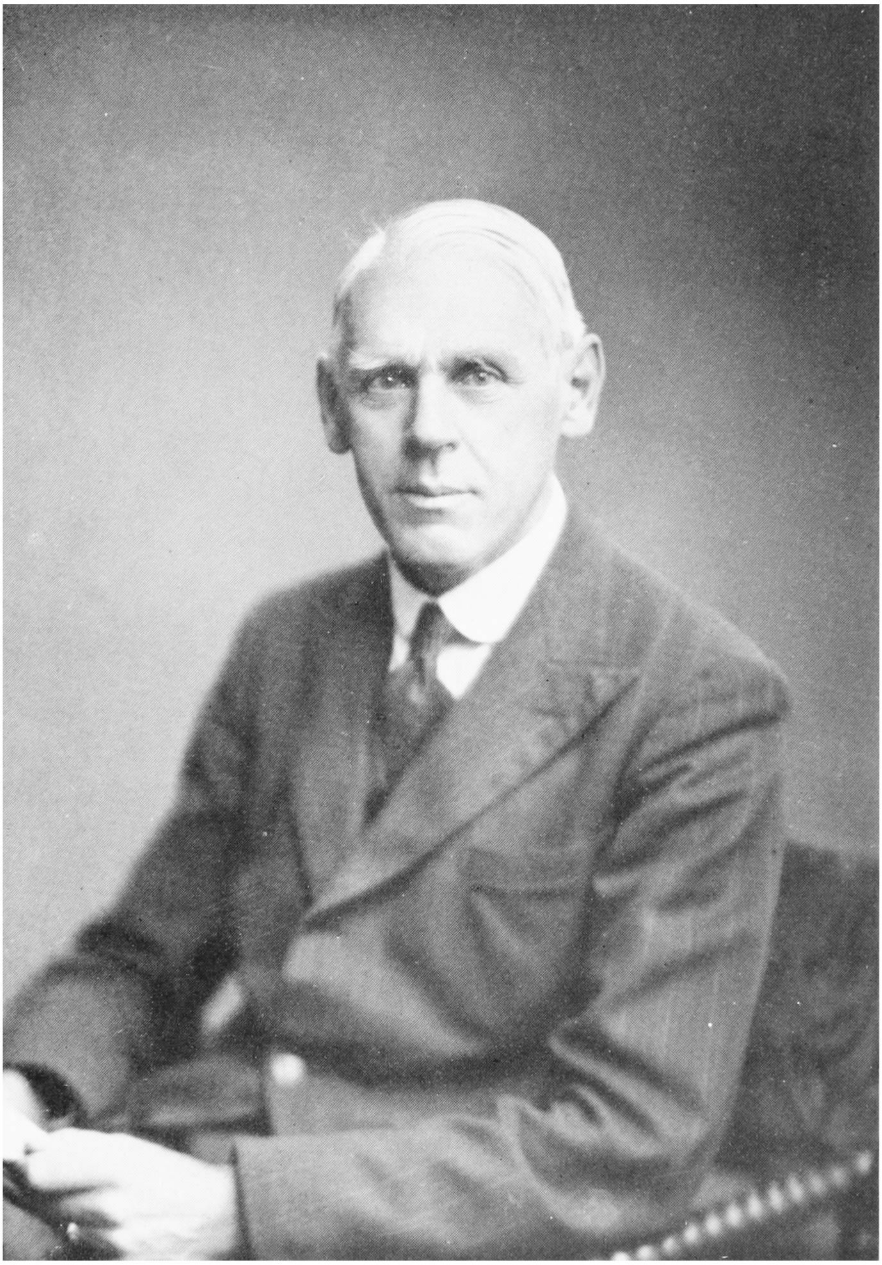
To face p. 289]



Reproduced by courtesy of Mr. Walter Stoneman

SIR NELSON K. JOHNSON, K.C.B., D.Sc., A.R.C.S.

M.O. 567 AIR MINISTRY

METEOROLOGICAL OFFICE

THE METEOROLOGICAL MAGAZINE

VOL. 82, No. 976, OCTOBER 1953

DIRECTOR OF THE METEOROLOGICAL OFFICE

The retirement of Sir Nelson Johnson on September 1, 1953, closed another chapter in the history of the Meteorological Office.

Sir Nelson will always be known nationally as the Director who guided the work of the Office through the Second World War and the period of reconstruction which followed, and as the prime mover in the foundation of the Meteorological Research Committee. Internationally, he will always be remembered as the last President of the International Meteorological Organization and the first President of the World Meteorological Organization.

Sir Nelson graduated with honours in physics from the Royal College of Science in 1913. He was subsequently engaged in astrophysical work at the College and at the Norman Lockyer Observatory, Sidmouth. During the First World War, 1914–18, he served as a pilot in the Royal Flying Corps.

He joined the Meteorological Office in 1919, and after serving at Shoeburyness was given, in 1921, the task of forming the new meteorological section at the War Office Chemical Defence Research Establishment at Porton. The investigation then instituted at Porton of the meteorology of the lower layers of the atmosphere gave full scope to his ability in experimental research and led to important advances in the knowledge of atmospheric diffusion. Sir Nelson devoted himself especially to the study of the vertical gradient of temperature; new methods using electrical resistance thermometers were devised for measuring the gradient and his work in this field, published in *Geophysical Memoirs* Nos. 46 and 77, has become classic. Other papers by him, or in which he collaborated, during this period dealt with the measurement of the lapse rate of temperature by an optical method, measurements of temperature near the surface in various kinds of soils, the vertical gradient of wind velocity in the lowest layers of the atmosphere, and atmospheric oscillations shown by the microbarograph. He left the Meteorological Office in 1928 for service under the War Office, first as Director of Experiments at Porton and later as the Chief Superintendent of the Chemical Research Department.

In September 1938 he returned to the Meteorological Office as Director in succession to Sir George Simpson. Almost immediately he was confronted by the precautionary measures necessitated by the Munich crisis.

The Second World War, 1939–45, brought many new problems and requirements, which increased as the scope and character of military operations changed, with a corresponding increase in the Director's responsibilities. The staff of the Office, including the R.A.F.V.R. Meteorological Branch, increased during the war from about 800 to over 6,000. New methods of observation and analysis were developed. Networks of stations were established for making upper air soundings and "sferics" observations and meteorological reconnaissance flights were introduced. Close contact was maintained with, and much assistance given to, Allied Meteorological Services. All these activities made great demands on the Director, who was rarely away from his office in London except for brief intervals, in those unquiet years. Visits were paid early in the war to the British Expeditionary Force in France, and in 1944 to Allied Commands in the Middle East, India and Ceylon.

Sir Nelson has been greatly concerned to secure provision for research within the Office. Preliminary plans made in 1938–39 were inevitably delayed by the events of the next few years, but in 1941 the Air Ministry Meteorological Research Committee was set up by the Secretary of State for Air. In the major re-organization of the Office in 1947–48 Divisions and Branches were established to carry out a comprehensive programme of research. Since then provision has also been made for dealing with the meteorological aspects of agricultural and hydrological problems. In the post-war years Sir Nelson maintained developments in the methods and use of upper air observations and he encouraged and assisted the expansion of these observations in Commonwealth countries. He reviewed and developed the practice, initiated by Sir Napier Shaw, of monthly gatherings of the staff for the purpose of discussing research carried out in this and other countries. He was intimately associated with the introduction of the ocean-weather-ship scheme in 1947.

In 1946 at the first post-war International Conference he was elected President of the International Meteorological Committee. In that capacity he presided over the Washington Conference in 1947, which established the Convention of the World Meteorological Organization. In 1951 he became, for the period of its opening Congress, President of the new Organization.

Great progress in the organization of British and international meteorology has been made under Sir Nelson's guidance and his services were recognized by his appointment as K.C.B. in 1943.

All who have served under him will wish him good health for many years in which to pursue his varied interests, in which carpentry and the collection and renovation of antique clocks, play, we believe, a large part.

At a crowded ceremony in Victory House on August 28, Mr. J. Durward presented Sir Nelson, on behalf of the staff of the Office, with a cheque for a television set. In conveying to Sir Nelson the good wishes of the staff, Mr. Durward referred to the highlights of Sir Nelson's career and mentioned in particular the skill with which Sir Nelson had conducted meteorological affairs in the international, national and domestic field, his achievement in putting meteorological research within the Office on a sound basis and his consideration for the staff.

The remarks of Mr. Durward were supplemented by Mr. E. Gold who, before his retirement in 1947, had been Sir Nelson's deputy. Mr. Gold gave some touching recollections of his service with Sir Nelson, and mentioned the happy combination of scientific comprehension and administrative ability which Sir Nelson had displayed, and he quoted instances of Sir Nelson's flair for taking the right course with clear reasons for so doing. Both Mr. Gold and Mr. Durward voiced the wishes of the staff of the Office in expressing the hope that Sir Nelson would be able to catch up with the leisure which had been denied him for so many years.

After valedictory messages from staff overseas had been read out, Sir Nelson expressed his gratitude to those who had joined in the presentation and paid tribute to the loyal support which he had received from the staff. He referred especially to the cordial relations between the Meteorological Office and other Government Departments and stressed his appreciation of the friendly co-operation which he had received from colleagues both in the academic world and in other meteorological services.

COLD POOLS: A STATISTICAL AND SYNOPTIC STUDY

By E. J. SUMNER, B.A.

The cold pool is one of the more common synoptic models which have come to be recognized since the introduction of upper air charts into forecasting practice. There is already a considerable amount of literature on the subject, most of it however being concerned with studies of the life history and detailed structure of individual pools. Little work of a statistical and synoptic nature appears to have been done, at least in recent years (before which the observational coverage was scarcely adequate), and the present study was undertaken in order to fill in some of the gaps.

A cold pool may be defined as a mass of cold air in depth entirely surrounded by relatively warm air, and appears as one or more closed lines in the thickness isopleths for any fairly deep atmospheric layer. The area within the outermost of these closed lines may for present convenience be identified with the cold pool. A similar definition to the above was given by Douglas[1]. Various related terms are in use in the literature; these include cold domes, cold poles, cold drops (Kaltluftropfen), cold lows, cold highs and cold "cut-offs". A cold pool, in the sense used here, may occur with any of these phenomena.

Data and measurements.—The charts used in this study were the 0300 and 1500 G.M.T. circumpolar 1000–500-mb. thickness maps, prepared daily in the Forecasting Research Division of the Meteorological Office. The data are for the 5-yr. period from September 1946 to August 1951, and for the area between longitude 60°W. to 30°E. and south of latitude 80°N. These limits were chosen so as to exclude the semi-permanent winter cold pools over the Asian and American continents, and to confine the investigation to those features which might be of direct concern to the British Isles and its environs.

Thickness lines on the circumpolar charts are drawn at intervals of 200 ft. (the even hundreds). Only well defined and fairly persistent pools were considered, the minimum requirements being that there should be two or more closed thickness lines surrounding the pool which should appear on at least two successive 0300 G.M.T. charts, the closed lines lying entirely within the area delineated above. However, within a particular spell one-day interruptions during which the pool was represented by a single closed line at 0300 were included (5 cases in all), thus allowing for a period of temporary waning.

The central position of each pool was recorded to the nearest degree of latitude and longitude, and also the interpolated value of the 1000–500-mb.

thickness at the centre to the nearest 50 ft. The "centre" was taken as the approximate centre of gravity of the area of the pool (no matter how irregular in shape) and was estimated by eye. The intensity of the pool was also recorded on the scale: one closed thickness line, intensity one; two closed lines, intensity two; . . . and so on.

Some general statistics.—Within the 5-yr. period under consideration the total number of spells was 75, ranging from 2 to 10 days' duration, the average being almost exactly 3 days*. The total number of individual pools involved (i.e. occurrences on 0300 charts) was 224. There were 171 pools of intensity two, 41 of intensity three, 5 of intensity four and 2 of intensity five; all those of intensity greater than three were north of 65°N. There was no relationship between the initial intensity and the subsequent duration of a spell, although there was a small positive correlation between the duration and the average intensity within a spell.

With respect to the geographical and seasonal distribution of cold pools the greatest concentration was over Europe in all seasons, but in spring and summer there were several other clusters, more notably over the Atlantic and in the area between north-east Greenland and north Scandinavia. There was an almost complete absence of pools of intensity two or more just west of the British Isles, around and to the east of Iceland, and over the western Atlantic south of 50°N. (summer and autumn only); though actually a very small number of pools of intensity two did occur in these areas but did not last beyond a day.

