pressure differences between certain stations in Scotland as indices of the mean south-north and west-east air flow over the British Isles. He found interesting relations between these indices and the broad weather characteristics for this country, years of maximum west-east flow, for example, corresponding to conditions somewhat warmer and drier than average. More recently, Jones[2] used the daily difference of pressure between the Azores high and the Iceland low as a measure of the strength of the westerlies on the north-east Atlantic. There was some suggestion of periodicities ranging from 6 to 72 days in the occurrence of extreme values of this index.

The zonal indices introduced in America were devised to represent the strength of the circulation in a specified band or sector of the northern hemisphere. They are computed systematically for a network of points which usually has a fixed geometrical basis, determined by the mean positions of the main branches of the " normal " planetary circulation. The zonal westerly index of Rossby[3,4] is typical; it is the mean speed of the surface westerlies between 35°N. and 55°N. calculated by taking the mean pressure difference between those latitudes on equally spaced meridians and converting by means of the geostrophic relation. Corresponding indices for other branches of the circulation have been defined, the three principal surface zonal indices being:

Polar easterlies, 55–70°N.
Prevailing westerlies, 35–55°N. (often referred to as *the* zonal index).
Subtropical easterlies, 20–35°N.

There are corresponding indices for the standard upper levels of synoptic meteorology. In America attention has been given chiefly to the 700-mb. level, and mean values of the indices at this level and at the surface have been computed for use in extended forecasting.

The planetary wind belts are sometimes considerably displaced from their normal latitudes, overlapping the next zone, and then the principal indices as defined above, while giving some indication of the abnormal distribution, would fail to show the strength of the circulation. To meet this difficulty the so-called maximum–minimum or modified indices have been devised; they are computed for a variable zone for which the mean flow is a maximum when averaged over the whole or half hemisphere as the case may be.

Some other indices devised to represent particular aspects of the atmospheric circulation may be briefly mentioned. The " meridional index " is a measure of the total flow of air across a selected parallel of latitude at a specified level. If computed on the geostrophic assumption, with variations of density neglected, this index obviously gives equal northward and southward components when taken round the hemisphere—that is zero net flow. The true net flow for the whole depth of the atmosphere may be obtained from the variation of the " total-mass index " expressed by the integral of the surface pressure over the polar segment bounded by the given latitude. The " solenoidal index " is computed in the same way as a zonal index but using the thickness (or mean virtual temperature) for a specified pressure interval. This is, in effect, a " thermal-wind index " and may alternatively be found as the difference between the zonal indices for the two levels. " Transport indices " provide measures of the resultant flux, across a specified latitude, of such physical properties as momentum and heat content of the air. They are computed by integrating the product of the meridional velocity with the zonal velocity (momentum transport) or the temperature and water-vapour content (sensible and latent heat transport) round the selected circle of latitude, as for example in a recent paper by Priestley[5].

Indices and the general circulation of the atmosphere.—*Mechanism of the general circulation.*—Indices providing numerical measures of properties or processes in the atmosphere on a large scale are an obvious and even essential aid to the study of general circulation problems. Some understanding of the working of the circulation may be sought through possible correlations among the various indices. The most extensive work in this field is that described by Willett[6,7,8] in a series of voluminous unpublished reports. The following summary of Willett's results is taken from a detailed and critical review prepared by Mr. E. J. Sumner in the Meteorological Office.

Willett calculated contemporary and lag correlation coefficients for almost every possible combination of index pairs amounting to many thousands in all. The coefficients obtained were almost invariably low, the highest absolute values obtained lying between about 0·30 and 0·40 with a few exceptions. Correlation coefficients of this magnitude are not without significance but they have little practical value. Moreover when the indices were corrected for seasonal trend the correlation coefficients were often reduced to complete insignificance. Results of little or no significance were also obtained when monthly mean indices were correlated for the northern and southern hemispheres. When indices were correlated with certain solar phenomena such as sunspot number and monthly mean pyrheliometric value the coefficients were also quite small on the whole.

As might be expected, Willett's conclusions[7] from these results do not encourage the idea that indices can be profitably used in studies of general-circulation problems. They would appear to indicate that the processes which control the fluctuations of the strength of the circulation are not revealed by these particular indices. It may be that the controls are situated outside the portion of the atmosphere studied, for example in the stratosphere or in very low latitudes where observations are scanty; or they may be situated outside the atmosphere altogether, for example the earth's surface influences or solar phenomena. It is, however, well to recognize, as indeed Willett himself does, that there is a certain unreality about indices calculated on the basis of a geometrical network of points without regard to geographical features. Moreover, owing to the process of averaging by which they are computed these indices cannot specify important details of the prevailing circulation. It is difficult to believe that the fluctuations of the atmospheric circulation are without some degree of internal control; it appears however that these indices are not a suitable means of revealing it.

Among these generally low correlation coefficients obtained by Willett there was, however, one relating to transport indices which appeared to have some significance. Theoretical work by Prof. V. P. Starr (unpublished) having indicated the likelihood of a connexion, Willett investigated the contemporary correlation between the pressure deficit from normal northward of latitude 45°N. and the transport of heat across the same parallel. The resulting correlation coefficient 0·52, was substantially higher than most coefficients hitherto found for circulation indices. This result conforms with the view that transport indices are useful aids towards an understanding of the mechanism of the general circulation. The transport of heat and momentum across a given circle of latitude are obvious factors to consider as affecting the strength of the circumpolar circulation and the intensity of the " cold pole " in high latitudes. Considerable attention is being given to these processes by workers in several countries.

Relation of indices to large-scale circulation types.—It would appear not unreasonable to expect that one of the uses of indices might be as convenient indicators of large-scale weather types in the sense that particular values or ranges of values of an index could be recognizably associated with characteristic types of circulation. It has been found however that the value of indices in this connexion is very limited. For example, a high value of the zonal westerly index is associated with low pressure near latitude 55°N. and high pressure near 35°N. over a large part of the hemisphere, so that the Icelandic and Aleutian lows and the subtropical highs are all well developed. On the other hand a very low or negative value of this index is associated with a type in which the pressure systems are elongated in the north-south direction or with an " inverted " type with high pressure to the north and low pressure to the south of the middle-latitude belt. These associations were pointed out by Namias[9] and Willett[8]. These typical patterns are commonly referred to as " high " and " low " index types. But it was quickly realized that use of an index as a type indicator is limited to the few occasions on which it takes extreme values; any intermediate value may be associated with a number of different circulation types, or indeed with patterns having no semblance of type or order at all.

It is worth remarking that the above index and type associations apply to surface indices only, a fact not realized in the early studies of these indices. Namias[10] concludes that the upper westerlies often reach their greatest strength when the surface zonal index is low. This is confirmed by the small correlation coefficients between the surface and upper indices found by Willett[6]. In this connexion Namias[10] remarks that the terms " high " and " low " index type appear to be misnomers. Certainly, the use of these terms as implying vigorous or weak circumpolar westerlies throughout the troposphere, introduced in earlier works on this subject, now seems improper.

Indices in relation to medium-range forecasting.—The prominence given to indices in recent years has been largely on account of their study in connexion with the extended-forecasting project in the United States (R. A. Allen and collaborators[11]). In the earlier reports on this project it was implied, if not explicitly stated, that certain indices, zonal indices in particular, were sufficiently precise indicators of circulation types for their forecasting to be a worth-while problem in itself. It must, however, be reiterated that it is only when the indices take extreme values that they give any indication of the associated circulation patterns.

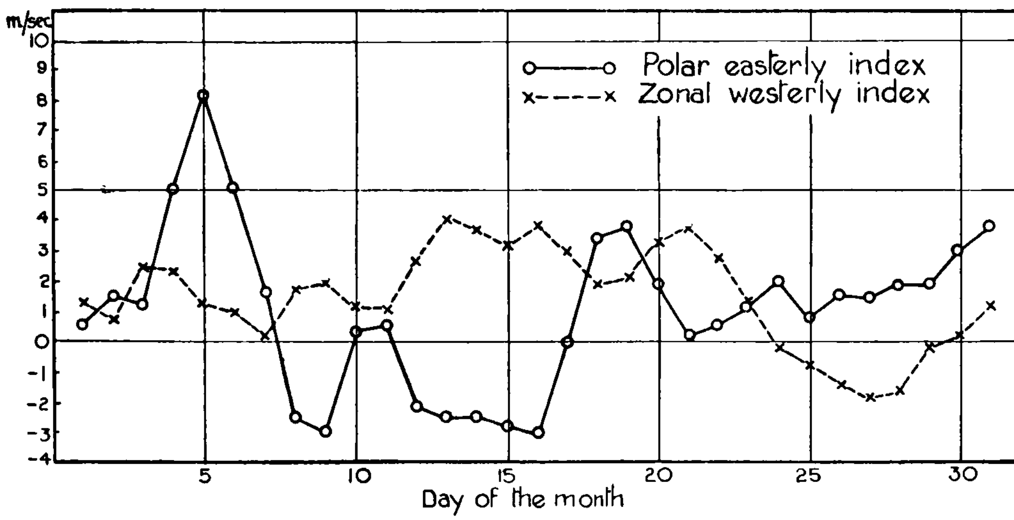

FIG. 1—DAILY VALUES OF THE POLAR EASTERLY AND ZONAL WESTERLY INDICES IN THE HALF-HEMISPHERE, ROCKIES TO THE URALS, MARCH 1950

Nevertheless, considerable attention has been given to the problem of forecasting indices. For this purpose it has been the practice in America, and also to some extent in this country in connexion with experimental four-day forecasting, to prepare graphs showing the time variation of certain indices. As examples of these the daily values of the zonal westerly and polar easterlies for the half hemisphere from the Rockies to the Urals for a typical month are shown in Fig. 1. The graphs almost invariably show the irregular and sometimes quite large fluctuations from day to day which are so characteristic of many meteorological time-variation curves. No method of forecasting these changes appears to have been put forward yet, apart from the ordinary statistical rule that if the value of the index departs widely from the normal the most probable change will be back towards the normal. The work of Willett shows that indices have no significant lag correlations or periodicities. It is evident that the forecasting of indices statistically is not a very promising field of inquiry.

