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The Electrical Structure of Thunderclouds

Of the many theories that have been put forward to explain the mechanism of thunderstorms there are two which still find considerable support, viz:—Wilson's influence theory and Simpson's breaking-drop theory. Until recently the evidence for and against these theories has been derived almost wholly from observations made at the surface of the earth, and it seemed that no further advance towards the correct solution of the problem could be made except by means of direct observations of the distribution of electricity in and above thunderclouds. A method of obtaining such observations was devised at Kew Observatory in 1934, and an account of the results which have since been obtained has been published recently*.

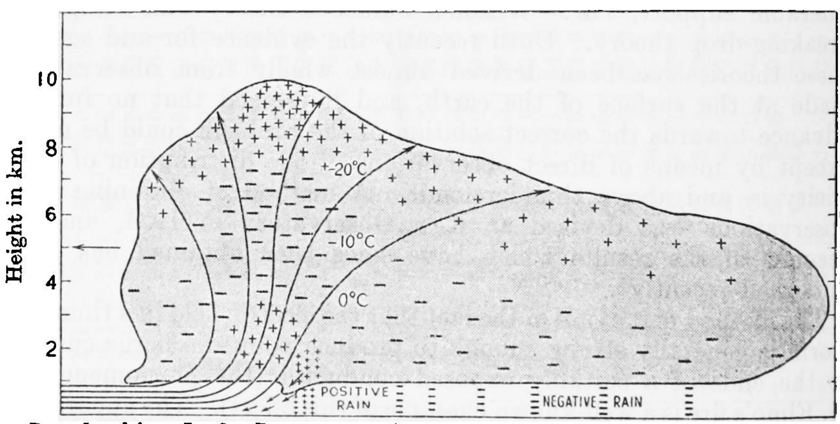
The method makes use of the fact that the electric field in a thunderstorm is generally strong enough to produce point-discharge current at the ends of a suitably exposed conductor (the phenomenon of St. Elmo's fire is a well-known example of this effect). The apparatus, which was carried up by a sounding balloon, consisted essentially of a thin wire about 20 m. long hanging vertically from a recording device that indicated, by means of pole-finding paper, in which direction, up or down the wire, the point-discharge current flowed;

* "The Distribution of Electricity in Thunderclouds," by Sir George Simpson. K.C.B., D.Sc., F.R.S. and F. J. Scrase, M.A., B.Sc., *London Proc. roy. Soc.* A, **161**, 1937, pp. 309–52.

an aneroid recorder for determining the height was included in the apparatus. From the direction of the point-discharge current the sign of the electric field producing it was determined and the distribution of positive and negative electricity at various heights was deduced from this.

A statistical examination of 31 soundings which yielded good records showed that in nearly every case there was evidence of positive electric charge in the upper parts of the thunderclouds, and in about two-thirds of the cases there was negative charge in the lower parts of the clouds. On the other hand, there were a number of occasions in which there was a positive charge at the base of the cloud as well as in the upper part, the negative charge lying between the two. An examination of the data, obtained from ground apparatus as well as from balloon soundings, for individual storms showed that the lower positive charge was generally concentrated in a relatively small region near the front part of the base of the cloud and was associated with the heaviest rain which was positively charged. Estimates of the temperatures at various heights in the clouds showed that the region of separation between the negative charge and the upper positive charge occurred at levels where the temperature was well below the freezing point; the lower region of positive charge occurred at the base of the cloud where the temperature was above the freezing point.

From these results it is concluded that a well-developed thundercloud has a structure similar to that shown in the generalised diagram reproduced in Fig. 1. In this diagram the charges in the



Reproduced from London Proc. roy. Soc. A, 161, 1937, p. 350.

FIG. 1—GENERALISED DIAGRAM SHOWING AIR CURRENTS AND DISTRIBUTION OF ELECTRICITY IN A TYPICAL HEAT THUNDERSTORMS.

cloud and on the rain are indicated by positive and negative signs; the unbroken lines with arrow-heads represent stream-lines of air, their distance apart being proportional to the wind velocity. There is a strong upward current of air in the base of the cloud near the front and it is just above this strong current that the lower region of positive charge is located; to the rear of this region the vertical air current is weaker and the heavy rain which falls out is positively charged. Apart from the local concentration of positive electricity the lower half of the cloud is negatively charged. The upper part of the cloud is positively charged and the region of separation between this upper positive charge and the negative charge occurs at a level where the temperature is between $-10°$ and $-20°$ C.