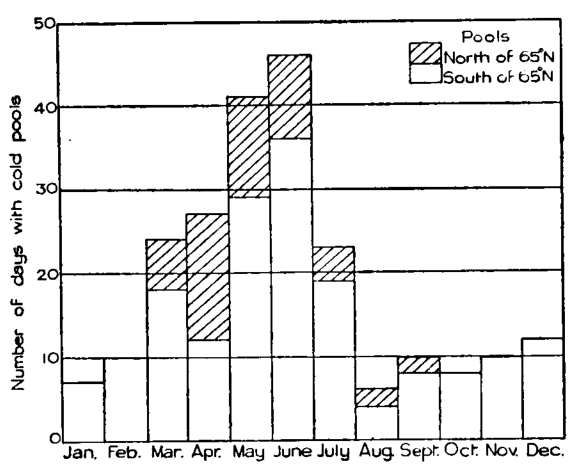


FIG. 1—FREQUENCY DISTRIBUTION OF INTENSE COLD POOLS
5-yr. period September 1946–August 1951

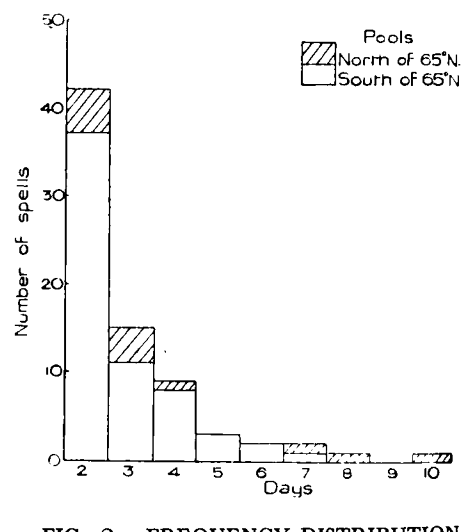


FIG. 2—FREQUENCY DISTRIBUTION OF SPELLS

These gaps possibly arise in part from the shelter provided by the (warm) American continent in summer and the Greenland ice-cap at all seasons. However, the preference of blocking (usually warm) highs for the north-eastern Atlantic in May and June, when the pools are most frequent (see Fig. 1), is also associated with the general paucity of pools in the Iceland region.

* A spell is said to be of *n* days' duration if the same cold pool, beginning and ending with intensity two or more but possibly with one-day interruptions of intensity one, appeared on *n* successive 0300 charts.

Most of the pools were fairly slow moving (usually less than 500 miles a day), and any rapid displacements were seldom continued beyond a day. In particular the pools in high latitudes showed no tendency to come southwards beyond 65°N.; these latter are presumably the cold "poles" of the northern hemisphere, and in what follows they were conveniently separated from the others and later left out of account.

Fig. 1 shows the frequency distribution of pools by months (5 Januaries, 5 Februaries, etc.), pools north and south of 65°N. being distinguished. Table I gives the number of spells by months. It is evident that, within the area considered, these intense cold pools are largely spring and early summer phenomena, an outstanding maximum occurring in May and June.

TABLE I—NUMBER OF SPELLS

	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	Total
South of 65°N.	3	2	7	5	12	14	6	2	3	3	2	3	62
North of 65°N.	0	0	2	2	4	1	2	1	1	0	0	0	13

The frequency of spells in days is given in Fig. 2. A persistence of two days, the minimum required by our definition, is very much more likely than any longer spell. This applies to all seasons. The average spells north and south of 65°N. were 3·9 days and 2·8 days respectively. North of 65°N. there were 51 pools (13 spells) in all, the corresponding figures south of this parallel being 173 pools (62 spells).

Pools south of 65°N.—In the following pages only those pools south of 65°N. will be considered, partly for the reason given previously and also because the more detailed study of weather, cloud, etc., attempted here is not possible in higher latitudes owing to insufficiency of observations.

Mode of formation and disappearance.—The greatest number of pools starting a spell—49 out of 62—were formed as a result of a partial or complete cutting-off of the cold air near the southernmost extremity of a cold trough. The cold trough was usually fairly slow moving and of large amplitude at the time of cutting-off or was increasing in amplitude, the low-latitude part slowing down still further or stagnating while the high-latitude part moved on. A good example of this cut-off process is given in Figs. 3, 4 and 5. In this example there was marked anticyclonic building across the middle of the trough (blocking) with a cyclone maintained to the south in association with the developing pool. A certain amount of warm advection from the west round the top of the anticyclone completed the cutting-off*. There are, however, many variants of this basic model mainly depending on the degree of development of these surface features. In 8 of the 49 cases the depression predominated, and warm advection from the east round the northern flank of the low seemed to be responsible for cutting off the pool; on 19 occasions the low was vestigial and marked anticyclonic building and presumably subsidence across the neck of the trough appeared to be the main agency; in a further 8 cases both these effects seemed to be important. In 2 cases the cold pool actually formed "over" the surface high

* In connexion with blocking and the seasonal distribution of cold pools, the indirect agreement with the results of Brezowsky, Flohn and Hess[2] is striking. These authors found a pronounced maximum of blocking highs, with axes in the sector 20°W.–10°E., to occur in May and June (70 years' data).

but was then quickly transferred—almost "jumped"—south to come more in association with the low. The remaining 14 cases were due to a more subtle combination of advectional and dynamical thermal processes (including local cooling at the centre of the pool and warm-air advection from the west round a depression in high latitudes) operating in different parts of the field. It is not suggested that the above remarks adequately represent what goes on, or that such thermodynamical processes are primarily responsible for this type of development.

Of the remaining 13 pools, 6 moved into the area from outside, 5 of them into the western Atlantic from the north-west, one from the east into the Baltic, and 7 were formed in association with a surface low in rather higher latitudes than usual (55–60°N.), partly by a vague sort of cutting-off but with a certain amount of cooling *in situ* as an important contribution. However, these cold lows were not associated with a "blocking" of the westerlies, whereas the "cut-off" pools almost invariably were.

The greatest number of pools (33 out of the 62) disappeared, or were reduced in intensity and therefore no longer considered, by warming more or less *in situ*. In 9 further cases the pool moved so as to be absorbed into the colder air of higher latitudes, 2 were re-absorbed into the original cold trough by renewed advection from the north, and another 2 seemed to be re-absorbed in this way

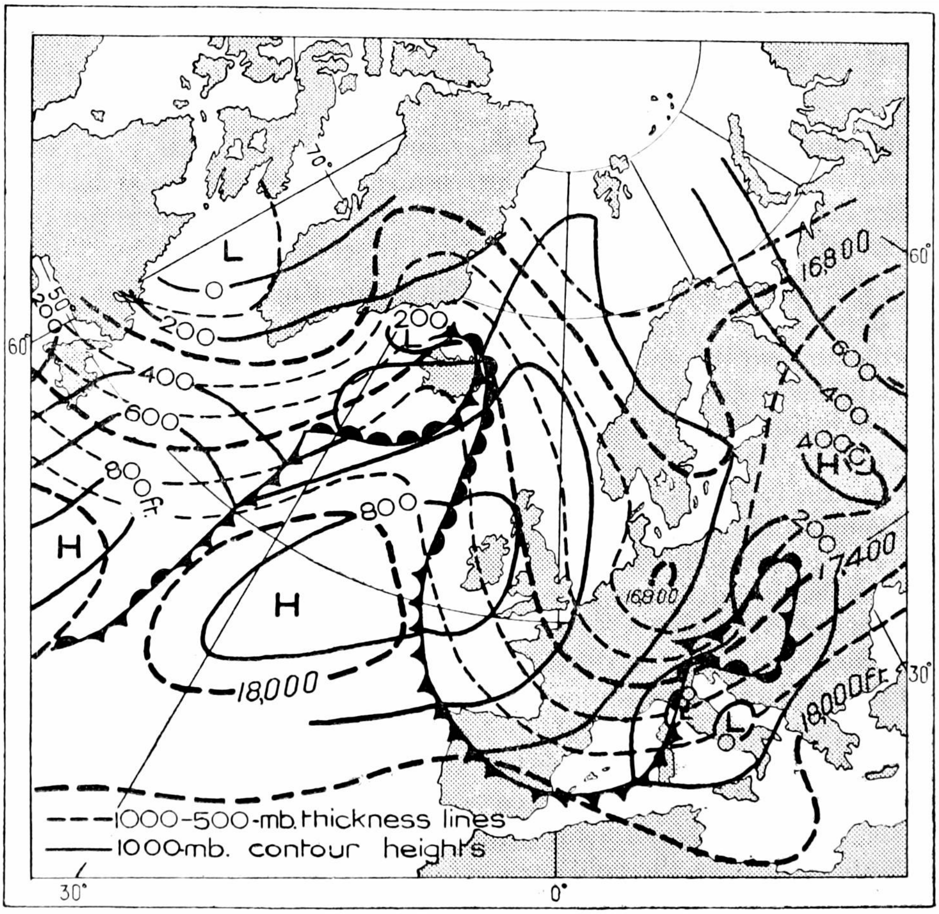


FIG. 3—1000-MB. CONTOUR PATTERN AND 1000–500-MB. THICKNESS LINES, 0300 G.M.T., MARCH 19, 1949

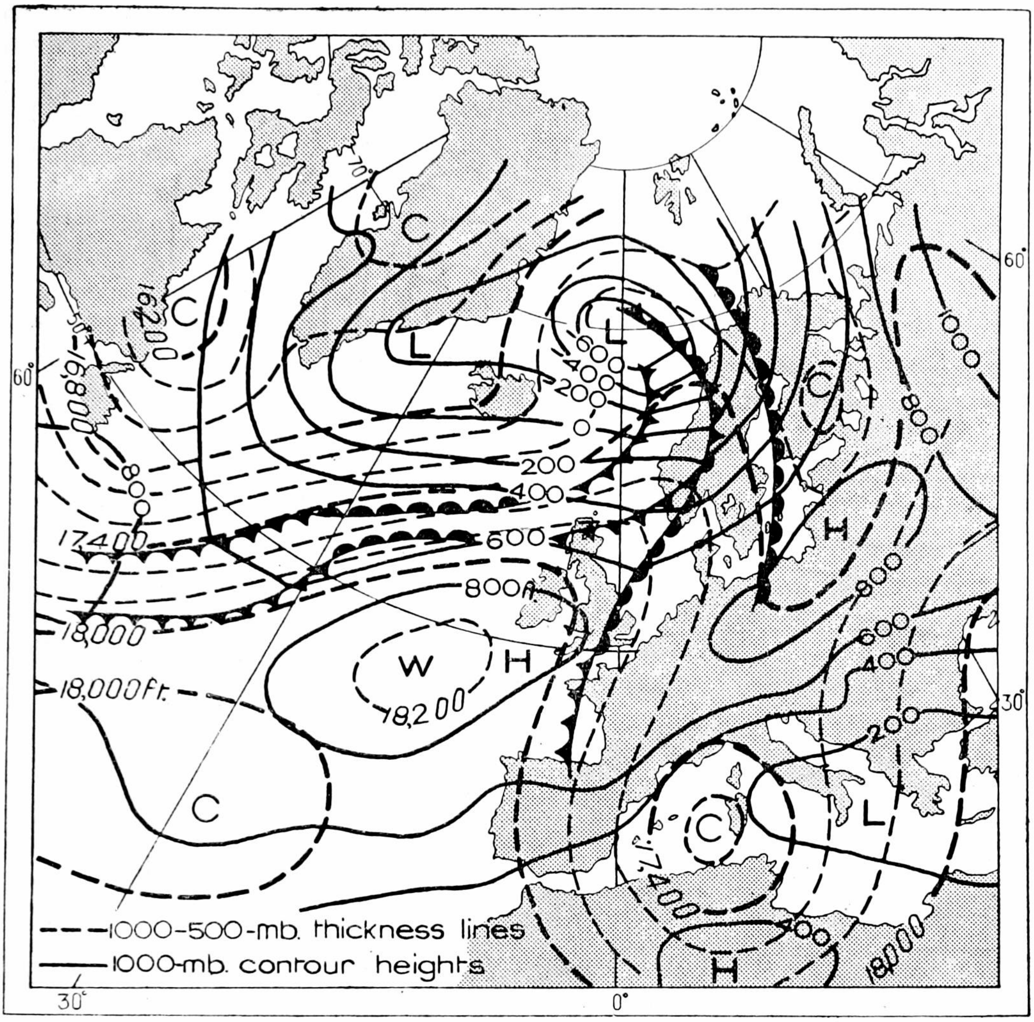


FIG. 4—1000-MB. CONTOUR PATTERN AND 1000–500-MB. THICKNESS LINES, 1500 G.M.T., MARCH 20, 1949

by local cooling to the north of the pool. The remaining 16 disappeared as a result of a combination of these factors, warming of the central core being one important agency in most of them. In all these classes about half the pools remained at intensity one for a further day or more before finally disappearing from the charts.

Surface-pressure systems associated with cold pools.—It is evident from experience that cold pools may be associated with practically any synoptically possible surface-pressure field. It is however convenient to classify associated surface patterns in terms of a few well known types as follows: a low (L), a trough (T), a high (H), a ridge (R), a slack area or col (C)*, and a fairly straight run of isobars more or less midway between a large high and a large low (S). Three of these types are usually called the cold low (L type), the cold high (H type) and the cold drop (S type) respectively, but the terms cold trough or cold ridge are not used in this context. The results of this classification on a seasonal and "land-sea" basis are shown in Table II.

* Actually only one instance of a col was recorded, the rest were cases of a very weak and irregular pressure field.