It has been claimed that it is occasionally possible to see long-period trends in indices which may be indicative of impending type changes. Evidence on this point, however, is far from convincing both in our own experience and in the literature, and it is doubtful whether the detection of such trends is a really objective process. An index trend might perhaps be useful in giving added weight to a conclusion arrived at by other reasoning.

In the course of the work referred to earlier in this article Willett investigated contemporary and lag correlations between circulation indices calculated for the quadrants of the hemisphere separately. The results showed nothing significant, indicating that little help is to be got from the application of indices to the idea that bands of strong zonal circulation tend to be propagated eastward from sector to sector.

There is however one indirect use of indices in forecasting which should be mentioned. That is their application as a parameter in formulæ for the movement of long atmospheric waves, the atmospheric flow patterns indicated by the large-scale troughs and ridges on upper air contour charts. The best known of such formulæ is that due to Rossby[3]; it is

$$c = U - \frac{\beta L^2}{4\pi^2}$$

where c is the velocity of the wave-pattern, U the general west-to-east velocity of the air stream, β the rate of change northwards of the Coriolis parameter and L the wave-length. This formula, or modifications of it, has been used in the medium-range forecasting problem, sometimes quantitatively but more often to give a very rough approximation to the " stationary wave-length " obtained by putting $c=0$; if the actual wave-length is near this stationary value it seems reasonable to assume that departures from it will take place only slowly, that is, the large-scale situation is relatively static. The significance for our present subject is that the quantity U in the formula is conveniently taken as one of the zonal indices, preferably an index based on a latitude band, selected for each case in accordance with the current location of the zone of main flow.

Conclusions.—We conclude that zonal and similar indices have little application either to problems of practical forecasting or to studies of the general atmospheric circulation. Investigation has revealed neither any recognizable regularity in the variations of these indices such as might be used in forecasting nor any statistical relations which might aid an understanding of the mechanism of the general circulation. For the most part they show no significant periodicities neither do they throw any light on the possible connexion between variations of the atmospheric circulation and solar phenomena. This however does not necessarily mean that such periodicities or connexions have no existence, but simply that the indices considered do not appear to be suitable for revealing them.

Acknowledgement.—I wish to express my thanks to Dr. R. C. Sutcliffe for his helpful criticism in the preparation of this article and an earlier paper on which it is based.

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VARIATIONS OF THE WINTER MEANS OF TEMPERATURE, WIND SPEED AND SUNSHINE, AND THEIR EFFECT ON THE HEATING REQUIREMENTS OF A HOUSE

By R. E. LACY, B.Sc.

In the course of experimental work on house heating it was required to determine the likely variation in the fuel requirements of a particular house from winter to winter. From measurements made in the house over two winters an equation had been determined, connecting the daily heat requirement of the house with the mean outside air temperature, mean wind speed and duration of bright sunshine. Now it can be shown that this equation may be used to predict the fuel requirement for the house for the whole of a winter, given the mean values of the elements for that winter. It is not necessary to know the individual daily values of the elements.

The equation used to predict the daily fuel requirement of the house is of the form

$$H = a + b\,\Delta t + c\,v\,\Delta t + d\,S \qquad \ldots (1)$$

where:

H =fuel requirement
Δt =difference between mean house and air temperatures
v =mean wind speed
S =duration of bright sunshine
a, b, c, d are constants.

The house under consideration was heated throughout the winter to a uniform temperature of 65°F., and the equation* derived from the observations was

$$H = -\ 13{\cdot}87 + 3{\cdot}02\,\Delta t + 0{\cdot}098\,v\,\Delta t - 1{\cdot}01 S \qquad \ldots (2)$$

With these values of the constants the heat requirement H is obtained in kilowatt-hours, when temperature is measured in degrees Fahrenheit, wind speed in miles per hour and sunshine duration in hours.

As noted above, this equation can be used to predict the overall fuel requirements over a period by substituting the mean values of the elements for that period and multiplying the result by the number of days in the period.

* These equations have been derived from heating trials on two temporary bungalows, the work on which is to be submitted for publication elsewhere.

For a heating season of 212 days this particular equation gives an estimate of the total fuel requirement for the house with a standard error of estimate of about 1 per cent. provided the values of temperature, wind speed and sunshine used do not differ greatly from those from which the equation was derived.

However, the variance in the fuel requirement of the house from winter to winter may be determined without calculating the requirements for each winter. It may be derived from the variances of the individual elements by the following relationship:

$$\text{var}\,(H) = b^2\,\text{var}\,(\Delta t) + c^2 v^2 \text{var}\,(\Delta t) + c^2\,(\Delta t)^2\,\text{var}\,(v) + d^2\,\text{var}\,(S) \quad . \ . \ . \ (3)$$

In these equations we are using Δt, the difference between the temperatures of the house and the outside air, but as the house temperature is assumed to be constant, the variance in Δt is the same as the variance in the air temperature.

The house for which equation (2) was derived is situated at Garston, Hertfordshire, but as the required meteorological data for this locality were not available for more than a few winters it was decided, for the purpose of this investigation, to use data obtained at Kew Observatory during the period 1919–49. Monthly means of air temperature, wind speed and daily duration of bright sunshine were obtained, for the most part from published figures in the *Observatories' Year Book*, or in the *Monthly Weather Report* and *Daily Weather Report*. Some war-time figures which were missing from these sources were obtained directly from Kew Observatory.

From these figures the means of each of the thirty winters, 1919–20 to 1948–49, were computed, winter being defined for this purpose as the seven months, October to April inclusive, which approximates to the normal heating season. In Table I the mean values of each element are listed for each of the thirty heating seasons used. Fig. 1 shows by means of histograms the frequency distribution of each element. The distributions of wind speed and sunshine might be regarded as approximating to the statistical normal, but that of temperature clearly does not, the most striking feature being the almost complete absence of values in the range 43·0° to 43·9°F. It would seem therefore that thirty heating seasons is not really a large enough sample to give a fully representative group of data, but it is probably adequate for the present purpose.

Table II gives a brief analysis of the data. The seasons in which the highest and lowest values occurred are given in brackets alongside the appropriate figures.

The comparable means for the period 1906–35 are, for temperature 44·5°F., and for sunshine 2·57 hr./day. There is no published figure for wind speed. It would appear that the winters of the period 1919–49 did not differ significantly as regards average figures from those of the period 1906–35.

It will be noted from Tables I and II that in this series of heating seasons all the extreme values of the elements have occurred in the last nine seasons. The warmest season of the series (1947–48) followed immediately on the coldest one (1946–47). Examination of the individual winter means shows that there is a tendency for deviations from the overall mean value to be greater in the later seasons. To ascertain whether this tendency was real, the data were divided into three groups, each consisting of ten consecutive seasons, and the standard deviations for each group computed separately. The standard deviations for

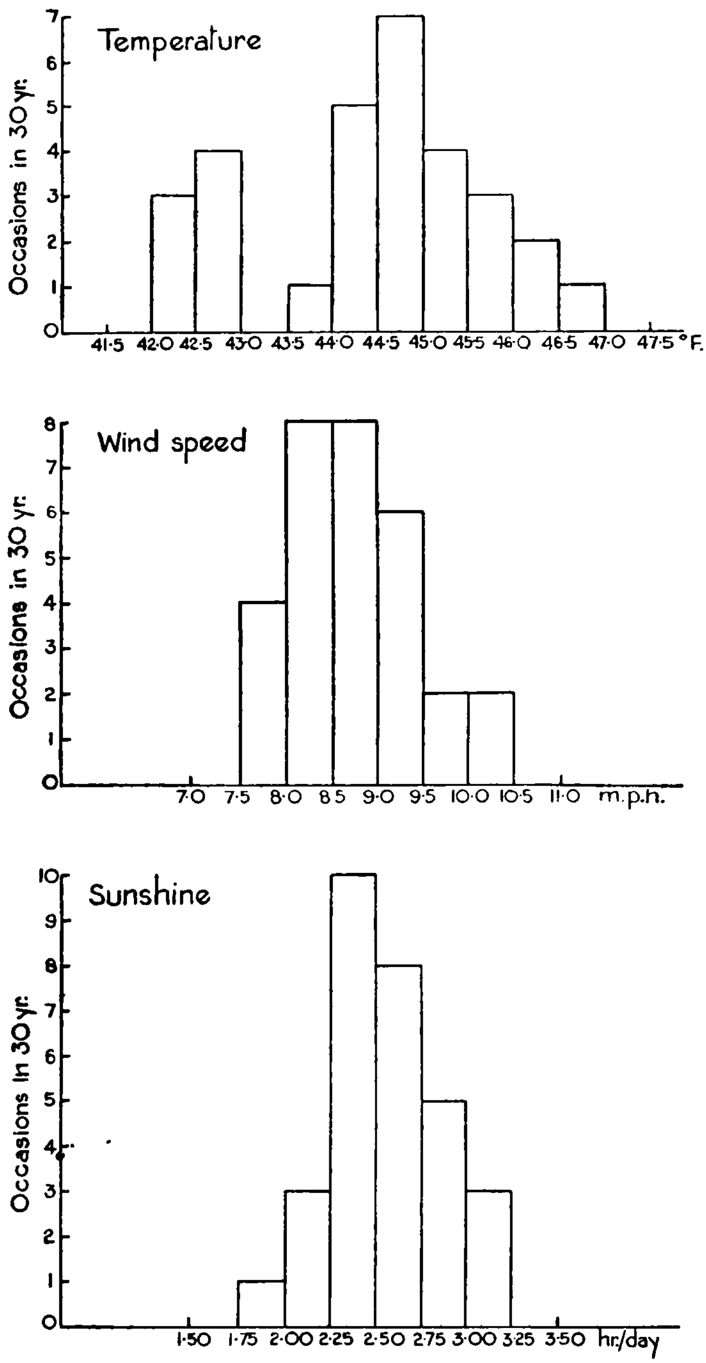


FIG. 1—FREQUENCY DISTRIBUTION OF TEMPERATURE, WIND SPEED AND SUNSHINE AT KEW OBSERVATORY

Period.—30 heating seasons (Oct.–Apr.), 1919–49

all three elements did in fact increase with time, but the increases were not significant, and it is concluded that the changes were not real.