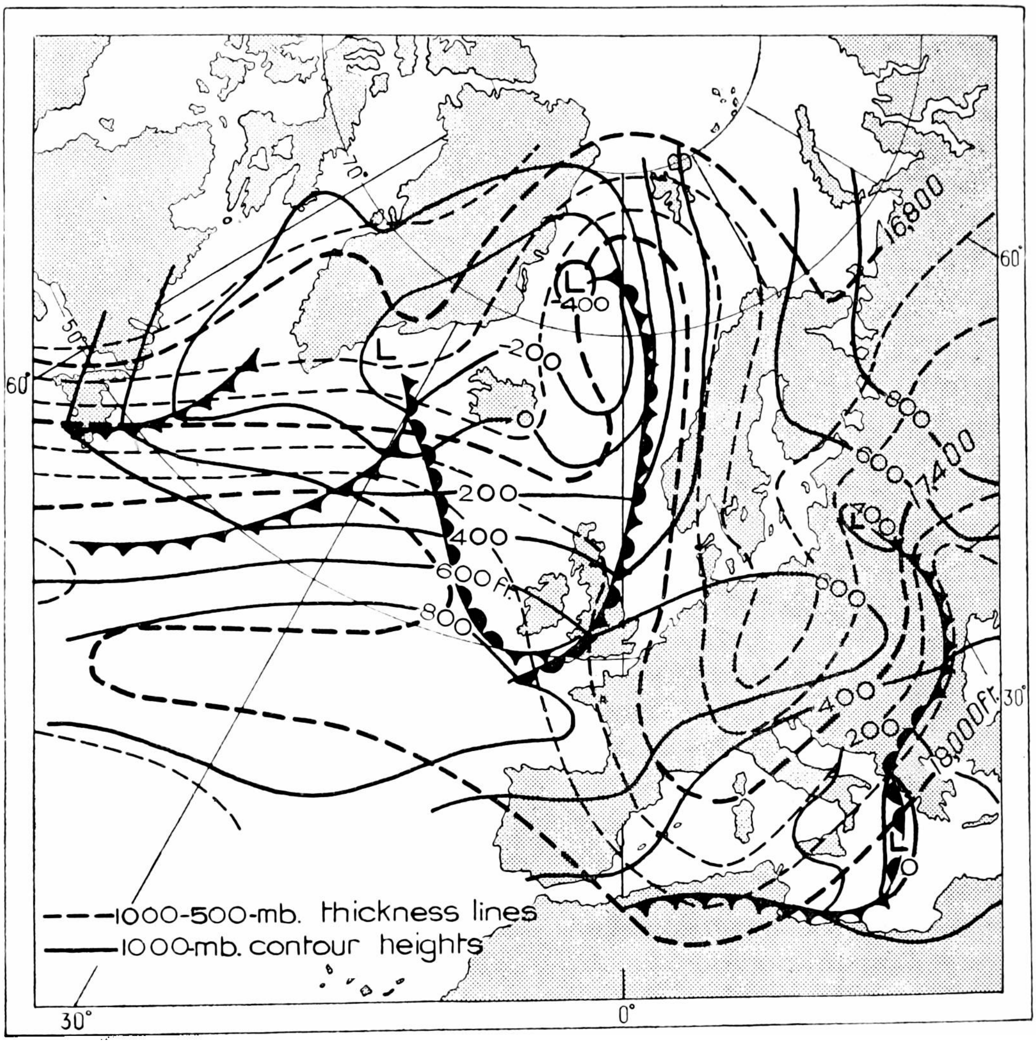


FIG. 5—1000-MB. CONTOUR PATTERN AND 1000–500-MB. THICKNESS LINES, 0300 G.M.T., MARCH 22, 1949

TABLE II—CLASSIFICATION OF SURFACE-PRESSURE PATTERNS ASSOCIATED WITH COLD POOLS

Associated surface-pressure system	Winter Dec.–Feb. Land	Winter Dec.–Feb. Sea	Spring Mar.–May Land	Spring Mar.–May Sea	Summer June–Aug. Land	Summer June–Aug. Sea	Winter Sept.–Nov. Land	Winter Sept.–Nov. Sea	Year Land	Year Sea	Year Both
L	9	2	7	23	4	18	7	1	27	44	71
T	0	2	3	4	7	6	1	1	11	13	24
H	1	1	0	0	1	0	3	2	5	3	8
R	3	0	1	0	5	0	3	1	12	1	13
C	4	2	3	2	5	4	2	1	14	10	24
S	5	2	11	4	3	6	2	0	21	12	33
Total	22	9	25	33	25	34	18	6	90	83	173

By far the greatest number of cold pools were associated with surface lows at all seasons, the second greatest being cold drops. Associated troughs and slack areas were next in almost equal proportions, ridges and anticyclones being in a minority. Lows and troughs were relatively more frequent over the sea, and all other types (highs and ridges especially) over land. Except in the case of highs and ridges, the seasonal distribution for each class was in keeping with Fig. 1, i.e. with a maximum in spring and summer. In winter and autumn cold pools are more frequent over the land than over the sea, and *vice versa* in spring and summer.

Within about half the spells, there was no great change of surface type from beginning to end. The remaining half showed day-to-day type changes, usually within the combinations L-T-S and R-H-C, respectively. Extreme changes from an associated high or ridge to a low or trough, or *vice versa*, were very infrequent. When they did occur pressure gradients were usually slack (border-line C type) with a high general level of pressure; in such circumstances comparatively small pressure changes would suffice to produce definite ridges and troughs (or even weak lows) on alternate days.

There was a definite tendency for the straight isobars of the S type to become more cyclonically curved with time, with a change to a T or even an L type; in fact, over the sea, there were no pure S types—all changed, mostly to L or T types.

Most of the associated lows were 300 miles or less from the cold pools, although few of them (especially over the land) were quite concentric with the pool. The average distance between the centre of the pool and that of the surface low was about 300 miles over the land and 220 miles over the sea. All lows more than 300 miles away were situated in the sector between south-east and north-east from the associated pools; the remainder were randomly distributed in direction with respect of the centre of the pool. The corresponding averages for the few cold anticyclones were 340 miles over the land and 700 miles over the sea.

The surface pressure was read off, to the nearest millibar, at the centre of each pool and at the centre of an associated high or low, if any. Corresponding pressure anomalies (departures from a 40-yr. normal) were also computed. The average pressure and pressure anomaly at the centre of the pool were 1013·3 mb. and −1·8 mb. respectively. The corresponding averages for the individual types (anomalies in brackets) were:—

L	1007·0 mb. (−8·0)	S	1017·5 mb. (+2·0)
T	1013·5 mb. (+0·5)	R	1021·0 mb. (+2·5)
C	1017·5 mb. (+1·5)	H	1028·5 mb. (+12·0)

For the cold lows the average pressure was 6·5 mb. less over the sea than over the land; in the remaining types there was little significant difference. The average pressure and pressure anomaly at the centre of the associated low were 1001·5 mb. and −13·0 mb. respectively; the average pressure was 5·0 mb. less on the sea than over the land. The corresponding figures for cold highs were 1034·5 mb. and +19·5 mb., average pressures being 3·0 mb. higher over the sea than the land.

It is evident from the above that cyclonic circulations tend to be more intense and (from Table II) relatively more frequent over the sea. A few cases are on record where a cold pool associated with more or less straight surface isobars or with a weak surface low, moved from the land to the relatively warm sea in winter. In each case there was a noticeable increase in the associated cyclonic circulation at the surface (with the formation of a low if one were not present originally), although with a pressure drop of only a few millibars in the general level of pressure.

For pools over the sea, the mean surface pressure at the centre of the pool was about 8 mb. less in spring and summer than in autumn and winter, and the pressure anomalies changed from positive in the latter to negative in the former seasons. Over the land there was no corresponding variation in the mean pressure anomalies. There was practically no latitudinal variation of mean surface-pressure anomaly at the centres of the pools, either over the land or over the sea. This was also the case for the mean surface-pressure anomaly at the centres of the associated lows; there were not enough data on cold highs to decide one way or the other.

The lowest central pressure of an associated low was 976 mb. and the highest 1022 mb., but nearly 90 per cent. of the cases were within 10 mb. of the average, namely 1001·5 mb. The corresponding extremes for associated highs were 1025 and 1040 mb. respectively (average 1034·5 mb.). A comparison with the 40-yr. statistics of the frequency of occurrence of all lows and highs in particular localities, revealed that the cold lows were usually shallow for the area in question whereas the cold highs were well up to their usual intensity.

Surface-pressure changes at the centres of the pools were usually small; the overwhelming majority were less than 10 mb. (rise or fall) a day, the average, irrespective of sign, being 4·5 mb./day (5·5 mb./day over the sea and 3·5 mb./day over the land). The greatest pressure rise found was 16 mb. in 24 hr. (with an associated surface low) and the greatest fall was 23 mb. (cold-drop type); both were over the sea. There was a definite tendency at all seasons, no matter what the associated pressure system, for the pressure at the centre of the pool to return to normal; this was however less marked for pools over the sea.

The pressure changes at the centre of an associated low or high were even smaller, most of them being less than or equal to 5 mb./day. The greatest 24-hr. rise was 11 mb. (over the land) and the greatest fall, 9 mb. (over the sea); both were in a low. The average changes irrespective of sign were 4·5 mb./day, whether over land or sea. There was no noticeable tendency for these central pressures to return to normal. However for depressions, whatever the initial anomaly, the chances were slightly in favour of a rise rather than a fall of central pressure, although day-to-day changes were very erratic both in sign and magnitude.

Weather associated with cold pools.—The amount of cloud and the type of precipitation within the area of the cold pool (not that associated with the surface-pressure system) were recorded for 0300 and 1500 G.M.T.* The cloud amount was classified as b if the weather were predominantly fine ($<\frac{1}{4}$ cover of cloud) over the entire area, bc if it were partly cloudy (between $\frac{1}{4}$ and $\frac{3}{4}$ cover), c if it were mainly cloudy ($>\frac{3}{4}$ cover) and o for completely overcast. A note was also made of the type of precipitation (rain, hail, snow or sleet), if any, and whether it was reported predominantly as showers, intermittent or continuous precipitation, and its intensity (light, moderate or heavy). The occurrence of thunderstorms was also noted.

More than half the pools were classified as cloudy, about a quarter as partly cloudy, while there were relatively few cases of overcast or fine (each just under

* Since the coverage of "surface" observations is usually better at the main synoptic hours, the weather at 0300 was based on a general impression of the 0000, 0300 and 0600 G.M.T. charts; and that at 1500 on the 1200, 1500 and 1800 G.M.T. charts.

10 per cent. of the total). Pools of the L type usually had the largest cloud amounts, and the S and C types the smallest. There was a definite diurnal variation of cloudiness in pools situated over the land, the proportion of occasions classified as o and c increasing from 55 per cent. at 0300 to 70 per cent. at 1500 G.M.T. However, within this general trend from lower to higher cloudiness there was an appreciable counter-drift, since about 15 per cent. (of the total) changed from o or c at 0300 to bc or b by 1500 G.M.T. This diurnal rhythm was present irrespective of the type of associated surface-pressure system. There was, on the other hand, no discernible diurnal variation in the cloud over the sea, but this is more uncertain owing to the scantier observation coverage.

On the whole there were slightly more cases with than without precipitation of some sort. Within the above cloud groupings the proportion with precipitation increased from nil with fine conditions to 100 per cent. with completely overcast, the figures for partly cloudy and cloudy being about 45 and 55 per cent. respectively. The L type had the highest proportion with precipitation (nearly 70 per cent.), the S and C types the lowest (about 40 per cent.). The H and R types showed a surprisingly high proportion with precipitation. This was however invariably slight snow or sleet in the case of highs; but with ridges in association all forms and intensities of precipitation occurred, including one case of widespread moderate rain and another with thunderstorms. General precipitation over the entire area of the pool was recorded on about 20 per cent. of the total occasions, 30 per cent. had only local precipitation and the remainder none at all.

Of the 62 spells, 6 were predominantly dry throughout with variable cloud (average duration 2·1 days), 13 were predominantly cloudy or overcast with fairly general precipitation most days (average duration 3·2 days; this figure is heavily weighted however by 1 eight-day spell), the remainder (average duration 3·0 days) being mainly fair to cloudy with intermittent and/or local precipitation, often infrequent.

Only 6 cases of thunderstorms were noted; on the other hand there were very many more occasions of "sferics" reported within the area of the pool, mostly occurring in the warmer months over Europe. These showed a definite diurnal variation with the greater frequency in the afternoon. The positioning error in "sferic" observations is, however, such that they might often have referred to thunderstorms in the peripheral regions of the pools. Although it is possible that some storms escaped observation, their reported infrequency within cold pools is probably real. The paucity of thunderstorms in the central regions of cold lows has been remarked on by E. A. Amman[3].

There was a fairly clear-cut division in the value of the central thickness of the pool as between rain and snow. For showery precipitation, all cases of snow had a central thickness of 17,150 ft. or below, and all cases of rain had a value above 16,900 ft. For precipitation other than showers (including intermittent as well as continuous precipitation) there was a fairly distinct separation at 17,200 ft.; there were no instances of rain below this value and only 3 cases of snow (out of 47) with a higher value, none of them occurring with a thickness above 17,350 ft. There were only 6 cases of sleet (2 showers, 4 otherwise) and these had a central thickness between 16,950 and 17,200 ft. The intensity of the precipitation did not affect these criteria perceptibly.

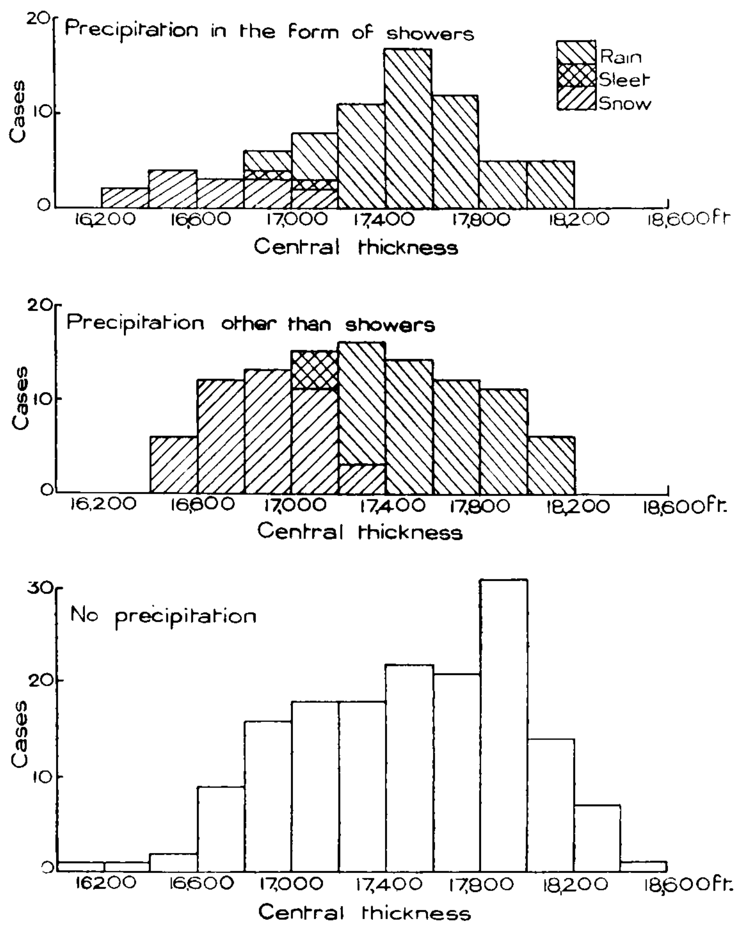


FIG. 6—FREQUENCY DISTRIBUTION OF 1000–500-MB. THICKNESS AT THE CENTRES OF COLD POOLS

Fig. 6 shows the frequency distribution of central thickness, rain, snow and sleet being distinguished. Both the 0300 and 1500 G.M.T. observations are taken into account in these diagrams, and in the values given in the above paragraph; the implication is that if the thickness changed across any of the above limits between these times, the nature of the precipitation would also change.

1000–500-mb. thickness values at the centres of cold pools.—The average central thickness showed a marked seasonal variation with a maximum in summer, and, except for summer, was significantly less over the land than the sea; all these differences are in the sense one would expect. The land-sea difference also showed up in most of the different types of cold pool.

The average thickness anomaly (departure from the 5-yr. mean) for all cases was −540 ft., −480 ft. for pools over the sea and −590 ft. for those over the land; the numerical value of the anomaly was on the whole smallest in the summer. The greatest and least anomalies for all the data were −1,150 ft. and −150 ft. respectively, but such extreme values were very infrequent; every pool had a central thickness below the 5-yr. mean for the time and place, and for as long as it maintained the requisite intensity. There was no relationship between the initial anomaly and the subsequent duration of a spell. Nor was there any between 24-hr. thickness and surface-pressure changes at the centres of the pools.

There was a marked and smooth latitudinal variation of mean thickness anomaly. The data were segregated in 5° latitude bands from 30° to 65°N., and the greatest departure from normal (−660 ft.) occurred in middle latitudes (46–50°N.) falling fairly uniformly to minima on either side (anomaly about −375 ft. in both cases). This sort of distribution was in evidence both over land and sea.

In general, anomalies less than about −450 ft. were followed by rising central thickness and the (numerically) smaller anomalies by falling thickness. Since the changes which occur at the centre of the pool are being followed, thermal advection may be neglected, and the implication is that warming from below and dynamical and radiational processes (presumably a net cooling) tend to balance out about this value of the thickness anomaly. This rough "point of balance" seemed to be independent of the presence of cloud or precipitation, or whether the pools were situated over the land or the sea.

There was a definite diurnal variation of central thickness with the higher values in the afternoon, both over land and sea, the average amplitude being about +75 ft. and +60 ft. a day respectively. These values were based on the average difference of 1000–500-mb. thickness between the 1500 and 0300 values, with the mean "trend" (amounting to about +40 ft./day over the land, and +35 ft./day over the sea) eliminated. The diurnal variation in the winter months was only 50 ft. over land, but 100 ft. over the sea; however there were only 9 cases of the latter, and the increase as compared with the corresponding figure for all the data is scarcely significant. A selection of pools with broken cloud (b or bc) at one or both of the 0300 and 1500 observations and with no precipitation at either, showed very similar values for the diurnal variation as for all the data. From an inspection of the data there was no reason to suppose that any other selection would give very different results.

It may be assumed that the diurnal variation is mainly due to the interaction between the two factors: (*a*) the net long-wave radiational heat loss from the cloud and the air itself, going on night and day without much change; and (*b*) eddy fluxes of heat into the column and the absorption of short-wave radiation by water vapour and clouds, both associated with insolation and therefore have a diurnal variation with a maximum in the afternoon (this would be most marked in the warmer months when most of the cases occurred). With this oversimplified picture, then on the assumption that (*b*) operates for half the day (or more) and that the above values represent the total range, the radiational loss from the 1000–500-mb. layer, factor (*a*), works out as roughly 2°C./day (or less) over land, and somewhat lower over the sea. This is in keeping with other estimates currently accepted.

REFERENCES

1. DOUGLAS, C. K. M.; Cold pools. *Met. Mag., London,* **76,** 1947, p. 225.
2. BREZOWSKY, H., FLOHN, H. and HESS, P.; Some remarks on the climatology of blocking action. *Tellus, Stockholm,* **3,** 1951, p. 191.
3. AMMAN, E. A.; A discussion of the cold low. Washington D.C., 2nd edn, 1950.

RECURRENCE TENDENCIES IN KEW SURFACE PRESSURE

By R. P. WALDO LEWIS, M.Sc. and D. H. McINTOSH, M.A., B.Sc.

Introduction.—It has been variously suggested that the time interval separating peaks (or troughs) in a series of daily pressure values for European locations is not entirely random, but that specified intervals appear more frequently than can be accounted for by chance. Thus, for instance, pressure "waves" of period 72 days and its submultiples have been recognized and associated with the "singularities" studied mainly by German meteorologists. Recently Essenwanger[1] has found, in winter months only, a significant "wave" of period about 30 days, with maximum amplitude in the North Sea. These pressure "waves" have generally been found by the methods of harmonic analysis and autocorrelation. Here the problem is examined, in so far as it affects Kew, in another way.

Method.—The method is an adaptation of that used by Chree and Stagg[2] to demonstrate the occurrence of what may, by analogy, be termed geomagnetic disturbance "waves" of period length 27 days, corresponding to the period of rotation of the sun. Two days of clearly defined midday pressure maximum at Kew were selected in each month in the period 1926–50. Independence was secured by ensuring that no two maxima in the whole pressure series were nearer than 7 days. The mean values of midday pressure were then determined on a large number of days round the 600 selected pressure-peak days. Mean midday pressure values were also determined round 600 pressure-trough days selected in a similar way. These mean values were calculated at intervals of 3 days, from days -6 to $+6$ (referred to the selected "0" day) then at day intervals to day $+38$; also at day intervals from $+46$ to $+50$, and from $+70$ to $+74$. Those intervals to which "wave" significance had mainly been attributed were thus included.

Results.—The variations of average pressure, referred to the two types of selected day, are shown in the accompanying graph in which the standard

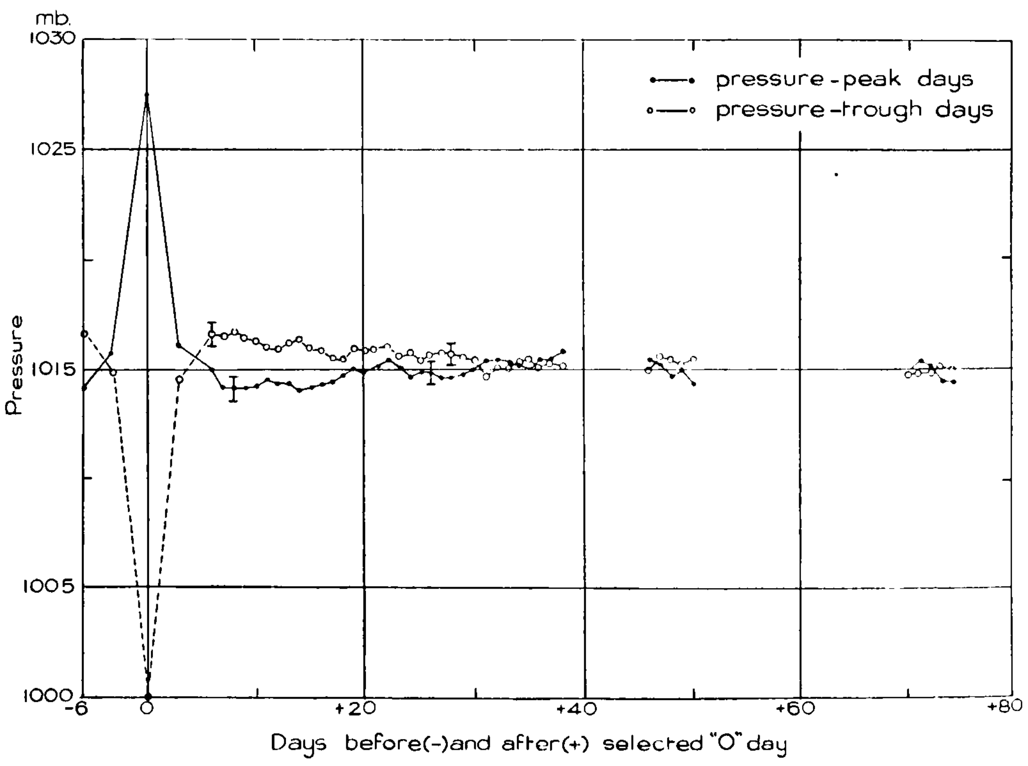


FIG. I—MEAN VARIATION OF KEW MIDDAY SURFACE PRESSURE AROUND 600 PRESSURE-PEAK DAYS AND 600 PRESSURE-TROUGH DAYS, 1926–50 errors of the means are indicated by vertical lines at intervals. The method of investigation implies that the levels of pressure following the chosen maximum and minimum days are, for a period after the "coherent" interval of about 5 days, respectively below and above the long-period average. Inspection of the graph indicates that this "compensation" effect is complete by about day +30. In the assessment of the results in terms of possible pressure "waves" allowance must be made for this effect of a slow recovery to the long-period mean. This allowance is made in Table I by expressing the means on those days up to +30 as departures from appropriate running mean values; for days +31 and upwards the departures from a value approximating closely to the long-period mean are considered.

Table I shows, in numerical form, the results subdivided according to the occurrence of the selected days in "winter" (October–March) and "summer" (April–September). The pressure means are here expressed (i) on days +12 to +30, as departures from the corresponding running mean value of 11 consecutive days, e.g. the value for day +12 is the departure from the mean value of the 11 days +7 to +17; and (ii) on day +31 and upwards, as departures from the seasonal mean value of all such days. The standard error of the means forming the departures is given for ready consideration of the significance of the results. The figures are given only for alternate days.

TABLE I—DEPARTURES FROM APPROPRIATE MEANS OF AVERAGE KEW PRESSURE, FOLLOWING SELECTED DAYS OF HIGH AND LOW PRESSURE

Type of "o" day	Season	Approximate standard error of mean	Days following "o" day: 12	14	16	18	20	22	24	26	28	30
			millibars									
High	Winter	0·7	+0·2	−0·4	−0·1	+0·4	0	+0·6	−0·9	−0·3	+0·2	+0·6
	Summer	0·5	0	−0·1	−0·4	−0·4	+0·2	+0·4	+0·3	+0·2	−0·9	−0·7
	Year	0·4	+0·1	−0·3	−0·2	0	+0·1	+0·5	−0·2	−0·1	−0·3	0
Low	Winter	0·7	−0·7	+0·4	−0·1	−0·7	−0·4	+0·5	+0·3	0	+0·1	0
	Summer	0·5	−0·1	+0·1	−0·3	−0·3	+0·5	+0·1	−0·3	0	+0·3	0
	Year	0·4	−0·3	+0·4	−0·1	−0·4	+0·1	+0·3	0	+0·1	+0·7	0

Type of "o" day	Season	Approximate standard error of mean	Days following "o" day: 32	34	36	38	46	48	50	70	72	74
			millibars									
High	Winter	0·7	−0·2	−0·5	+0·1	+0·7	+0·1	+0·1	−0·4	+0·3	+0·5	−0·2
	Summer	0·5	+0·5	+0·9	+0·5	+0·6	+0·4	−0·9	−1·2	−0·6	−0·4	−0·9
	Year	0·4	+0·2	+0·2	+0·4	+0·7	+0·3	−0·4	−0·7	−0·1	+0·1	−0·5
Low	Winter	0·7	0	+0·4	−0·2	−0·2	−0·2	+0·2	+0·5	−0·4	−0·5	+0·3
	Summer	0·5	−0·1	0	+0·1	0	0	+0·7	+0·2	−0·2	−0·1	−0·7
	Year	0·4	0	+0·2	0	0	−0·1	+0·5	+0·4	−0·3	−0·2	−0·3

Conclusion.—The method of investigation adopted here is one that should reveal any intermittent pressure influence of changing phase—an influence, in fact, of such a nature as has usually been attributed to pressure "waves". A tendency for pressure recurrences after *n* days would, for instance, be revealed by a peak centred at this point on the curve on which the "o" day is a maximum; or by a trough centred at day +*n* on the minimum "o" day curve. No such effects appear on the graph, and inspection of the numerical results shows that the pressure departures from appropriate means are no larger than can readily be accounted for by the range of day-to-day pressure variation. This result is interpreted as showing that there is no reason to believe that there is, at Kew, anything of the nature of pressure "waves" of any specified length within the limits which have been considered here. This conclusion applies to "winter" and "summer" separately; a further subdivision of the data for varying sun-spot epochs also gave a negative result.