Applying the variances obtained for the three elements over the thirty seasons 1919–20 to 1948–49 to equation (3), we find, for the seasonal heat requirement of the house under consideration, a coefficient of variation of 8·1

TABLE I—MEANS OF AIR TEMPERATURE, WIND SPEED AND DAILY SUNSHINE DURING 30 HEATING SEASONS, 1919–49

Kew Observatory October–April, inclusive.

Season	Temperature	Wind speed	Sunshine
	°F.	m.p.h.	hr./day
1919–20	44·2	8·7	2·41
1920–21	44·2	8·0	2·79
1921–22	44·1	8·6	2·82
1922–23	44·6	7·9	2·32
1923–24	42·3	8·1	2·67
1924–25	45·3	8·4	2·16
1925–26	45·1	8·1	2·42
1926–27	44·7	8·5	2·61
1927–28	44·7	8·8	2·40
1928–29	42·3	7·6	2·78
1929–30	45·1	9·2	2·60
1930–31	44·0	8·7	2·58
1931–32	44·2	8·9	2·36
1932–33	44·8	9·2	3·02
1933–34	42·8	8·0	2·54
1934–35	46·3	8·9	2·19
1935–36	43·7	8·4	2·34
1936–37	44·7	9·3	2·43
1937–38	44·7	9·0	2·79
1938–39	45·6	10·1	3·02
1939–40	42·6	9·5	2·28
1940–41	42·6	10·3	2·26
1941–42	42·8	9·3	2·49
1942–43	46·1	8·1	2·67
1943–44	45·2	7·5	2·12
1944–45	44·6	8·5	2·66
1945–46	45·6	8·0	2·65
1946–47	42·1	9·8	1·99
1947–48	46·7	9·2	2·96
1948–49	45·8	7·8	3·18

per cent. We may say therefore, bearing in mind that some error may be introduced by the fact that the data are not normally distributed about the mean, that in two seasons out of three we may expect that the house will require an amount of fuel within about ±8 per cent. of that used in an average season. The heat requirement in extreme seasons may vary from the mean by about ±15 per cent.

TABLE II—ANALYSIS OF THE DATA FROM 30 HEATING SEASONS, 1919–49

	Temperature	Wind speed	Sunshine
	°F.	m.p.h.	hr./day
Highest value ...	46·7 (1947–48)	10·3 (1940–41)	3·18 (1948–49)
Lowest value	42·1 (1946–47)	7·5 (1943–44)	1·99 (1946–47)
Overall mean ...	44·4	8·7	2·55
Standard deviation ...	1·26	0·72	0·29
Variance	1·59	0·515	0·086

It will be seen that the variance in the heat requirement of the house from season to season due to variations in the weather is very much greater than any error in the estimate of the requirement due to inaccuracies in the equation. In this particular case in fact we may, for all practical purposes, ignore the standard error of estimate of the equation. We may not however be able to do this when dealing with other types of houses, for we cannot always make measurements of temperature and fuel consumption with such precision as was possible in the present case.

It is hoped in due course to extend this analysis to meteorological data from other parts of the country and to other types of houses and heating systems, and so obtain the likely variation in fuel requirements for the whole country from season to season.

* This note is published by permission of the Director of Building Research.

FESTIVAL OF BRITAIN, 1951

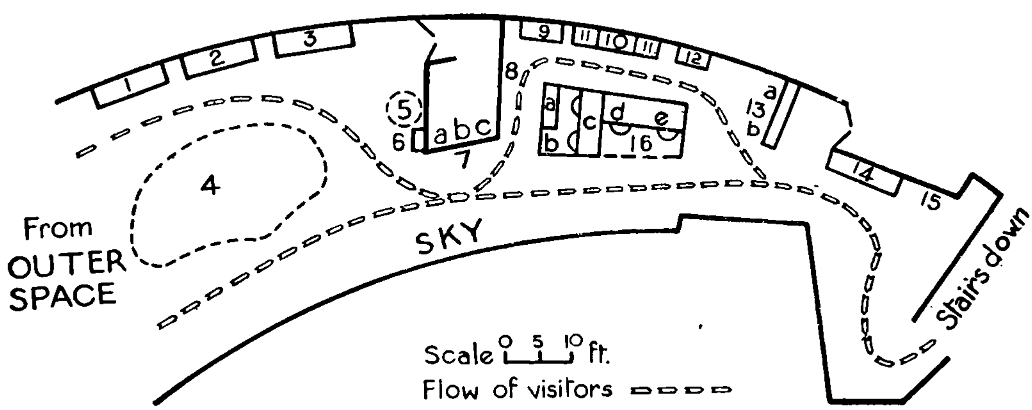
By W. A. L. MARSHALL

Early in 1950 the Festival of Britain authorities asked whether the Meteorological Office would provide a " live " weather forecasting unit to form the main part of the meteorological exhibit in the Dome of Discovery on the South Bank Site, London. It was clear that this was an opportunity of placing before the public some aspects of their weather service on a scale hitherto impossible. The request was approved, and consultations with the Design Research Unit of the Festival began without delay. Proposals by the Meteorological Office on the technical aspects of the exhibit were agreed and implemented by those skilled in the art of modern presentation. At the same time ideas by the designers—which would probably not have been included in an exhibit designed exclusively by meteorologists—were accepted in the Festival spirit. Arrangements were also made with His Majesty's Stationery Office for a *Souvenir Weather Report and Forecast* to be prepared, reproduced and sold to the public in the Dome. Relations between all those engaged in the work of the exhibit were of the happiest character, and although all the items were not in position on the opening day, May 4, 1951, the exhibit was sufficiently complete to do justice to the large amount of work involved and, it is hoped, to the Meteorological Office.

Meteorology has been given a prominent and generous amount of space in the section of the Dome relating to Inner Space. The exhibit is arranged in a broad sweep along the top balcony—appropriately named Sky—and is connected by ionospheric and radio exhibits to Outer Space, dealing with astronomy. Incidentally the view from the balcony is one of the most striking in the whole of the Dome, and is a favourite point at which visitors stop to admire the brilliant panorama made by other galleries and the ground-floor exhibits set out before them.

The general lay-out of the meteorological section is shown in the plan. As a gesture to modernity, the designers included a decorative model of the sun as the source of life, worked in plastic and metal, and forming part of the panel relating to " The earth's atmosphere ". This panel, painted in striking shades of blue, gives a straightforward picture of the height in the atmosphere at which weather phenomena occur, and indicates the heights to which aircraft, balloons, radio-sondes and rockets have ascended. Another panel devoted to " Seasonal weather " contains an artist's conception of the development of nature through the seasons from the delicate green leaves of spring to ripe autumnal fruit; it is edged by zodiacal signs with a snow-flake at the base! The whole frieze illustrates the gradual change from the dullness of January, the snow of February, the increasing brightness of spring and summer to the mellow shades of autumn and eventual return to chilly winter. The "Maypole scene ", for instance, is charming.

A thematic display model symbolizing sunshine, rain and clouds contrasts effectively with the orthodoxy of illuminated rainfall and sunshine charts and cloud-form transparencies in the " Climatological panel " which, appropriately, pays a tribute to the five thousand voluntary observers throughout the country to whom climatology owes so much. In the middle of the balcony, set out on a green background, is a comprehensive and well captioned display of instruments.