REFERENCES

1. ESSENWANGER, O.; Beiträge zur Statistik mittellanger Luftdruckwellen in Mitteleuropa. *Ber. dtsch. Wetterdienstes, U.S. Zone, Bad Kissingen*, Nr. 20, 1951.
2. CHREE, C. and STAGG, J. M.; Recurrence phenomena in terrestrial magnestism. *Phil Trans., London*, A, **227**, 1927, p. 21.

ON THE DISTRIBUTION OF RAINFALL RATES AT SOME COASTAL STATIONS IN THE BRITISH ISLES

By D. J. McCONALOGUE

Services Electronics Research Laboratory.

This note describes the results of an investigation to find the proportion of the total time during which the rate of rainfall exceeds a specified value.

The stations chosen were: Lerwick (Shetlands), Ronaldsway (Isle of Man), St. Eval (Cornwall) and Valentia (Co. Kerry). The rainfall for the year 1951 was considered in detail. The information was abstracted from the day-by-day records of a Meteorological Office tilting-siphon rain recorder, which gives the rate of rainfall R as the gradient of an automatically traced curve, by the relationship $R = 1 \cdot 14 \tan \alpha$, where α is the angle of the gradient. The lower rainfall rates are therefore more accurately measurable than the higher. Histograms of percentage time against rainfall rate were computed, and from these, cumulative curves were constructed for months in which rain fell for more than 2 per cent. of the time. These curves give the time during which rain fell at a rate exceeding R mm./hr. as a percentage of the total time. This percentage is designated by P_R. The percentage time during which rain of any intensity was falling is thus P_0.

Examination of these cumulative curves showed a remarkable similarity of form, especially for months in which the percentage time of rainfall was high, and the curve correspondingly smooth. On fitting exponential curves, $P_R = P_0 \times 10^{-\lambda R}$, very close agreement was got. λ was obtained by making the curve pass through a convenient point on the graph. The following are typical:—

	R: 0	½	1	2	3	4	5	7	10
	LERWICK, September, $P_0 = 5 \cdot 3$, $\lambda = 0 \cdot 2937$								
P_R empirical	5·3	3·6	2·5	1·4	0·7	0·4	0·3	1	0·03
P_R exponential	5·3	3·8	2·7	1·4	0·7	0·4	0·2	0·05	0·01
	RONALDSWAY, December $P_0 = 11 \cdot 3$, $\lambda = 0 \cdot 3073$								
P_R empirical	11·3	8·5	6·1	2·7	1·3	0·8	0·4	0·2	0·1
P_R exponential	11·3	7·9	5·6	2·7	1·3	0·7	0·3	0·1	0·01
	ST. EVAL, February, $P_0 = 5 \cdot 2$, $\lambda = 0 \cdot 2007$								
P_R empirical	5·2	3·8	2·6	2·0	1·3	0·7	0·5	0·2	0·05
P_R exponential	5·2	4·1	3·3	2·1	1·3	0·8	0·5	0·2	0·05
	VALENTIA, October, $P_0 = 10 \cdot 9$, $\lambda = 0 \cdot 2075$								
P_R empirical	10·9	8·1	6·8	4·2	2·6	1·9	1·2	0·6	0·2
P_R exponential	10·9	8·6	6·8	4·2	2·6	1·6	1·0	0·4	0·1

Equally close agreement was obtained for longer periods. The cumulative curve for Valentia for the entire year is shown in Fig. 1.

If the cumulative curve is given by $P_R = P_0 e^{-\mu R}$, then the distribution function $f(R)$ must be $P_0 \mu e^{-\mu R}$

$$\text{since } P_R = \int_R^\infty f(R)\, dR.$$

This relationship is found to give good agreement with the observed data; the histogram for Ronaldsway, January–March, is shown in Fig. 2, together with the exponential distribution function as calculated from the cumulative curve.

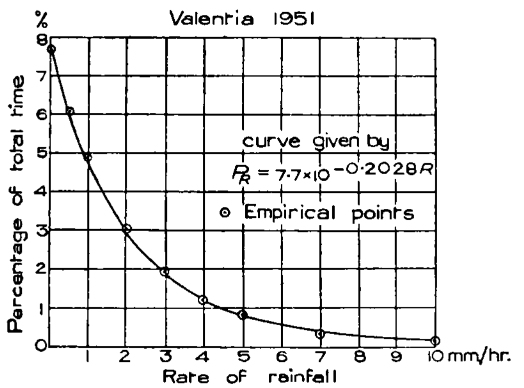


FIG. 1—CUMULATIVE CURVE, VALENTIA

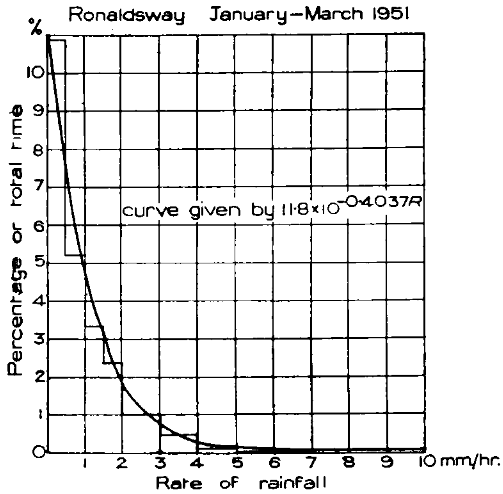


FIG. 2—HISTOGRAM, RONALDSWAY

The total precipitation p mm. is given by

$$p = k \int_0^\infty R\, f(R)\, dR$$

$$= k\ P_0 \mu \int_0^\infty Re^{-\mu}\, dR$$

where k is the number of hours in 1 per cent. of the period.

This gives $$p = \frac{kP_0}{\mu}$$

$$\text{or } \mu = \frac{kP_0}{p}$$

$$= \frac{1}{R_0}$$

where R_0 is the average rate of rainfall in millimetres per hour.

Thus the original formula becomes

$$\frac{P_R}{P_0} = e^{-R/R_0}$$

and the distribution function $f(R) = \dfrac{P_0}{R_0} e^{-R/R_0}$.

These relationships, if generally true, would allow a prediction to be made of the distribution in any period, if the total duration of rainfall in the period kP_0 and the total precipitation were known. While exponential distributions are not additive, nevertheless a reasonable approximation to the distribution in any period can be made by an exponential curve, which has the advantage of being analytically simple.

Acknowledgements.—Thanks are due to the Director of the Meteorological Office, London, and the Director of the Meteorological Service, Dublin, who supplied the charts from which the information was obtained. This note is published by permission of the Admiralty.

THE RATE OF RISE OF PILOT BALLOONS

By F. H. LUDLAM

In many places it is the practice to deduce the height of a pilot balloon from an assumed constant rate of rise. However, observers who have measured balloon heights (e.g. by the tail method or by using two theodolites) will agree that the upward speed is usually rather irregular, and that its mean is not always close to that which would be assumed from the standard formula. The following questions arise: do the balloons rise steadily relatively to the air, and are the observed irregularities reliable indications of vertical motions in the atmosphere?

The authorities at the Royal Albert Hall very kindly allowed members of the Imperial College staff to experiment with balloons in their building; our results do not answer the questions conclusively but are interesting and probably worth recording.

Experiments.—The balloons (which were supplied by the Meteorological Office) were released from the floor and rose 120 ft. to a skylight in the circular roof. Observers stationed on the galleries timed the intervals between the release of each balloon, its passage at their level, and its arrival at the skylight. The balloons reached the roof in about 15 sec., and the deduced speeds are liable to an observational error of about $\pm$ 2 per cent.

First, four 20-gm. balloons (Nos. 1–4) were inflated to have free lifts of 62, 72, 82, and 91 gm., their diameters increasing from 50 to 55 cm. (Their mean diameters at right angles to the diameters through the necks were found from the measured circumferences.) These all reached their terminal speeds within 20 ft. of the floor, and thereafter their speeds were the same, within the observational error, amounting to 2·5 m./sec. or about 490 ft./min. The balloons wavered from side to side and rolled a good deal.

Next, three balloons (Nos. 5–7) were loaded with suspended weights of 8, 35 and 60 gm. and given the same free lift of 62 gm. These held a rather steadier attitude and their rising speeds were indistinguishable from those of the first balloons.

On another day, four balloons (Nos. 8–11) were each brought to a dead weight of exactly 61 gm. by a suspended load of about 40 gm. and given a free lift of 62 gm. In flight they were not particularly steady; their ascent speeds were 2·3, 2·5, 2·2 and 2·6 m./sec.

Finally, ten balloons were inflated to a constant circumference (measured horizontally, with the neck beneath) such that the mean diameter was 50 cm.; the balloons became ellipsoidal with the longer diameter through the neck varying from 51 to 54 cm. Their free lift was then about 65 gm. Three hit lamps before reaching the skylight, and one hit the metal roof; excluding these the remaining six rose at a speed (measured this time from 23 ft. above the floor to the roof) which was constant within the observational error: 2·5 m./sec. The mean drag coefficient was 0·8.

Discussion.—When a balloon of cross-section A rises at a constant speed v, its buoyancy or free lift is equal to the drag:

$$H - W = \tfrac{1}{2} C_D A \rho v^2$$

where H is the total lift and W the total weight (including any load), ρ is the air density and C_D is the drag coefficient, a function of the Reynolds number ($R_e = vd/\nu$, d being the balloon diameter and ν the kinematic viscosity of the air).

After some manipulation the equation can be written

$$v^2 = \frac{4dB}{3C_D}$$

where $B = 1 - \dfrac{W}{H}$,

and from this C_D can be calculated from the data and plotted against R_e as shown by the full lines in Fig. 1. The pecked line shows that, over this range of R_e, values of C_D found for a sphere held fixed in an air stream are practically constant.

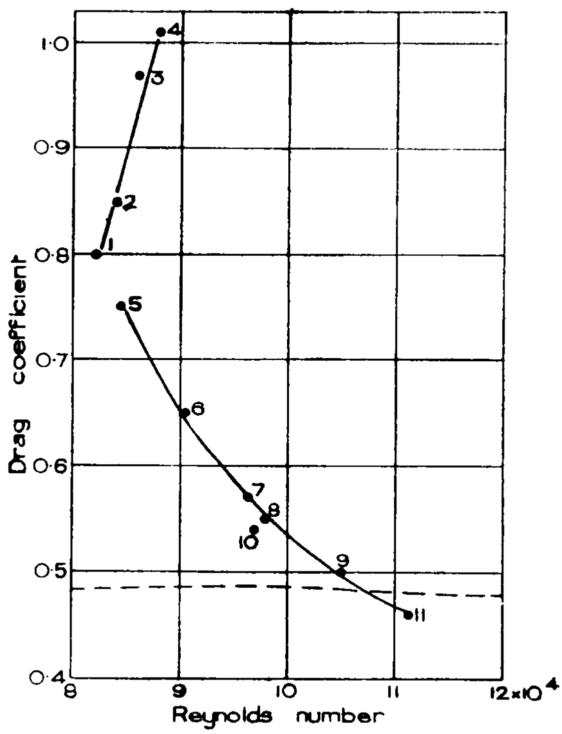


FIG. 1—DRAG COEFFICIENT AGAINST REYNOLDS NUMBER FOR 20-GM. BALLOONS:
Balloons 1– 4: free lift 62, 72, 82 and 91 gm. respectively; no added load.
Balloons 5– 7: free lift 62 gm.; loads of 8, 35 and 60 gm. respectively.
Balloons 8–11: dead weight brought to exactly 61 gm. by loads of about 40 gm.; free lift 62 gm.
The point 1 also represents the mean values for six balloons inflated to a mean diameter of 50 cm. and released without loads.
The pecked line shows accepted values for a sphere held in an air stream.

The drag coefficient of the balloons is considerably higher, apparently on account of their unsteady motion (wavering or rolling) for as they are steadied by an increasing load C_D falls towards the value for a sphere (balloons Nos. 5–7). The decrease of C_D as R_e increases under these conditions is confirmed by balloons Nos. 8–11, and is in striking contrast to the opposite trend shown by the unloaded balloons Nos. 1–4. This latter is the desirable trend, for a change in the buoyancy (as might be produced in the atmosphere by strong sunshine or a slow leak) is accompanied by a change in the drag coefficient which tends to leave the rising speed unaffected. This effect was discovered by J. S. Dines[1] in his original work on the rate of ascent of pilot balloons.

It must be admitted that these results are not in agreement with those which Cave and Dines[2] found, also in the Albert Hall.

They tested a formula

$$V = \frac{qL^{\frac{1}{2}}}{(W + L)^{\frac{1}{3}}}$$

L and W being respectively the free lift and the total weight of the balloon, in grams; they found that q was almost constant, varying by only a few per cent. about a mean value of 84 (when V is expressed in metres per minute). In our experiments q varied between 73 and 109; even with balloons Nos. 8–11, for which the value of $L^{\frac{1}{2}}/(W + L)^{\frac{1}{3}}$ was in each exactly the same, the speeds of ascent varied from 2·2 to 2·6 m./sec. and q from 96 to 109. In general the value of q rose with an increase in the load of the balloon, but more sharply than Cave and Dines found using smaller loads; our value of q for those balloons liberated without a load and given a free lift of about the customary amount agrees fairly well with the mean value of Cave and Dines, being about 82.