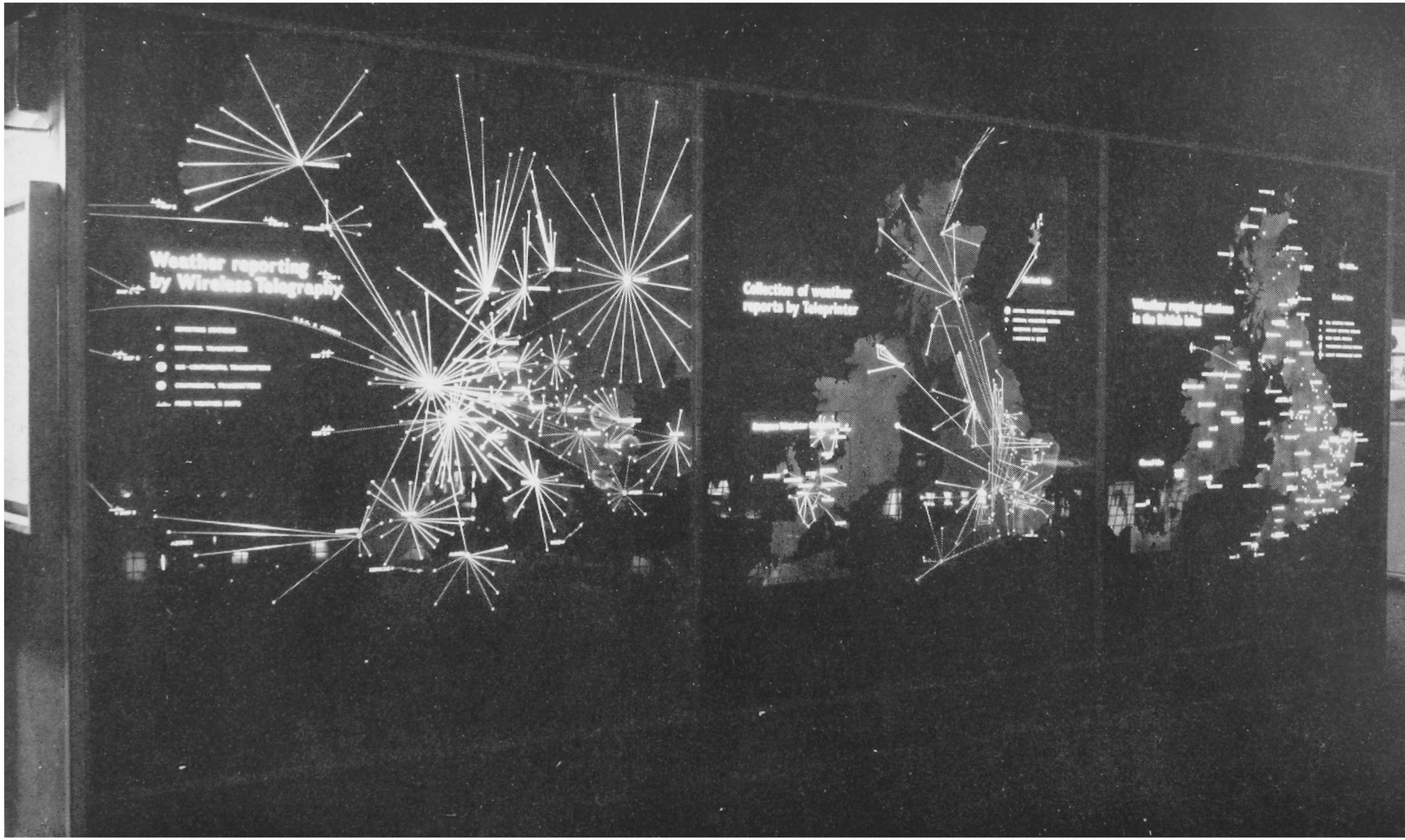
METEOROLOGICAL SECTION OF THE DOME OF DISCOVERY

1. The earth's atmosphere
2. Seasonal weather
3. Climatology and clouds
4. Meteorological instruments
5. Tempest prognosticator, 1851
6. Weather report, 1851
7. Collection of weather reports
   a. Collection by W/T
   b. Collection by teleprinter
   c. Synoptic reporting stations in the British Isles
8. Weather reporting by teleprinter
9. Reports from ships at sea
10. Weather Quiz
11. Weather on the move
12. Special forecasts and climatological information
13. Upper air
    a. Upper winds over the world
    b. Radio-sondes and radar
14. Thunderstorm location
15. Cloud scape
16. Forecasting unit
    a. Teleprinters
    b. Sale of Souvenir Report
    c. Charting benches
    d. Preparation of Souvenir Report
    e. Forecaster

Meteorological links with the Great Exhibition of 1851 are the replica of Dr. Merryweather's Tempest Prognosticator and a copy of the first *Daily Weather Report* to be produced and sold to the public. Dr. Merryweather, of Whitby, claimed that leeches contained in glass jars would climb into the necks of the bottles when a thunderstorm was pending; a small piece of whalebone concealed in the neck of each bottle was thus dislodged, releasing a chain which rang a bell. The leeches on display are dummies, so there has been no opportunity of checking the efficiency of the apparatus! However, it draws a smile from even the most cynical critic of modern forecasting.

[To face p. 166

GENERAL VIEW OF THE METEOROLOGICAL SECTION OF THE DOME OF DISCOVERY



DIAGRAMS ILLUSTRATING THE COLLECTION OF WEATHER REPORTS IN THE DOME OF DISCOVERY

FORECASTING UNIT AT THE DOME OF DISCOVERY

To face p. 167]

Reproduced by courtesy of La Météorologie Nationale, Paris

CONGRESS OF THE WORLD METEOROLOGICAL ORGANIZATION, PARIS, 1951

Leading to the forecasting unit are three beautiful glass charts each 8 ft. × 6 ft. illuminated in red, white, blue and green on a black and grey background, which form the most effective inanimate exhibits in the Sky section of the Dome. Few of the tens of thousands who pass this point each day fail to stop, examine and admire them; the directors of Commonwealth and foreign meteorological services fresh from the Conference of the World Meteorological Organization, who were passing through London at the time the Festival was opened, were particularly impressed with this display. The first chart summarizes the highly organized international exchange of weather reports by wireless telegraphy; observing stations on land and sea are shown connected to their national headquarters and the functions of national, sub-continental and continental transmitting stations—Dunstable in the case of Europe—are depicted in a colourful manner understandable at a glance. The middle chart features the elaborate British meteorological teleprinter networks, with lines radiating from Dunstable not only to all parts of the British Isles but to places as far away as Norway, Finland, Germany, Italy and France. The third chart shows the position of all weather reporting stations in the British Isles: full synoptic stations (with place names) in red, auxiliary stations in green, radio-sonde stations in white and thunderstorm-locating stations in a rich blue; prominence is given to the one remaining meteorological reconnaissance flight over the Atlantic Ocean. The complete panel is a mass of colour visible from the opposite side of the 365-ft. Dome.

Just around the corner the eye is immediately caught by the words " Weather reporting by teleprinter ", shining, as it were, through large teleprinter keys mounted on isobaric patterns cut into the wall. Teleprinter tapes connect a cluster of illuminated reporting stations to their collecting centre. Legends describe the collection and broadcasting of reports by teleprinter, while suitable symbols representing the interception of wireless broadcasts from foreign capitals give exciting emphasis to the importance of the Central Forecasting Office at Dunstable as a hub of meteorological communications.

Then there is a panel devoted to weather reporting from ships at sea. It contains an elegant model of one of our own weather ships. Photographs of some of the activities aboard them are supplemented by a caption acknowledging the services of voluntary observers in merchant ships of all nations, whilst a coloured transparent map shows the method of collecting the vital reports from shipping routes throughout the world.

Push buttons that work have an unfailing attraction. Such an attraction is afforded by the " Weather Quiz " in which a full weather report, as plotted on a forecaster's weather chart, is prominently displayed in red and blue on an illuminated glass screen. To the layman it is at first merely a collection of unintelligible symbols grouped around a central circle. But for every symbol contained in the plotted report there is a similar symbol ranged along the bottom of the exhibit. To find out what, for example, the " two black dots" signify the visitor presses the appropriate button and the words " intermittent moderate rain " flash on the glass screen before him, and so on, through all the 18 items of which the full weather report is composed.

Another panel entitled " Weather on the move " shows a weather map of the Atlantic Ocean and Europe with a deep depression centred near Iceland and a well marked trailing cold front along which very active secondaries subsequently developed. Transparencies provide an interesting series of charts at 12-hr. intervals showing the rapidity with which depressions can form and move and thus how tomorrow's weather may depend on changes taking place today thousands of miles away.

The uses to which special forecasts and climatological information are put are presented very attractively in pictorial form. Pride of place is given to agriculture, but industry, transport, aviation, public utilities and sport are all indicated. The racing pigeon appears to be rather surprised and somewhat uncomfortable at his inclusion, but he typifies the continually widening range of activities served by the Meteorological Office.

The visitor now reaches the " Upper air section ". The important work of British meteorologists on upper winds over the world is shown in an illuminated push-button model; and a radio-sonde exhibit, surmounted by an inflated balloon reaching the roof of the Dome, demonstrates, together with a small radar panel, recent means of improving meteorological knowledge and forecasting technique. Nearby is a " sferic " display prepared by the National Physical Laboratory; illuminated arrows from two stations point towards a lightning symbol which appears intermittently in continually changing positions, thus showing the simple principle of direction finding. The latest " sferic " set with its many knobs and flashing cathode-ray tube, and a plotting table as used when all four British thunderstorm-locating stations are making simultaneous observations, round off the upper air display.

It might be said that more prominence should have been given to meteorological research. Unfortunately fundamental meteorology does not lend itself readily to presentation in a form suitable for exhibition purposes. However, the Duty Forecaster at the forecasting unit is able to enlighten those who are particularly interested in the more specialized work of the Office.

Finally, a few words about the centre piece of the Meteorological Office display—the " Weather forecasting unit ". Reception of both main and second channel teleprinter broadcasts from the Central Forecasting Office at Dunstable ensures a continuous flow of weather reports from Spitsbergen to north Africa and from the Urals to Canada. Practising forecasters are sometimes apt to look on the rapid collection and dissemination of weather reports as commonplace, but Festival visitors are fascinated to see reports from a weather ship in mid Atlantic being received in the Dome ten minutes after the observations were made. The organization displayed on the walls around them comes to life as they see weather reports come in from some 150 British reporting stations and many places on the Continent within about half-an-hour of the time of observation, and from the far ends of the Atlantic, Greenland, Europe and western Russia within an hour or so. Crowds gather several deep for hours on end to see the two Scientific Assistants entering the observations so quickly and neatly on the charts—and it is not only small boys who are intrigued by the expert manipulation of two pens bound together to facilitate plotting in two colours. Every day scores of visitors from home and abroad are supplied on request with the latest weather at their home town with, to the inquirers, surprising detail and promptitude. Even a Philadelphian visitor was served in a couple of minutes after consultation with Dunstable on the direct telephone tie-line.

The Duty Forecaster is occupied with an almost continuous barrage of questions—some frivolous, but mostly serious. He has to discuss everything ranging from existing and future weather to climatology, the technicalities of radiosondes and thunderstorm locating, or the activities of the Meteorological Office as a whole. Moreover, he has to frame his replies in the manner best suited to meet the comprehension of the inquirer. Concurrently, the forecaster supervises the preparation of the *Souvenir Weather Report and Forecast.* This has an attractively designed cover in red and green embodying the Festival of Britain and Meteorological Office badges, a foolscap weather chart inside and an explanation on the back. It is issued twice daily. The morning report, available for sale at 10.30 a.m. (except on Sundays), contains a chart of the weather over northwest Europe at 0600 G.M.T. together with a general forecast for the whole country and a detailed forecast for the " London area " until midnight supplied by the Central Forecasting Office. The afternoon report, on sale at 3 p.m., contains a chart for 1200 G.M.T. and forecasts for the following day. Prepared in two colours by a Meteorological Office draughtswoman in full view of the public, the report is reproduced and sold on the spot at 3*d.* each by staff of His Majesty's Stationery Office who are attached to the forecasting unit. It is a measure of the popularity of this feature that 21,000 copies were sold in the first fortnight. It is fitting that the Stationery Office and Meteorological Office, who have produced so many valuable contributions to meteorology between them over the years, should be associated together in this commemorative venture.

If the mere number of visitors is any criterion, the success of the Meteorological Office contribution to the Festival of Britain 1951 is already assured. Its ultimate value is more difficult to assess. The large numbers of searching questions from visitors of all classes suggest an increasing desire for more background knowledge on meteorology in general and weather forecasting in particular. The results must be of educational value, and should lead to a more intelligent use of the weather information made available to the public through radio, television and the Press.

METEOROLOGICAL OFFICE DISCUSSION

Vorticity in dynamical meteorology

The Discussion of March 12, 1951, was devoted to consideration of the significance of vorticity in dynamical meteorology. Mr. J. S. Sawyer opened the discussion.

In his introduction Mr. Sawyer described the hydrodynamical concepts of vorticity and circulation. Vorticity can be regarded as the average angular velocity of a small fluid element, and circulation round a closed curve is the integral of the average normal component of vorticity over any area bounded by the curve. Under certain restrictive conditions, the circulation has the important property that it remains constant round any closed curve which moves with the fluid. The most important of these restrictions is that the density of the fluid should be a function of pressure only, and although this condition is not satisfied in the atmosphere the direct effect of density gradients on changes of the horizontal circulation is usually small and can be ignored.

The rotation of the earth is another important factor which must be introduced into simple hydrodynamical theory before it can be applied to the atmosphere. By expressing the condition for the constancy of circulation in the atmosphere in terms of co-ordinates with respect to axes moving with the earth instead of with respect to axes fixed in space, some of the basic equations of meteorological dynamics may be derived. Of these the most important is the so-called " vorticity equation", which may be written,

$$\mathrm{div}_z\, \mathbf{V} = - \frac{1}{\zeta + l} \frac{d}{dt} (\zeta + l) \qquad \ldots (1)$$

where $\mathrm{div}_z\, \mathbf{V}$ is the horizontal divergence of velocity, ζ is the vertical component of vorticity (i.e. the vorticity of the horizontal motion), l is the Coriolis parameter and d/dt denotes differentiation following the fluid motion. Several approximations enter into this equation but it appears to describe the main features of the large-scale horizontal motions of the atmosphere.

Synoptic studies of atmospheric motion in large-scale features such as depressions and anticyclones have shown that the horizontal convergence in the lower troposphere is usually largely balanced by divergence at a level near the tropopause, and that divergence near the ground is associated with convergence aloft. There must be some intermediate level at which the divergence is zero, but this is not necessarily the same everywhere; however, some American authors have attempted to identify it with the 500- or 600-mb. levels.

The vorticity equation (1) has two important applications. First, if applied to the level of non-divergence where $\mathrm{div}_z \mathbf{V}=0$, it shows that the vertical component of absolute vorticity, $\zeta+l$, is constant following the fluid motion. As a consequence of the increase of the Coriolis parameter, l, northwards, it follows that at the level of non-divergence the vorticity of northward moving air must decrease relative to the earth — become more anticyclonic — and the vorticity of southward moving air must decrease — become more cyclonic. In a series of troughs and ridges superimposed on a westerly air stream it is possible for the decrease of vorticity from trough to ridge to be just balanced by the increase of the Coriolis parameter northward. The troughs and ridges can then be stationary. This defines Rossby's stationary wave-length which varies with latitude and wind velocity from 40 to 120 degrees of longitude.

On the other hand the vorticity equation (1) can be used to measure the divergence, and this is probably its most important application. It seems likely that geostrophic winds can give an adequate approximation to the vorticity, and thus a knowledge of the changes of the geostrophic wind (or the pressure field) can lead through equation (1) to a knowledge of the divergence. The divergence is of vital importance in synoptic meteorology because of its direct connexion with vertical air movements and rainfall, but the divergence cannot be estimated directly from geostrophic winds because it depends essentially upon geostrophic departures. The vorticity equation provides a way round this difficulty.

Use of the vorticity equation applied to two levels together with the hydrostatic equation has led Dr. R. C. Sutcliffe to formulate a very useful expression for the relative divergence, i.e. the difference between the divergence at the two levels. It is a valuable measure of cyclonic development and can be written

$$- \frac{V'}{l} \frac{\partial}{\partial s} (l + \zeta' + 2\zeta_0)$$

where V' is the thermal wind speed, ζ' is the vorticity of the thermal wind field, ζ_0 is the vorticity of the geostrophic wind field at some low level in the troposphere, l is the Coriolis parameter and $\partial/\partial s$ denotes differentiation following the fluid motion.

Mr. Sawyer went on to explain how vorticity could be estimated from isobaric charts on the basis of the geostrophic assumption, and he illustrated this with a series of charts (one of which is reproduced as Fig. 1). Vorticity is most conveniently evaluated by means of a small scale engraved on transparent material in the form shown in Fig. 2 and placed on a chart of the contours of the isobaric surface appropriate to the level considered. In latitude 50° it is

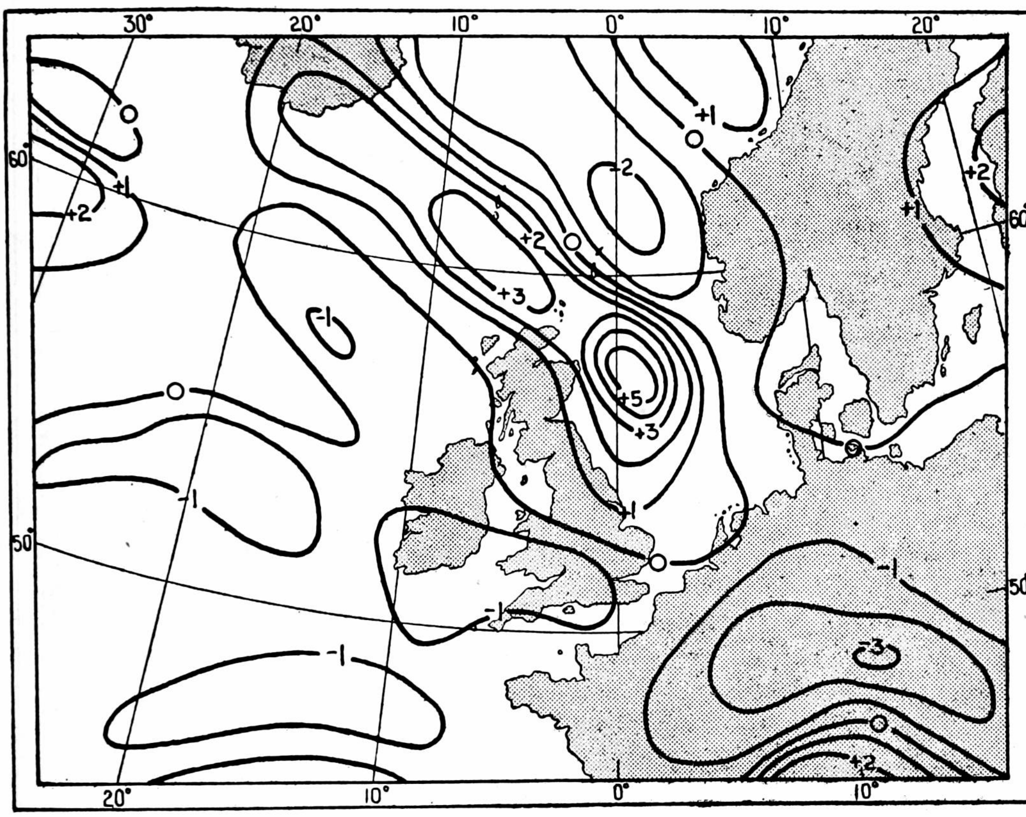
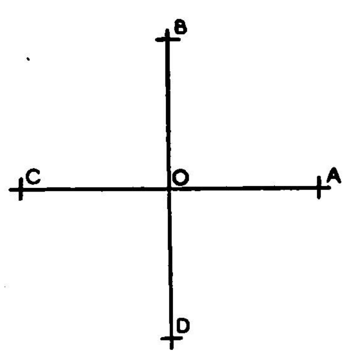


FIG. 1—RELATIVE VORTICITY AT 1000-MB. LEVEL, 0300 G.M.T., MARCH 16, 1949
Units: 10^{-1} hr.$^{-1}$



OA = OB = OC = OD = 168 nautical miles

FIG. 2—SCALE USED FOR ESTIMATING VORTICITY

convenient to use a map distance of 168 nautical miles between each point A, B, C and D and the centre O. If the height of the isobaric surface is then read off the chart at A, B, C, D and O in units of 100 ft. and denoted by h_A,h_B, etc., the vorticity of the horizontal motion is then given in units of one every ten hours (10^{-1} hr.$^{-1}$) by the expression,

$$h_A+h_B+h_C+h_D-4h_O$$

The expressions of the form $V'\partial\zeta_0/\partial s$ arising in Sutcliffe's expression for development can also be evaluated by a similar simple process.