It is interesting in our results to find that the rate of ascent of the ten unweighted 20-gm. balloons was constant within the observational error ($\pm$2 per cent.), although the free lift varied from about 62 to 91 gm. and the mean diameter from 50 to 55 cm. This suggests that in field work such balloons may most conveniently be inflated to a particular circumference rather than to gain a certain free lift, without any loss in uniformity in the rate of ascent. Moreover, it seems that variations in the rate of rise of a single balloon, or of a succession of balloons, may be ascribed to vertical motions in the air if they considerably exceed some 5 cm./sec., or about 10 ft./min. It also appears that there is no advantage in loading balloons if they are intended to rise at about the usual rates, although our field experience leads us to think that a load has a valuable steadying influence on a balloon intended to rise very slowly, at less than 50·8 cm./sec. (100 ft./min.).

More accurate observations of the rate of rise of balloons might well show that their ascent speeds are, or could be made to be, even more reproducible, so that the pilot balloon might regain some of its former prestige, this time as a rather sensitive indicator of vertical movements in the atmosphere.

REFERENCES

1. DINES, J. S.; Rate of ascent of pilot balloons. *Quart. J.R. met. Soc., London,* **39,** 1913, p. 101.
2. CAVE, C. J. P. and DINES, J. S.; Further measurement of the rate of ascent of pilot balloons. *Quart. J.R. met. Soc., London,* **45,** 1919, p. 276.

BOOK RECEIVED

Jaarboek, A. Meteorologie 1950. Koninklijk Nederlandsch Meteorologisch Instituut. No. 97. 13¼ in. × 9½ in., pp. xiv + 94. Staatsdrukkerij-en Uitgeverijbedrijf, 's-Gravenhage, 1951. Price *fl.* 7.50.

OFFICIAL PUBLICATIONS

The following publications have recently been issued:—

METEOROLOGICAL REPORTS

No. 13.—1000–500-mb. thickness, North America to Europe, 1946–51. Monthly means and extremes.

The enormous increase, since the early 1940s, of aerological data for the northern hemisphere has added considerably to the statistical information about the atmosphere available to a wide class of users, particularly those concerned with aviation. The professional meteorologist, however, has his own peculiar requirements, and in the British Meteorological Service the "thickness" of the atmospheric layer between the 1000-mb. and 500-mb. surfaces has been given particular prominence both in dynamical theories and synoptic practice; circumpolar thickness charts are now a commonplace tool of research workers and forecasters alike.

This publication includes maps of the distribution of mean thickness for each month of the year (based on one observation a day from the main upper air stations) for the 5-yr. period October 1946 to September 1951, and for the area from the Rockies eastwards to the Urals. The individual thickness isopleths are drawn at intervals of 200 ft. Separate monthly maps are also given of the envelopes of the extreme northward and southward penetrations of selected thickness lines, namely for the 18,000-ft. thickness and for intervals of 600 ft. above and below this value. These maximum and minimum positions are usually reached in, respectively, the thermal ridges and troughs associated with the largest-amplitude long waves of tropospheric flow patterns. Little attempt has been made to interpret and to explain the uses of these charts, although references are given to two papers concerned with their use in forecasting.

PROFESSIONAL NOTES

No. 107.—Upper air circulation in low latitudes in relation to certain climatological discontinuities. By R. Frost, B.A.

The most striking features of the upper air circulation over Arabia are the westerly jet stream of over 100 kt. at a pressure level of about 200 mb. in latitudes 25–30°N. during the winter months and an easterly jet stream of over 70 kt. at a pressure level of 100 mb. in about latitude 15°N. during July. The westerly jet stream reaches its maximum intensity in midwinter, moves slowly northwards and decreases slightly during the spring, and then moves to a position about 40°N. and weakens rapidly during midsummer. The easterly jet stream weakens rapidly during the autumn and is non-existent during the spring and winter. As the westerly jet stream moves north over Iraq there is an abrupt change in the level of the tropopause, and it is suggested that the break-down in this tropopause barrier helps to explain the surface discontinuities of temperature and wind which occur during these months and the spectacular onset of the monsoon over India.

METEOROLOGICAL RESEARCH COMMITTEE

The 26th meeting of the Synoptic and Dynamical Sub-Committee of the Meteorological Research Committee was held at Dunstable on May 21, 1953.

The Sub-Committee considered three papers by Mr. F. H. Bushby and Miss M. K. Hinds on numerical methods of assessing cyclonic development using an electronic computer. The first[1] discussed the computation of the field of atmospheric development, the second[2] discussed the computation of the 500-mb. height tendency in a baroclinic atmosphere and the third[3] discussed the computation of the 1000–500-mb. thickness tendency, the 1000-mb. height tendency and the horizontal field of vertical motion. Other papers discussed at this meeting included one by Mr. Crossley[4] dealing with measures of success in forecasting, and a study by Dr. A. G. Forsdyke[5] of depressions crossing the region of Labrador and the St. Lawrence Basin.

The Sub-Committee also reviewed the progress made in research.

ABSTRACTS

1. BUSHBY, F. H. and HINDS, M. K.; Computation of the field of atmospheric development by an electronic computer. *Met. Res. Pap., London*, No. 765, S.C. II/126, 1953.
A method of evaluating the Sutcliffe development formula for relative divergence between two pressure levels, using a grid (length 160 miles) and a reiterative process on an electronic computor, is described. It was applied to 12 synoptic charts for the North Atlantic and west Europe (surface isobars and 1000–500-mb. thickness), total time 1 hr. each. The computed developments are analysed. The method is a promising forecasting aid.

2. BUSHBY, F. H. and HINDS, M. K.; Computation of the 500-mb. height tendency in a baroclinic atmosphere, using an electronic computer. *Met. Res. Pap., London*, No. 790, S.C. II/139, 1953.

3. BUSHBY, F. H. and HINDS, M. K.; Computation of the 1000–500-mb. thickness tendency, the 1000-mb., height tendency, and the horizontal field of vertical motion, using an electronic computer. *Met. Res. Pap., London*, No. 794, S.C. II/140, 1953.
Referring to baroclinic model of J. S. Sawyer and F. H. Bushby, the authors reduce equations to a form suitable for use with an electronic computer. These were used first (*Met. Res. Pap.*, No. 790) to compute height tendency of the 500-mb. field over a grid centred on the British Isles for three synoptic situations, and later (*Met. Res. Pap.*, No. 794) to compute base-height and thickness changes in feet per hour, and vertical motion fields. Computing times were 12 and 15 min., and results were satisfactory—the chief difficulty being boundary conditions.

4. CROSSLEY, A. F.; Measures of success in forecasting. *Met. Res. Pap., London*, No. 788, S.C. II/138, 1953.
The paper deals first with forecasts of one or two alternative events ("black or white"), both with some persistence. If c, c' are forecast accuracies of these events, $I = \frac{1}{2}(c + c')$ and I_0 is the value of I obtained by forecasting persistence, criterion of success is $(I - I_0)/(1 - I_0)$. Examples of meteorological forecasts are assessed on this basis. C. H. B. Priestley's index (1945) of success in forecasting continuously varying elements is also applied to forecasts of upper winds and equivalent headwinds.

5. FORSDYKE, A. G.; A study of depressions crossing the region of Labrador and the St. Lawrence Basin. *Met. Res. Pap., London*, No. 777, S.C. II/134, 1952.
Relations between tracks of depressions near the American coast and the associated thickness and upper air patterns are studied. Depressions were classified according to track into and out of the area and the broad features of their behaviour are listed. Spells of the order of 10 days of similar types are described synoptically in Part 1. In Part 2 the deepening and movement of depressions are studied statistically in relation to thickness patterns. The large-scale upper-flow patterns give no consistent indications useful for medium-range forecasting, as the thermal and surface patterns evolve together.

ROYAL METEOROLOGICAL SOCIETY

At the meeting of the Society held on June 17, 1953, the main event was the delivery of Sir Charles Normand's presidential address.

Presidential Address—Monsoon seasonal forecasting

Sir Charles Normand opened his address by pointing out that the rainfall of the summer monsoon is the vital feature of the Indian climate on which the great mass of the population depends for its daily bread. Sir Charles traced the history of monsoonal forecasting beginning with the early work of Blanford in the 1870's and 1880's. Blanford noticed droughts were often preceded by heavy snow in the Himalayas, and based his forecasts on that and, later, on his inference that droughts were preceded by high pressure over parts of Asia and Australia. Sir John Eliot, Blanford's successor, continued the forecasting. He worked with "parallel curves" and "analogues" and believed, in opposition to his predecessor and successor, that high pressure at Mauritius was favourable to heavy monsoon rain. Sir Gilbert Walker, taking charge in 1903, extensively developed the correlation-coefficient technique, though fully conscious of its limitations and empirical nature. He began with the results of Hildebrandsson and Lockyer on relations between pressure variations at distant points, found a correlation between Indian rainfall and pressure variations in the Indian and Pacific Oceans, and went on to make a world-wide survey of tele-correlations. One of the difficulties for forecasting which emerged was that the monsoon rainfall was found to be better correlated with later events than with earlier events. Sir Gilbert examined the possibility of forecasting the rainfall of individual months but got much better results for the whole monsoon season. One important feature of his work was the introduction of statistical verification of the validity of the forecast. In 1930 Sir Charles Normand who succeeded Sir Gilbert in 1927 introduced numerical forecasts of the minimum rainfall expected, expressed as a percentage of normal and qualified by a statement of the odds against error. These were issued until 1948. In the course of his Address Sir Charles showed diagrams of the monsoon rainfalls of India from 1875 to 1948, and concluded with a broad appreciation of the value of the forecasts. The general result was that the overall accuracy of forecasting the total monsoon rainfall was much better than would have been obtained by chance, but the accuracy of forecasting of poor monsoons was decidedly lower than the overall accuracy, and the bad seasons were of course the most important.

As regards future work he considered that attempts to forecast the total monsoon rainfall should continue, but that the results need be made available only to scientific workers. He believed the oscillation of pressure between the Indian and Pacific Oceans merited re-examination, and if it still holds, a strong effort should be made to understand its physical basis, especially of the control of the southern summer on the succeeding winter.

The address will be published in the *Quarterly Journal of the Royal Meteorological Society.*

The summer meeting of the Royal Meteorological Society was held on July 15, at the Building Research Station, Watford. The Society was welcomed to the station by Mr. Pickles who spoke of the need for meteorological information in the design of buildings because buildings were a means of defence against the weather, producing an internal climate in which man could live. Information was needed on temperature, radiation, wind and rainfall.

Sections of particular interest to meteorologists seen by the visitors were the investigations of the thermal transmission of walls and roofs and of the weathering of materials used in external building. Thermal transmission of walls and ceilings is measured by the heat loss from small rooms maintained at constant temperature having their only external wall facing north. Weathering of materials is examined by exposing them to the atmosphere under varying degrees of protection. Bricks, for example, are exposed in shallow trays where they stand for long periods in rain-water as well as on a platform from which rain could drain away. A point of meteorological interest was that the damage to stonework by frost depended on the manner of the fall of temperature as well as on the minimum temperature reached.

The thanks of the Society to the station were expressed by Mr. R. G. Veryard at the close of an excellent tea in the canteen.

ROYAL SOCIETY OF ARTS

The scientist's place in the Services

The Pope Memorial lecture on the subject "The scientist's place in the Services" was given by Dr. O. H. Wansbrough-Jones, Chief Scientist, Ministry of Supply, to the Royal Society of Arts on April 29, 1953.

He traced the rise of scientists in the Services. Traditionally, the scientist was merely called in to solve some specific problem placed before him by the military authority; and his services were purely occasional. This was the state of affairs from the time of Archimedes almost to the beginning of the twentieth century. A number of very interesting examples of the work of scientists in this era were quoted; among the later ones, it was stated that Michael Faraday "advised very sensibly, on meteorological grounds, against the use of sulphur dioxide in the Crimean War." The scientific department giving full-time employment to scientists is largely a product of the twentieth century. Until the Second World War, its function was still "to give the Services what they wanted, which is not necessarily the same thing as giving the Services what they needed". Today, however, the scientist is an accepted and valued member of the planning team. The scientist must not expect special deference to his opinion outside his own particular field of knowledge; but he has certain qualities of mind which help him to contribute to the solution of service problems. Primarily he has a knowledge of certain special techniques, and is qualified to lead a team, or establishment, engaged in scientific work. He should also have a habit of formlating his problems precisely, and of using simplified models to represent them; he has a desire to test all results and opinions by every quantitative method available; and he will never commit himself to an answer until he is, at least, nearly sure he is right. Not all these qualities have, or should have, a place in the service mentality; and the great step forward made in the last war was the integration at high level of the two disciplines, service and scientific. The new position was generously and readily accepted by the Services, largely because the standard of scientific understanding in the Services themselves was, and is, much higher than is generally admitted. The Services have indeed made impressive contributions to science. The work of the Navy in hydrography and navigation has been outstanding for centuries, and Whittle's great work was carried out while he was a serving R.A.F. officer. Since the war, the Services have made further advances in their technical education, notably by the re-establishment and expansion of the Royal Military College of Science at Shrivenham. Some of the outstanding problems which await research are very difficult, and we cannot afford to work on all of them. The cost of research is very high, but the public has come to accept it as necessary, and press comment on the allocation to research in the recent estimates was favourable. Not all the questions of liaison between the Services and science have been answered, but there is good reason to hope that the present harmonious relationship will continue.

A meteorologist listening to this lecture could hardly help feeling a little isolated, because underlying much of it was the assumption that all scientific work is research. A comparison of the weather forecaster's approach to his work with the qualities of the scientific mind as stated by Dr. Wansbrough-Jones will reveal some wide differences. The forecaster may formulate his problems precisely, in the sense that he knows exactly what he wants to find out, but there is no precision about the rules by which the problem is to be attacked. If one could analyse a forecaster's mental processes, one would find that possibly half consists of fairly rigid scientific reasoning. The rest consists of a vague feeling that one solution looks right, while another does not; a memory of what happened last week, plus a somewhat inaccurate memory of something that happened about this time last year; and a determination so to word the forecast that, if it does go wrong, the result will be as little embarrassing as possible. But above all, it is the statement that the scientist "will never commit himself to an answer until he is at least nearly sure that he is right" which sets the meteorologist apart. He is in a special category and, perhaps, needs his own philosophy, distinct from the general philosophy of science. His nearest neighbour is probably the doctor, who also has a routine job to do, and who also has to adopt "working hypotheses" based on inadequate data.

B. C. V. ODDIE

LETTER TO THE EDITOR

Gale of December 17, 1952

In discussing the squall at Cranwell which was accompanied by the record gust for inland stations in Great Britain, 111 m.p.h. (96 kt.), Mr. C. K. M. Douglas states* that he has no knowledge of anything closely similar having been recorded in this country. I notice that before and after this gust, and a few smaller ones accompanying it, the mean wind speed lay mainly below 40 m.p.h. (34 kt.).

For many years the record gust in Great Britain was that at Quilty, Co. Clare, Ireland, on January 27, 1920, but its value, exceeding 111 m.p.h. (96 kt.), was quoted as open to doubt, as, unlike the recent Cranwell gust, nobody was watching the anemometer pens at the time, and this doubt was strengthened by the fact that the mean speed, apart from the big gust, was no more than 52 m.p.h. (45 kt.). This gust continued to be quoted until 1941, but after December 6, 1929, the highest gust in Great Britain was generally stated to be equal to (and not exceeding) 111 m.p.h. (96 kt.), as that value was touched at Scilly on that date. The question as to where the honour should go was finally resolved when a gust of 113 m.p.h. (98 kt.) was recorded at St. Ann's Head on January 18, 1945. However, the ratio of the maximum gust to that of the mean wind speed at Cranwell is of the same order as that at Quilty in 1920, and it would appear therefore that there may have been no justification for doubting the latter record; in fact it had probably genuinely exceeded that at Scilly in December 1929 and even that at St. Ann's Head in January 1945. Fortunately all these gusts have been exceeded in 1952 and 1953, and there is now no doubt that it is in one of these latter years that the record gust has occurred. However, it is regrettable that we have no instrument in general use capable of recording the very highest wind speeds that occur.

---

*See *Met. Mag., London*, **82**, 1953, p. 73

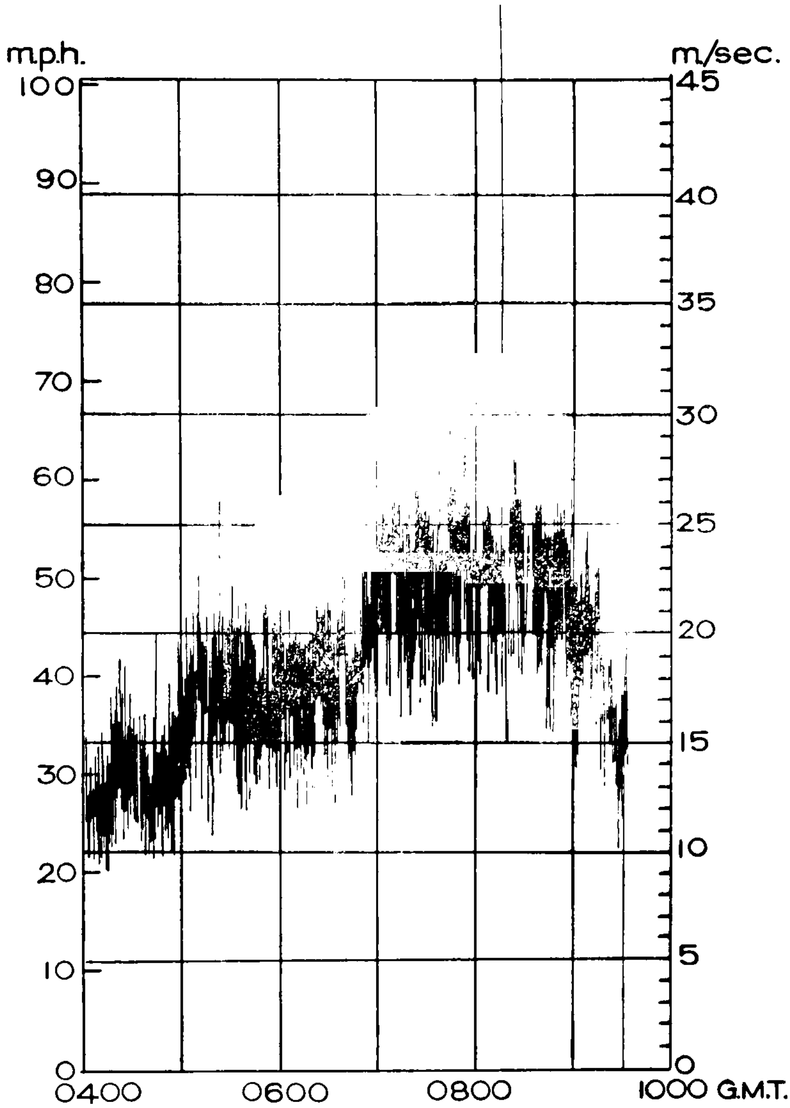


FIG. 1—ANEMOGRAM FROM QUILTY, JANUARY 26, 1920

Unfortunately at Wrexham the anemometer went out of order in the early stages of the gale of December 17, 1952; but the day was notable for virtually continuous hail from 9.15 a.m. to 6 p.m.; it was heavy enough to whiten the ground at times, but borne on the gale much of it failed to be registered by the rain-gauges.

S. E. ASHMORE

11 Percy Road, Wrexham, North Wales, May 11, 1953

[A tracing of the relevant part of the Quilty record is reproduced in Fig. 1 for comparison with the record from Cranwell for December 17, 1952, published in the *Meteorological Magazine* for March 1953, p. 73. The following paragraph is taken from the *Meteorological Magazine* for February 1920, p. 7:—

"There were several gusts of 31 m./sec. and over between 7h. and 8h. and one of 36 m./sec. at 7.45. After this the pen did not rise above 31 m./sec. until 8.20 when it rushed up to the very edge of the chart. It seems to have caught on the edge of the sheet and spluttered as it came down. The indicated speed of the wind was at least 50 m./sec. (over 110 m.p.h.). The duration of the squall cannot have been much more than a minute and the average strength of the wind afterwards was about the same as before, 22 m./sec."

Later, doubts were felt about the validity of the record and in the *Meteorological Magazine* for May 1922, p. 102, it was said that "the excursion of the pen was isolated and there is room for doubt as to its interpretation" and in the *Monthly Weather Report*, 1929, p. 195, "This gust (> 50 m./sec.) occurred as an isolated gust at a time when the mean wind speed was 23 m./sec. It appeared very exceptional and apparently artificial. The custodian affirmed in reply to an inquiry that the record had not been tampered with; unfortunately the circumstances at the time prevented personal investigation on the spot by a meteorological expert. Accordingly the record has been published in the absence of any positive external evidence of its apparently artificial nature".

Mr. Douglas has examined the working charts of January 27, 1920, and writes that an occlusion passed Quilty about the time of the squall and that the geostrophic wind on both sides of the occlusion was fully 130 m.p.h. and so much higher than the geostrophic wind at Cranwell at the time of the gust of December 17, 1953. He considers there is no good reason for doubting the Quilty record.

With reference to Mr. Ashmore's comment on anemometers for reading very high gusts, trials of a suitable recorder are in hand in the Meteorological Office.—Ed., *M.M.*]

NOTES AND NEWS

Wind damage to trees

In March, members of the Agricultural Branch of the Meteorological Office visited a Forestry Commission plantation at Bryncynfil (Dovey Forest), some five miles south-east of Machynlleth. The plantation lies along a narrow valley running south-south-west to north-north-east and sealed by a very steep scree at the southern end. Trees well exposed high up on the sides of the valley suffered little wind damage, but susceptible species, such as Douglas Fir and Norway Spruce, planted on the floor of the valley, suffered considerable "blasting", due apparently to consistent vicious down-draughts in the lee of the steep valley head. The photographs at the back of this issue of the magazine show the wind effect on the natural vegetation and the young conifers.

L. P. SMITH

REVIEWS

Effects of weather on the determination of heights by aneroid barometer in Great Britain. By B. W. Sparks. *Geogr. J., London,* **119,** 1953, p. 73.

Mr. Sparks's interesting article is based on practical experience of height measurement to an error of ±5 ft. checked against the final errors found on reaching a known height shown on the 6-in. ordnance maps after an hour's traverse. Winds exceeding force 3 make aneroid work impossible owing to the erratic pressure variations in the gusts. Sufficiently accurate surveying is possible in anticyclones and during large falls or rises of pressure provided no front actually crosses the area. Of course, when pressure is changing rapidly there will usually be too much wind. Intermediate errors are estimated by distributing the closing error over the readings proportionate to the time.

When there are fronts over the area or during showery and especially thundery weather pressure variations are so erratic that it is impossible to use an aneroid to obtain readings accurate to ± 5 ft. Mr. Sparks estimates that in south-east England 59 per cent. of days are suitable in summer and 48 per cent. in winter, but in north-west Scotland these figures fall to 33 per cent. and 19 per cent. Mr. Sparks regrets the ending of AIRMET but finds the early morning B.B.C. forecast of assistance.

He does not mention that for a small fee a special forecast of suitable weather can be obtained from the Meteorological Office; such forecasts would be of great value to surveyors waiting for an opportunity to make an aneroid traverse.

G. A. BULL

Present-day forecasting practice, by F. H. Ludlam, and *Watching the sky*, by R. S. Scorer. *Sci. Progr., London*, **41**, 1953, p. 84 and p. 54. Edward Arnold & Co., London.

Several reviews of the history of weather forecasting during the present century and of its present problems and possibilities have been published in the last few years. The major ones were those by C. K. M. Douglas and R. C. Sutcliffe in the 1952 numbers of the *Quarterly Journal of the Royal Meteorological Society* and by H. C. Willett in the "Compendium of meteorology". Now in the January number of *Science Progress* F. H. Ludlam gives a useful summary of these and some other papers on the subject. In the same number R. S. Scorer contributes a short article, illustrated with some admirable photographs, on the value and delight of watching the sky. He looks forward to the use of more informative cloud classifications which will provide reports of clouds of greater value in revealing to the meteorologist the three-dimensional air movements.

G. A. BULL

Geographical Journal. Vol. CXIX. Part 2, June 1953

The June 1953 number of the *Geographical Journal* includes much of meteorological and geophysical interest.

Mr. G. de Q. Robin's lecture to the Society on the International Expedition to Antarctica 1949–52 includes a preliminary report on the meteorological and glaciological observations of the expedition. Interesting points are that on clear calm winter days the temperature inversion between the bottom and top of a 10-m. mast was as large as 15°C. and the confirmation of the phenomenon, originally observed by the U.S.A. expedition in 1947, of the absence of a tropopause at times in winter over the Antarctic.

The review by Jean Fortt of the H.M. Stationery Office publication *Land and Population in East Africa* includes a discussion of the rainfall of the marginal areas of that territory. Mr. F. Kingdon-Ward gives a vivid description of his experiences in camp near the epicentre of the great Assam earthquake of August 15, 1950 and of the topographical changes it produced.

G. A. BULL

OBITUARIES

Walter Charles Reynolds.—Mr. Reynolds was killed instantly on August 1, 1953, while travelling home on his motor-cycle; he was 32. The news of his untimely death came as a great shock and leaves those of us who knew him with a profound sense of loss. We offer our deepest sympathy to his bereaved parents.

Charles Reynolds joined the Meteorological Office as an Assistant III in March 1939 at Bircham Newton. He served at the Training School and at White Waltham and in July 1942 received his forecasting training course. For the next 2½ yr. Reynolds served as an Assistant II at Bomber Command stations in Yorkshire and was commissioned in the R.A.F.V.R. in April 1943. The period July 1945 to March 1948 was spent in India; he was promoted to Flight-Lieutenant and to Assistant I early in 1946. Release from the R.A.F.V.R. in April 1948 did not break the continuity of his service for he returned to duty immediately and was promoted to Experimental Officer in July 1948.

It was here that the final period began; the period during which we had countless opportunities to appreciate his sterling honesty and determination to succeed. For 2 yr. he fulfilled the exacting duties of a forecaster in constant touch with the daily press; in 1950 these changed to the no less onerous duties of a forecasting instructor at the Training School. During these four years, Reynolds attended evening lectures at Birkbeck College, studying for the B.Sc.(Special) degree in mathematics. It was in connexion with this course that we had occasion to admire his tenacity and determination; success crowned his efforts in 1952 and in October he was moved to the Special Investigations Branch where full use was made of his mathematical ability. Such was Reynolds' deep interest in theoretical meteorology, however, that he was well aware that its problems require more advanced mathematics than he had learnt and he continued his studies of the mechanics of continuous media with a view to obtaining the Ph.D. degree.

His untimely death cheated him of this success. His loss has made the office poorer and deprived his colleagues of a stimulating companion and a worthy friend.