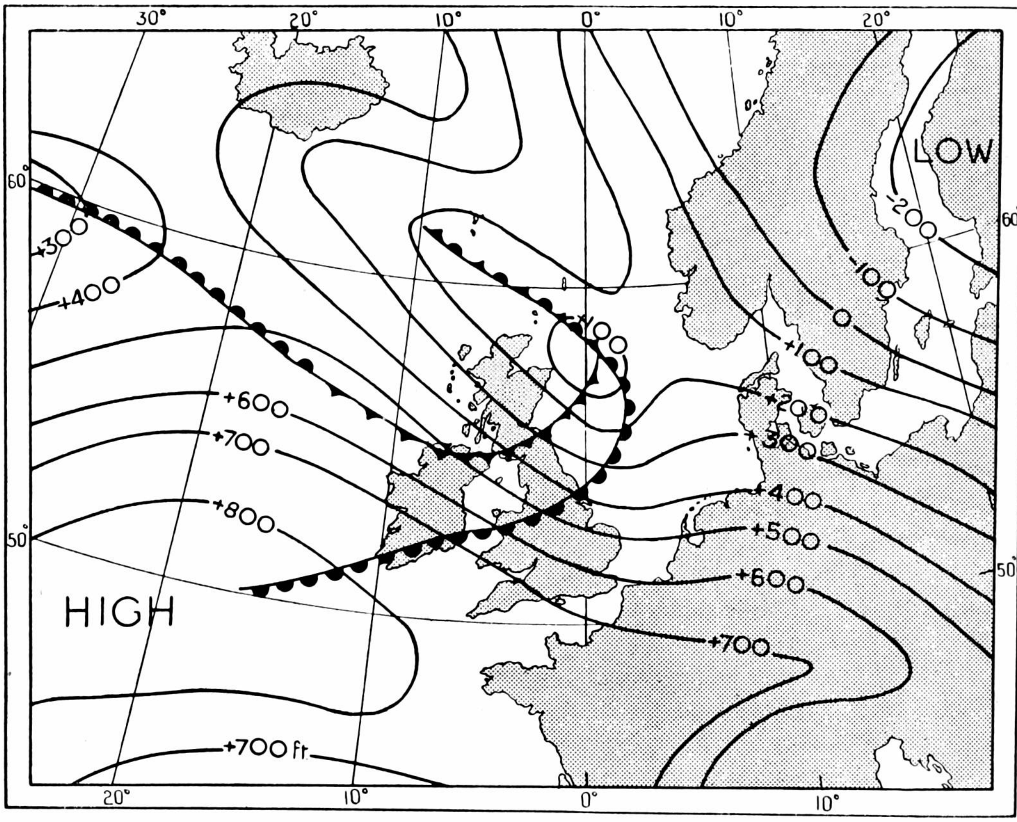


FIG.3—1000-MB. CONTOURS, 0300 G.M.T., MARCH 16, 1949
This chart is used in estimating the vorticity for Fig. 1

In the discussion which followed several speakers expressed some doubt as to whether upper air charts were sufficiently accurate to permit calculations of vorticity and vorticity gradients to be carried out with the required accuracy.

Mr. Briggs also drew attention to the omission of the ageostrophic wind and to the fact that the very high values of vorticity at frontal surfaces were necessarily smoothed out in these computations. Mr. Sawyer, in reply, admitted that the errors were considerable, but experience of working with vorticity charts suggested that values were probably accurate to something like 30 per cent., and the agreement between calculated development and rainfall areas suggested that the computations were physically sound and meaningful.

Dr. Scorer drew attention to some of the theoretical approximations in the theoretical treatment of vorticity. He said that vorticity would not be strictly conserved at a level of non-divergence because of the advection of vorticity from levels above and below by vertical air movements.

Mr. Hurst pointed out that as yet vorticity charts had no direct numerical application to forecasting. Mr. Sawyer agreed, pointing out that the calculations of development and rainfall applied to the time of the chart on which the calculations were based, and gave results which could only confirm existing observations of rainfall and pressure tendency. The important problem of integrating with respect to time had not been tackled yet, although assessment of future development was made by inspection of charts in relation to Sutcliffe's development expression.

Mr. Bannon mentioned the possible use of the Bjerknes circulation theorem as a tool to study the vertical circulations in jet streams, but Mr. Sawyer pointed to the need for caution in studying changes in the horizontal components of vorticity; these are dependent on departures of wind from geostrophic.

Mr. Dight asked whether vorticity theory would throw any light on surges of pressure which affected simultaneously areas of several thousand square miles in extent. Mr. Sawyer was doubtful.

Mr. Gold remarked that, although the subject was vorticity, little had been said about vortices. He referred to earlier work which showed that two co-existent vortices must rotate about one another. He also said that if the study of vorticity could explain obscure dynamical changes, it was a valuable contribution to our knowledge even though its application to forecasting was not immediate.

Mr. Matthewman demonstrated the practical procedure of drawing charts of development and the use of isopleths of the sum of the heights of the 500-mb. and 1000-mb. surfaces to simplify the process.

Mr. Bushby[1] mentioned the numerical calculations of vertical velocities which had been made at the Central Forecasting Office by the application of relaxation methods to the solution of a differential equation involving the horizontal field of development.

Dr. Sutcliffe was sceptical about the use of a level of non-divergence. On the other hand the horizontal divergence was one of the most important parameters in atmospheric motion on the synoptic scale. It was not easy to evaluate directly from wind observations and it was fortunate that the vorticity equation provided another approach to the problem—it was not likely that any other simpler and more practical parameters would be derived from the equations of atmospheric motion.

REFERENCE

1. BUSHBY, F. H.; Relaxation methods and their application to meteorological problems. *Met. Mag., London*, **80**, 1951, p. 71.

METEOROLOGICAL RESEARCH COMMITTEE

The 15th Meeting of the Physical Sub-Committee was held on April 6. Dr. T. W. Wormell has now joined this Sub-Committee.

The problem of the formation of radiation fog is acquiring increasing importance and the Sub-Committee considered some detailed proposals for research to assist the forecaster in dealing with it.

Various aspects of turbulence were represented by four widely different papers, a paper[1] on severe clear-air turbulence at high altitude on November 2 and 7, 1950, by Mr. J. K. Bannon, a paper[2] by Mr. R. F. Jones dealing with the track of thunderstorms on June 5, 1950, as seen by radar, a paper[3] on the effect of a hedge on the flow of air by Mr. N. E. Rider and a note[4] by Mr. A. C. Best on the effect of turbulence on drop-size distribution in cloud.

Mr. Murgatroyd presented the results of a re-analysis of some anomalous sound-reception experiments[5] and other papers considered included one on the evaporation of raindrops[6] and one on the occurrence of high rates of ice accretion on aircraft[7].

The 11th Meeting of the Instruments Sub-Committee was held on April 26, 1951. Progress made with the development of a searchlight method for investigating the upper atmosphere was reviewed, and it was decided to concentrate effort on the two-station technique for the present.

The Committee considered the possible uses of the vortex-tube thermometer and it was decided to seek further information concerning this instrument.

Consideration was also given to the possibility that there might be a dynamical explanation of the apparent diurnal variation of temperature in the upper air.

[1]*Met. Res. Pap.* ,*London*, No. 631, 1951
[2]*Met. Res. Pap.*, *London*, No. 613, 1951
[3]*Met. Res. Pap.*, *London*, No. 602, 1951
[4]*Met. Res. Pap.*, *London*, No. 627, 1951
[5]*Met. Res. Pap.*, *London*, No. 611, 1951
[6]*Met. Res. Pap.*, *London*, No. 603, 1951
[7]*Met. Res. Pap.*, *London*, No. 610, 1951

NOTES AND NEWS

Meteoros

We welcome the appearance of the first number of the new quarterly journal *Meteoros* (Year 1, No. 1, January 1951), published by the National Meteorological Service of the Argentine. The first number contains 120 pages, 9¾ in. × 7 in.

The main articles in the first number deal with the application of Thornthwaite's climatic classification to the Argentine, statistical methods of medium-range forecasting of the temperature at Buenos Aires, variations in the annual rainfall of the Argentine, errors in measurements of height by barometer ascribed to irregular fluctuations of pressure, the effects of climate on the flowering of the peach, forecasting the floods of the Paraná River, and the optimum temperature for human beings. The articles are all in Spanish with summaries in Spanish and either English or French.

In addition to the major articles, there is a brief history and summary of present activity of the National Meteorological Service, notes on current events such as the first Congress of the World Meteorological Organization, and reviews.

REVIEW

The atmospheres of the earth and planets. Edited by Gerard P. Kuiper. 9½ in. × 7 in., pp. viii+366. *Illus.* University of Chicago Press, Chicago, Ill., 1949, Cambridge University Press, London, and W. J. Gage & Co., Ltd., Toronto. Price: $7.50 or 56*s*. 6*d*.

This book is composed of contributions from several authors on the atmospheres of the earth and planets, presented at the Fiftieth Anniversary Symposium of the Yerkes Observatory in September 1947, sponsored by the University of Chicago.

For the meteorologist the book starts off on familiar ground with an exposition of the pattern of atmospheric circulation by Rossby in which the new concept of the jet stream (new in 1947) is fitted into the circulation and energy- exchange processes of the atmosphere. However, the reader is soon moved off into the dimly defined border regions where meteorology merges into other sciences and which are normally familiar only to the specialist. Nevertheless the meteorologist need not fear that his time is not well spent in covering these regions as there he will find new and exciting subjects which have developed greatly in the last few years.

The larger part of the subject matter is covered by articles by Van de Hulst on the scattering and polarization of light (including ultra-violet and infra-red) in the atmosphere, and by P. Swings on the spectrographic analysis of the light from the night sky and the aurora. Van de Hulst deals with most aspects of the behaviour of light in the atmosphere. Starting from the deductions from Mie's equations, he explains the optical phenomena of the atmosphere, which serve as experimental checks on the theory. The discussion however is not confined to the earth's atmosphere but planetary atmospheres also are brought in. Of particular value are the references to the problem of secondary scattering and the ways of calculating its effect, and also to a suggested approximate method based on an empirical rule by Lyot of circumventing the problem of multiple scattering which should interest the instrumentalists. An extensive bibliography of 129 references is provided. Van de Hulst's article is matched by that of P. Swings who treats the subject of the spectra of the night sky and the aurora. This is still a young subject and there is much which is still unknown; however, great progress has been made in determining the origin of the light of the night sky. Fully a third of this light arises in our own atmosphere and is explained as coming from changes in molecular states, at very high altitudes, including the so-called " forbidden " transitions and transitions from meta-stable states in three particle collisions. Various theories to explain these transitions are outlined, including those of Chapman, Bates, and Nicolet.

There are several articles on the attack on the upper atmosphere by the aid of V-2 rockets in New Mexico, most of which information has appeared in report form elsewhere. Although the solution of some problems will depend on observations taken outside our atmosphere from rockets, one nevertheless cannot help contrasting the expense and complication of this line of attack with the simplicity of the methods of spectrographic analysis and to compare the results in both cases, with the balance heavily in favour of the simpler method. The comparison should give heart to the individual or to the small group of workers eager to make some real contribution to the knowledge of the upper atmosphere but possessed of limited means.

In other chapters Whipple's method of atmospheric-density measurement by observations on meteor velocities and decelerations is described, and the results are analysed to show the seasonal density variations. Spitzer discusses the atmosphere above 300 Km., and there are interesting articles on the origin and composition of the atmospheres of the earth and the planets, including the results of the Mount Wilson observations presented by Theodore Dunham Jr., and an article by Gerald P. Kuiper, the author. The book concludes with a short article on the laboratory work on absorption spectra and a discussion on the possibilities of plant life on Mars.

Although, for the most part this book touches only the fringes of what is usually understood as meteorology, it is recommended to the meteorologist as a comprehensive summary of knowledge in fields adjacent to his own from which he will draw useful ideas.

D. D. CLARK

HONOURS

The Birthday Honours List 1951 announced the award to Dr. R. Frith of the O.B.E. Dr. Frith, now Head of the Instrument Research (General) Branch, was for four years in charge of the Meteorological Research Flight. There must have been few flying men who made so many visits to the stratosphere during those four years, for his flying hours amounted to about 700 and many of the flights were devoted to measurements in the stratosphere and higher troposphere.

Members of the Meteorological Office will be specially interested in two other names which appear in the same Honours List. The first is that of Dr. G. M. B. Dobson, F.R.S., once for a short time on the staff of the Office, Chairman of the Meteorological Research Committee for the last four years and first Chairman of the Physical Sub-Committee. Dr. Dobson receives the C.B.E.

Another is Dr. W. R. G. Atkins, F.R.S., of the Marine Biological Laboratory, Plymouth. Dr. Atkins, who also receives the C.B.E., held a temporary appointment in the Meteorological Office, Instruments Division, during the war, when he was engaged on research on visibility.

OBITUARY

Mr. K. J. Pitt.—It was with great regret that we learned of the death of Mr. Kenneth James Pitt on May 30, at the early age of 31, after about two months' illness.

Mr. Pitt joined the Office at the beginning of the war as a temporary Assistant III and was successful in the Civil Service competition for established appointment as Assistant Experimental Officer in 1947. He was promoted Experimental Officer about six months before his death.

Soon after his release from the forces, in which he had served as a Flying Officer in the Meteorological Branch of the R.A.F.V.R., Mr. Pitt spent a little more than a year in the forecasting section at Victory House, and was then posted for a three-year tour in the Middle East from which he returned in December 1950.

Mr. Pitt's early death has deprived the Office of a capable forecaster and his fellow officers of a trusted colleague. To his wife and three young children we offer our deepest sympathy.

METEOROLOGICAL OFFICE NEWS

Colonial Meteorological Service.—The Office continues to assist the Colonial Meteorological Service by releasing staff to the Colonies. Mr. J. E. Stevens has been appointed the senior meteorological officer in the newly formed Meteorological Service of Northern Rhodesia. Four assistants, namely Messrs. G. A. Freeman, A. F. Gray, P. Howarth and R. A. Parsley have followed Mr. Stevens to Northern Rhodesia.

The British West African Meteorological Service has recently established a radio-sonde/radar wind station in Nigeria, and for that the Office has released a radio (meteorological) mechanic, Mr. W. Paton. The post of radio-sonde officer is being filled by Mr. G. Y. Benzies who served in the Office during the war.

Retirement.—Dr. Harold Jameson retired from the Meteorological Office on May 31, 1951, after serving 11 years in the Marine Branch.

Dr. Jameson spent the greater part of his working life in Colombo Observatory of which he became Director in 1932.

He retired from the Colonial Service towards the end of 1939 and returned to England. During his service in Ceylon he received first his M.Sc. and later his D.Sc. degree for published papers on the climatology of Ceylon. These papers covered a wide field, particularly concerning the rainfall in the island.

Dr. Jameson's arrival back in England coincided closely with the outbreak of the late war and he was not left long in retirement, for in February 1940 he volunteered for service with the Meteorological Office and was posted to the Marine Branch which had then taken up its war-time location at Stonehouse, Glos. Dr. Jameson came to the Branch at a time when incessant calls were being made for the solution of marine meteorological problems. With his great experience of handling and working up statistical data his services were invaluable in producing meteorological atlases covering all oceans of the world, work entailing the analysis of over 5,000,000 sets of observations including all meteorological elements. While at Stonehouse Dr. Jameson also served in the Home Guard. On the return of the Branch to London in 1945 he continued his service and has carried out research which includes the investigation of the diurnal variation of barometric pressure within tropical seas and within the Mediterranean Sea, the diurnal variation of fog at sea, and the relation between wind and pressure gradient over the oceans.

Of a very retiring and kindly disposition Dr. Jameson took a keen interest in the junior staff of the Branch, and was at all times ready to assist them in their study of meteorology and many are indebted to him for his patient help in this respect.

As a small parting gift his shipmates in the Marine Branch presented him with an inscribed barograph, so that while in retirement he can pursue his studies of diurnal range of barometric pressure.

In bidding farewell to "Jamey" as he was affectionately known we wish him good health and happiness in a well earned retirement.

Resignation.—Many members of the Office will learn with regret of the resignation of Mr. H. J. Ferrer. Mr. Ferrer joined the Office as a radar expert in 1943, and has specialized in the application of electronic techniques to meteorological equipment. He played a leading part in the adaptation of a war-time army radar set, the GL. III, for wind measurement and the development of the nylon mesh targets. He left to take up an appointment with a firm which makes radio-sonde equipment. He takes with him the good wishes of all his former colleagues in the Instruments Division and at many outstations.

Mr. H. E. Carter, who retired from the Office on August 31, has been appointed by the Crown Agents for the Colonies to work up the climatological records of the Falkland Islands Dependencies Survey for years up to 1950. He is working in the Meteorological Office at Harrow.

Dramatic Society at Harrow.—The Meteorological Office at Harrow has formed an amateur dramatic society which has been christened the " New Meteor Players ". Their first production " On Monday Next ", a comedy by Philip King, which was presented on a home-made stage in the Canteen gave considerable pleasure to a full house and was, incidentally, a financial success.

Sports and Athletics.—*Harrow.*—The second annual athletic meeting of the Harrow Meteorological Office Social and Sports Club was held at Headstone Manor Recreation Ground on the evening of May 30.

The championship events, inaugurated at the first meeting last year, were won by R. J. Garner, Binbrook (100 yd., men), Miss K. N. Newman, Training School (100 yd., ladies), W. Lawson, Leeming (440 yd. and 880 yd.). Outstations won the men's relay and Victory House the ladies' relay.

The Harrow Meteorological Office was divided into two teams, the Climatological Division and the rest, which competed for points in most of the events. The Climatological Division won by the narrow margin of 3 points, the scores being 40–37.

Mrs. F. J. Scrase kindly presented the medals and certificates.

WEATHER OF APRIL 1951

Mean pressure was above 1015 mb. over central Europe, the Mediterranean and most of the North Atlantic, while it was 1020 mb. or above, over Greenland; these pressures were about 2 to 6 mb. above the normal. Mean pressures over west Africa were generally between 1010 and 1015 mb. Mean pressure was below 1010 mb. over Scandinavia, about 4 mb. below normal.

Mean temperatures were in the neighbourhood of 50°F. over central Europe, about normal for April, but over the British Isles where mean temperatures were between 40° and 45°F. they were about 4°F. below normal.

In the British Isles cool, unsettled weather prevailed during the first half of the month and again from the 26th to the end. Snow or sleet showers were frequent, particularly in Scotland. Broadly speaking rainfall considerably exceeded the average over most of Great Britain but was less than the average in Ireland, while sunshine exceeded the average generally.