R. C. SIVILL

Dr. Wladyslaw Gorczyński.—It is with great regret that we learn of the death on June 25, 1953, in his 74th year, of Dr. Gorczyński, professor of meteorology and climatology at Copernicus University in Toruń, Poland.

After the First World War Dr. Gorczyński organized the State Meteorological Service in Poland and became the first director of the Meteorological Institute in Warsaw. In 1923 he undertook an actinometric expedition to Siam and Java, during which he discovered a diminution of intensity in the red part of the solar spectrum. In 1926–36 he carried out investigations of the solar climate of the Riviera, visited the Sahara and Tunis, where he observed the infra-red part of the solar spectrum, and twice went to Mexico. The outbreak of the Second World War found him in Washington and he had to stay in the United States of America throughout the whole war. In 1947 he returned to Poland where he was appointed professor of meteorology and climatology at the Copernicus University in Toruń.

During his lifetime Dr. Gorczyński published over 260 papers in different languages both in Poland and abroad, the main field of his scientific work being solar radiation and climatology. He also devised some instruments, of which his solarimeter became widely known.

Professor Gorczyński was a member of many societies and organizations including the Polish Academy of Science, the Academy of Science in Mexico and the International Solar Radiation Commission as a charter member from its constitution in 1912 until its dissolution in 1946.

METEOROLOGICAL OFFICE NEWS

Academic successes.—Information has reached us that the following members of the staff have been successful in examinations this summer; we offer them our congratulations.

London B.Sc. (Special): 2nd class honours in mathematics, C. H. Hinkel, H. D. Hoyle; 2nd class honours in physics, J. E. Burns; Pass in mathematics, R. C. Sivill.

Intermediate B.Sc.: pure and applied mathematics, physics, C. H. Chubb, A. W. R. Hewat, T. D. D. Jennings, Miss A. Leeves; pure and applied mathematics, geography, D. T. Tribble.

General Certificate of Education (Advanced level): pure and applied mathematics, physics, R. A. Cashmore, C. H. Chubb, A. A. Diver, M. Grimmer, J. H. Grundy, B. W. Hamilton; applied mathematics, physics, D. C. Davis, J. W. Rayner, J. Scot; physics, mathematics and distinction in chemistry, H. G. Griggs; pure mathematics, physics, R. C. Friend, P. J. S. Greenaway, F. B. Webster; applied mathematics, W. M. Mills; pure mathematics, R. F. Scarsbrook; physics, Miss U. M. Bannister, E. G. Butler, J. Gregson, O. M. Hull, A. Lambley, J. M. Ward; geography, M. Curme, A. G. Rogers.

Library Association Entrance Examination: Miss P. Gorringe.

M. Grimmer has been accepted for a studentship at the Royal Military College of Science, Shrivenham.

Higher National Certificate: mechanical engineering, A. L. Alexander.

Sport.—Messrs. A. F. and S. W. Lewis have been selected to play for the Civil Service representative water polo team, against the Navy on September 10 and the Army on September 14.

The brothers Lewis now have regular places in the Civil Service team.

WEATHER OF AUGUST 1953

Mean pressure was above normal over west and south Europe and the Bay of Biscay, and also over the east of the United States. Mean pressure was below normal over the Atlantic north of 45°N., excluding the Bay of Biscay, by as much as 5 mb. over Iceland and the sea area off south-east Greenland. The mean pressure was highest just south-west of the Azores, 1024 mb., and lowest, 1004 mb., off south-east Greenland.

Mean temperature differed little from normal. In Europe it varied from 55°F. in north Scotland and Norway to 75°–80°F. in the south of Spain, Italy and Greece. Mean temperature in the east of North America varied from 57°F. in southern Quebec to over 80°F. in Florida.

In the British Isles the weather was mainly fair and warm until the 12th, when it became less settled with local thunderstorms. The latter half of the month was rather cool with frequent rain, heavy at times in some areas. Rainfall was variable, exceeding the average in western Scotland, northern England, west Wales and over an area stretching across the Bristol Channel to Huntingdonshire. Sunshine exceeded the average on the whole.

In the first three days a wedge of high pressure moved slowly south-east across the British Isles maintaining fair sunny weather apart from some showers chiefly on or near the east coast. On the 4th and 5th a depression moved east across Iceland and a westerly type of weather prevailed with appreciable rainfall locally in the north of Scotland in the early hours of the 4th, and some scattered light rain or showers and a good deal of cloud in most parts of the country on the 5th and 6th; there was also fog on the south-west coasts at times during the period 4th–7th. Subsequently an anticyclone off our south-west coasts moved north-east and dry weather prevailed until the 12th, apart from some slight rain at times mainly in the extreme west and north-west. By the 12th pressure was highest over southern Scandinavia, while a trough of low pressure moved over the British Isles from the west giving thunderstorms on the 12th and 13th; the storms were heavy locally in north-east England on the 13th. A warm south-south-easterly air stream in front of the trough was accompanied by notably high temperatures, 90°F. or a little above being reached at a number of places in the eastern half of England. Temperature fell rapidly behind the trough; for example, at Dishforth the maximum on the 13th was 64°F. as compared with 92°F. on the 12th. From the 14th to 17th a depression south of Iceland moved very slowly north; on the 14th an associated trough gave rain in western districts and on the following day it moved slowly east giving thundery rain and local thunderstorms. On the 17th a secondary depression off west Scotland moved slowly north-east and troughs moved eastward across the British Isles giving general rain, heavy locally in the north and west (2·13 in. at Patterdale, Westmorland). From this time onward a westerly type of weather persisted, with frequent rain. On the 19th troughs associated with a depression off the Hebrides crossed England and Wales bringing heavy rain (2·87 in. at Maesteg, Glamorganshire) and on the 20th and 21st the main depression moved slowly over Scotland giving varying amounts of rain and rather widespread thunderstorms on the 21st and scattered showers on the 22nd. Further rain, heavy locally in the south, occurred on the 23rd and showers and scattered thunderstorms on the 24th. Thereafter a wedge of high pressure moving east was associated with a short spell of fair weather over most of the country on the 25th and 26th and over much of England also on the 27th, but troughs of low pressure brought renewed rain to the north on the 27th and to most parts on the 28th and 29th; the rainfall was heavy at times, particularly on the 29th (2·78 in. at Maesteg and 2·25 in. at Walton-in-Gordano, near Clevedon). Mainly fair weather prevailed over much of southern England on the last two days but showers and local thunderstorms occurred in Scotland and Northern Ireland on the 30th and widespread heavy rain in northern districts of England and Wales, southern Scotland and the Isle of Man on the 31st (2·63 in. at Ulverston, Lancashire, 2·51 in. at Oughtershaw, Yorkshire, and 2·31 in. at Kendal, Westmorland).

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 ...	93	36	+0·6	99	−3	115
Scotland	83	32	+0·4	91	+1	102
Northern Ireland ...	74	43	+0·3	93	−1	97

RAINFALL OF AUGUST 1953

Great Britain and Northern Ireland

County	Station	In.	Per cent. of Av.	County	Station	In.	Per cent. of Av.
London	Camden Square ...	2·08	94	*Glam.*	Cardiff, Penylan ...	5·55	131
Kent	Dover	2·12	92	*Pemb.*	Tenby, The Priory ...	3·40	89
,,	Edenbridge, Falconhurst	1·98	76	*Radnor*	Tyrmynydd	4·49	83
Sussex	Compton, Compton Ho.	2·47	80	*Mont.*	Lake Vyrnwy	5·01	94
,,	Worthing, Beach Ho. Pk.	1·81	80	*Mer.*	Blaenau Festiniog ...	11·31	101
Hants.	Ventnor Cemetery ...	1·62	79	,,	Aberdovey	6·00	135
,,	Southampton, East Pk.	1·86	71	*Carn.*	Llandudno	2·90	103
,,	South Farnborough ...	2·02	91	*Angl.*	Llanerchymedd ...	2·89	80
Herts.	Royston, Therfield Rec.	2·54	99	*I. Man*	Douglas, Borough Cem.	5·23	137
Bucks.	Slough, Upton... ...	1·58	73	*Wigtown*	Newton Stewart ...	3·20	77
Oxford	Oxford, Radcliffe ...	2·92	128	*Dumf.*	Dumfries, Crichton R.I.	2·85	71
N'hants.	Wellingboro' Swanspool	2·60	109	,,	Eskdalemuir Obsy. ...	4·90	95
Essex	Shoeburyness	1·92	108	*Roxb.*	Crailing	2·29	78
,,	Dovercourt	1·22	68	*Peebles*	Stobo Castle	2·66	75
Suffolk	Lowestoft Sec. School...	2·30	105	*Berwick*	Marchmont House ...	2·27	69
,,	Bury St. Ed., Westley H.	1·84	71	*E. Loth.*	North Berwick Res. ...	1·89	60
Norfolk	Sandringham Ho. Gdns.	2·42	90	*Midl'n.*	Edinburgh, Blackf'd. H.	2·03	63
Wilts.	Aldbourne	3·14	119	*Lanark*	Hamilton W. W., T'nhill	2·95	86
Dorset	Creech Grange... ...	2·49	87	*Ayr*	Colmonell, Knockdolian	2·18	55
,,	Beaminster, East St. ...	2·41	77	,,	Glen Afton, Ayr San. ...	3·37	62
Devon	Teignmouth, Den Gdns.	1·31	58	*Renfrew*	Greenock, Prospect Hill	5·00	97
,,	Cullompton	..	..	*Bute*	Rothesay, Ardencraig...	5·35	110
,,	Ilfracombe	4·90	136	*Argyll*	Morven (Drimnin) ...	6·01	114
,,	Okehampton	3·20	75	,,	Poltalloch	..	..
Cornwall	Bude, School House ...	2·75	98	,,	Inveraray Castle ...	7·81	119
,,	Penzance, Morrab Gdns.	2·40	76	,,	Islay, Eallabus... ...	4·71	108
,,	St. Austell	2·06	57	,,	Tiree	4·63	110
,,	Scilly, Tresco Abbey ...	2·25	82	*Kinross*	Loch Leven Sluice ...	2·03	53
Glos.	Cirencester	4·03	134	*Fife*	Leuchars Airfield ...	1·74	56
Salop	Church Stretton ...	2·97	89	*Perth*	Loch Dhu	6·07	90
,,	Shrewsbury, Monksmore	1·75	63	,,	Crieff, Strathearn Hyd.	2·11	50
Worcs.	Malvern, Free Library...	4·20	145	,,	Pitlochry, Fincastle ...	2·35	66
Warwick	Birmingham, Edgbaston	2·45	90	*Angus*	Montrose, Sunnyside ...	2·32	83
Leics.	Thornton Reservoir ...	2·14	76	*Aberd.*	Braemar	2·03	60
Lincs.	Boston, Skirbeck ...	3·02	126	,,	Dyce, Craibstone ...	2·51	83
,,	Skegness, Marine Gdns.	2·20	90	,,	New Deer School House	2·65	90
Notts.	Mansfield, Carr Bank...	1·35	48	*Moray*	Gordon Castle	2·12	67
Derby	Buxton, Terrace Slopes	5·14	117	*Nairn*	Nairn, Achareidh ...	2·73	112
Ches.	Bidston Observatory ...	2·99	97	*Inverness*	Loch Ness, Garthbeg ...	3·73	115
,,	Manchester, Ringway...	3·65	111	,,	Glenquoich	10·17	124
Lancs.	Stonyhurst College ...	6·47	128	,,	Fort William, Teviot ...	8·07	130
,,	Squires Gate	3·76	110	,,	Skye, Duntuilm ...	5·79	130
Yorks.	Wakefield, Clarence Pk.	2·48	95	,,	Skye, Broadford ...	..	..
,,	Hull, Pearson Park ...	2·52	87	*R. & C.*	Tain (Mayfield) ...	2·18	81
,,	Felixkirk, Mt. St. John...	3·64	128	,,	Inverbroom, Glackour...	4·32	103
,,	York Museum	2·88	114	,,	Achnashellach	6·67	106
,,	Scarborough	3·26	117	*Suth.*	Lochinver, Bank Ho. ...	3·52	105
,,	Middlesbrough... ...	3·54	129	*Caith.*	Wick Airfield	2·88	105
,,	Baldersdale, Hury Res.	5·21	157	*Shetland*	Lerwick Observatory ...	4·60	153
Norl'd.	Newcastle, Leazes Pk....	4·20	149	*Ferm.*	Crom Castle	3·80	92
,,	Bellingham, High Green	4·36	124	*Armagh*	Armagh Observatory ...	3·68	102
,,	Lilburn Tower Gdns. ...	2·08	74	*Down*	Seaforde	3·55	95
Cumb.	Geltsdale	5·38	131	*Antrim*	Aldergrove Airfield ...	2·52	70
,,	Keswick, High Hill ...	5·93	114	,,	Ballymena, Harryville...	4·30	101
,,	Ravenglass, The Grove	4·56	100	*L'derry*	Garvagh, Moneydig ...	3·90	99
Mon.	A'gavenny, Plâs Derwen	3·44	104	,,	Londonderry, Creggan	5·00	108
Glam.	Ystalyfera, Wern House	5·47	89	*Tyrone*	Omagh, Edenfel ...	3·43	80

Printed in Great Britain under the authority of Her Majesty's Stationery Office
By Geo. Gibbons Ltd., Leicester

Wt-34. K16.

Reproduced by courtesy of L. P. Smith

WIND DAMAGE TO PLANTATIONS
(see p. 315)

Reproduced by courtesy of L. P. Smith

WIND EFFECT ON NATURAL VEGETATION
(see p. 315)