On the 1st a depression to the west of Scotland moved south-south-east and then turned east across northern England causing general rainfall in England and Wales and scattered rain in Scotland and Northern Ireland. From the 2nd to the 5th a depression south-west of Iceland moved east to the west of Norway, while troughs or secondary depressions crossed the British Isles; rain fell generally on the 3rd, heavy in the west, while rain or showers occurred on the 4th (2·50 in. at Borrowdale, Cumberland, 2·28 in. at Glen Etive, Argyll and 2·16 in. at Carbost, Skye on the 3rd). On the 6th another depression south of Iceland moved south-south-east to our south-west coasts, while a secondary off south-west Ireland moved east-north-east over England and, on the 7th, the main depression moved east-north-east over southern England. Rain was general on the 6th, and rain, sleet or snow occurred on the 7th, while thunderstorms occurred locally in south-east England on the 7th. Thereafter another depression west of Scotland moved south-east to England and a secondary moved quickly across southern England to Denmark; fairly heavy rainfall was registered in the south of England on the 8th and 9th and wintry showers were widespread on the 10th. Subsequently a deep depression south of Iceland moved to south-west Norway, while troughs crossed the British Isles. Heavy rain occurred in the northern half of the country on the 11th and appreciable rain in the south on the 12th (2·25 in. at Borrowdale and at Glen Etive on the 11th). Widespread strong winds and gales were recorded on the 12th. In the rear of the main depression a spell of north-westerly winds prevailed, accompanied by wintry showers, local thunderstorms and long sunny periods. On the 15th and 16th another deep depression south of Iceland moved east-south-east to southern Norway; further precipitation occurred, chiefly in northern districts, and there were gales in the northern half of the country. Subsequently an anticyclone off our west coasts moved across England to Germany, while a trough moved east across Scotland. Precipitation occurred in north-west and north Scotland on the 17th but mainly fair sunny weather prevailed elsewhere. By the 19th a belt of high pressure extended from Greenland across the British Isles, and, on the 20th, a separate high over the Faeroes moved south-south-east to the North Sea where it remained almost stationary until the 23rd. The period from the 19th to the 23rd inclusive was generally dry and sunny on the whole. Temperature rose considerably in most places on the 23rd and the only really warm spell of the month was experienced from about the 23rd to the 25th (day temperature reached 70°F. or above at many places in England on the 24th and 25th and touched 78°F. at Wilmington, Kent, on the 24th and 79°F. at Camden Square, London, on the 25th). During the 25th a small depression south of Iceland moved east, and in its rear a cold northerly air stream covered the British Isles causing a rapid fall of temperature on the 26th. In the following days an anticyclone centred south of Iceland moved slowly south and became almost stationary westward of the British Isles, while pressure was relatively low eastward of the country. Cold weather prevailed, with wintry showers and long sunny periods, though it was rather dull locally including parts of east and south-east England. In the closing days of the month a shallow depression over the North Sea moved slowly south-west and turned west along the English Channel giving rain, sleet or snow in eastern districts on the 29th and in southern England on the 30th. Thunderstorms were experienced locally in the southern half of England on the 29th and 30th.

The general character of the weather is shown by the following provisional figures:—

	Air Temperature			Rainfall		Sunshine
	Highest	Lowest	Difference from average daily mean	Percentage of average	No. of days difference from average	Percentage of average
	°F.	°F.	°F.	%		%
England and Wales ...	79	23	−1·4	135	+1	125
Scotland	64	18	−2·4	150	+3	114
Northern Ireland ...	64	27	−1·6	71	−1	111

RAINFALL OF APRIL 1951

Great Britain and Northern Ireland

County	Station	In.	Per cent. of Av.	County	Station	In.	Per cent. of Av.
London	Camden Square ...	2·58	168	*Glam.*	Cardiff, Penylan ...	3·52	141
Kent	Folkestone, Cherry Gdn.	2·02	122	*Pemb.*	Tenby	2·74	119
,,	Edenbridge, Falconhurst	2·45	131	*Card.*	Aberystwyth	2·77	135
Sussex	Compton, Compton Ho.	3·59	180	*Radnor*	Tyrmynydd	5·91	160
,,	Worthing, Beach Ho. Pk.	2·39	153	*Mont.*	Lake Vyrnwy	5·42	171
Hants.	Ventnor Cemetery ...	2·43	142	*Mer.*	Blaenau Festiniog ...	7·78	125
,,	Bournemouth	3·10	173	*Carn.*	Llandudno	1·43	85
,,	Sherborne St. John ...	3·66	207	*Angl.*	Llanerchymedd ...	1·91	86
Herts.	Royston, Therfield Rec.	2·72	173	*I. Man*	Douglas, Borough Cem.	1·50	61
Bucks.	Slough, Upton	2·85	199	*Wigtown*	Port William, Monreith	1·23	56
Oxford	Oxford, Radcliffe ...	2·55	159	*Dumf.*	Dumfries, Crichton R.I.	2·34	99
N'hants.	Wellingboro' Swanspool	2·59	174	,,	Eskdalemuir Obsy. ...	5·40	159
Essex	Shoeburyness	2·06	170	*Roxb.*	Kelso, Floors	2·50	159
,,	Dovercourt	2·26	181	*Peebles*	Stobo Castle	3·76	180
Suffolk	Lowestoft Sec. School ...	3·81	257	*Berwick*	Marchmont House ...	2·77	137
,,	Bury St. Ed., Westley H.	4·12	269	*E. Loth.*	North Berwick Res. ...	2·37	169
Norfolk	Sandringham Ho. Gdns.	3·33	219	*Midl'n.*	Edinburgh, Blackf'd. H.	2·58	175
Wilts.	Aldbourne	3·51	190	*Lanark*	Hamilton W. W., T'nhill	2·82	151
Dorset	Creech Grange... ...	2·89	134	*Ayr*	Colmonell, Knockdolian	2·11	83
,,	Beaminster, East St. ...	2·36	100	,,	Glen Afton, Ayr San. ...	4·26	142
Devon	Teignmouth, Den Gdns.	1·78	89	*Bute*	Rothesay, Ardencraig ...	3·07	103
,,	Cullompton	2·27	100	*Argyll*	Morvern (Drimnin) ...	4·65	127
,,	Ilfracombe	4·14	198	,,	Poltalloch	2·94	97
,,	Okehampton Uplands	4·78	150	,,	Inveraray Castle ...	7·82	170
Cornwall	Bude, School House ...	2·45	130	,,	Islay, Eallabus	3·11	108
,,	Penzance, Morrab Gdns.	2·62	108	,,	Tiree	2·78	113
,,	St. Austell	3·99	141	*Kinross*	Loch Leven Sluice ...	2·43	127
,,	Scilly, Tresco Abbey ...	1·65	84	*Fife*	Leuchars Airfield ...	1·93	121
Glos.	Cirencester	3·02	162	*Perth*	Loch Dhu	6·00	127
Salop.	Church Stretton ...	2·41	111	,,	Crieff, Strathearn Hyd.	2·93	134
,,	Shrewsbury	1·84	124	,,	Pitlochry, Fincastle ...	2·54	114
Worcs.	Malvern, Free Library	2·88	160	*Angus*	Montrose, Sunnyside ...	2·15	118
Warwick	Birmingham, Edgbaston	2·95	170	*Aberd.*	Braemar	3·90	165
Leics.	Thornton Reservoir ...	2·31	136	,,	Dyce, Craibstone ...	2·66	129
Lincs.	Boston, Skirbeck ...	2·36	175	,,	Fyvie Castle	4·17	195
,,	Skegness, Marine Gdns.	2·66	199	*Moray*	Gordon Castle	2·87	164
Notts.	Mansfield, Carr Bank ...	1·34	77	*Nairn*	Nairn, Achareidh ...	3·40	243
Derby	Buxton, Terrace Slopes	3·69	126	*Inverness*	Loch Ness, Garthbeg ...	6·33	278
Ches.	Bidston Observatory ...	1·00	61	,,	Glenquoich	8·06	124
Lancs.	Manchester, Whit. Park	2·17	113	,,	Fort William, Teviot ...	6·88	153
,,	Stonyhurst College ...	2·62	97	,,	Skye, Duntuilm ...	4·56	140
,,	Squires Gate	1·45	81	*R. & C.*	Tain, Tarlogie House ...	4·30	235
Yorks.	Wakefield, Clarence Pk.	·89	53	,,	Inverbroom, Glackour...	7·20	194
,,	Hull, Pearson Park ...	1·07	69	,,	Applecross Gardens ...	5·36	157
,,	Felixkirk, Mt. St. John...	1·31	79	,,	Achnashellach	7·96	149
,,	York Museum	·87	54	,,	Stornoway Airfield ...	4·28	149
,,	Scarborough	1·46	94	*Suth.*	Loch More, Achfary ...	10·16	210
,,	Middlesbrough... ...	1·60	117	*Caith.*	Wick Airfield	2·45	123
,,	Baldersdale, Hury Res.	2·91	120	*Shetland*	Lerwick Observatory ...	4·40	192
Norl'd.	Newcastle, Leazes Pk....	1·45	91	*Ferm.*	Crom Castle	2·20	86
,,	Bellingham, High Green	2·72	126	*Armagh*	Armagh Observatory ...	1·72	82
,,	Lilburn Tower Gdns. ...	2·35	119	*Down*	Seaforde	1·73	66
Cumb.	Geltsdale	2·09	98	*Antrim*	Aldergrove Airfield ...	1·22	58
,,	Keswick, High Hill ...	4·84	158	,,	Ballymena, Harryville...	1·56	59
,,	Ravenglass, The Grove	1·16	47	*L'derry*	Garvagh, Moneydig ...	1·63	67
Mon.	Abergavenny, Larchfield	2·51	99	,,	Londonderry, Creggan	2·67	104
Glam.	Ystalyfera, Wern House	5·13	135	*Tyrone*	Omagh, Edenfel ...	2·02	77