It was natural to see, first of all, whether either of the current theories could satisfactorily explain the results of the investigation. According to Simpson's theory, when a raindrop breaks up into smaller drops the water becomes positively charged and the air negatively charged. The negative charge attaches itself to the cloud particles, which are carried upwards in the ascending air currents, leaving positively charged drops behind. As a result of this separation of electricity the positive charge is concentrated in regions near the base of the cloud where ascending currents can support large quantities of water whilst the negative electricity is distributed with the cloud particles in the middle and upper parts of the cloud. Now the results of the soundings support the breaking-drop theory in the following particulars: (*a*) regions of positive electricity are found in the lower parts of the cloud where the temperature is above the freezing point and (*b*) these regions are closely associated with the more active parts of the storms where ascending air currents are highly developed and where the heavy rain occurs. Thus the theory explains the concentration of positive electricity in the base of the cloud; it also accounts for part of the negative electricity higher up in the cloud but the breaking of drops certainly does not explain the positive charge found at the top of all the thunderclouds investigated. At first sight it seemed as if Wilson's theory would fill the gap left by Simpson's theory since the former was put forward to account for the positive electricity at the top of a thundercloud and negative electricity below. The basis of Wilson's theory is that drops of water suspended in an electric field have charges of opposite sign induced on their upper and lower halves. As the drops fall in ionised air they tend to gain a net charge by attracting the ions of opposite sign to the charge on their lower halves. An essential part of the theory is that the drops must fall more rapidly than the electric field drives the ions downwards, otherwise the upper halves would also attract ions and no net charge would be gained. The result of the process is that in, say, a field which was initially positive the drops carry down a negative charge to the lower part of the cloud whilst positive charge is left to accumulate at the top, the initial positive field being thereby increased. Now the results of the soundings showed that the boundary between the positive electricity in the upper part of the cloud and the negative in the lower, was in every case in a region where the temperature was well below freezing point and generally below $-10°$ C. In this part of the cloud the precipitation must be in the form of ice crystals (the cloud particles themselves may be supercooled water, but on coalescing they would immediately freeze). These crystals cannot play the part of raindrops in Wilson's theory for they are almost perfect non-conductors and do not become electrically polarised; moreover, their rate of fall relative to the air is slow. It appears then, that Wilson's influence theory does not explain the separation of electricity in the upper part of the thunder-clouds. On the other hand there is little doubt that this upper separation of charge is associated with the presence of ice crystals. Probably the mechanism by which this separation of electricity is brought about is the same as that which produces strong electric fields during blizzards in polar regions; these fields are nearly always positive, *i.e.*, in the same direction as the field in the upper part of a thundercloud. Simpson has suggested that the impact of ice crystals results in the ice becoming negatively charged and the air positively charged; the general settling of the crystals relative to the air would cause a separation of electricity with positive charge above the negative.

The final conclusion is that there are two different physical processes taking place in a thundercloud to produce the electrical effects: one is confined to the upper parts of the cloud where the temperature is below the freezing point and the other occurs in the lower part of the cloud where the temperature is above the freezing point. It is believed that the former is connected with the presence of ice crystals and that the latter is explained by the electrification due to the breaking of raindrops.

The Five Year Cycle in the Circulation of the Atmosphere over the British Isles

By C. E. P. Brooks, D.Sc.

In his interesting article on " British Wind-Direction Periodicities " published in the *Meteorological Magazine* for July, Mr. Baxendell refers to various periodicities of a few years in the frequency of winds from different directions at Southport. One of the most interesting of these, of slightly over five years, was discovered by Mr. Baxendell himself.*

A few years ago Miss T. M. Hunt and I tabulated long series of resultants of wind direction frequencies at London, Edinburgh and Dublin† and one of the first uses made of these figures was a preliminary investigation of periodicities of wind direction in London.‡ The results were of sufficient interest to decide me to carry out the

* *London, Quart. J.R. met. Soc.*, 51, 1925, p. 371.
† *London, Quart. J.R. met. Soc.*, 59, 1933, p. 375.
‡ *London, Met. Mag.*, 68, 1933, p. 155.

analysis in greater detail in order to study the variations of the atmospheric circulation involved. The analysis of the periodicity of just over five years has now been completed.

In the published tabulations* the resultants, calculated from frequencies of wind from different directions irrespective of force, were given only for the winter and summer seasons and for the year. It was first necessary to calculate the resultants for spring and autumn also, in order to have a continuous series of seasonal values ; at the same time the data were extended to 1936. The figures for each season were expressed as components from north and east, and these were analysed separately. Seasonal means of pressure were also calculated for Stykkisholm (Iceland), Edinburgh, London, Paris and Valentia, though the last series is relatively short.

The method adopted to investigate the periodicity was a simple arithmetical one. Each interval of five years, or 20 seasonal values, was regarded as one oscillation with a length of five years, and the values of a and b were evaluated in the expression

$$w = a \sin t + b \cos t.$$

Overlapping sums of six successive a's and b's were formed, and from each pair of sums the amplitude and phase angle of the 5-year periodicity were calculated for the 30-year interval. The phase angles were plotted and most of the graphs showed a slow decrease of phase, indicating that the trial period of five years was too short. The best fitting straight line was then worked out in each case by the method of least squares, weighting according to the amplitude. This process gave the most probable lengths of the cycle of about five years as follows :—

TABLE I.—CALCULATED LENGTHS OF PERIODICITY.

		Years.	Period.
London	... N. component ...	5·04	1715–44, 1772–1936.
	E. component ...	5·05	
Edinburgh	... N. component ...	5·05	1787–1936.
	E. component ...	5·14	
Dublin	... N. component ...	5·05	1726–65, 1831–50, 1872–1936.
	E. component ...	?	
Stykkisholm	... Pressure ...	5·08	1846–1935.
Edinburgh	... Pressure ...	5·06	1817–1906.
London	... Pressure ...	5·18	1787–1936.
Paris ...	... Pressure ...	5·11	1757–1936.

It will be seen that the calculated lengths of the cycle in the N. component of wind direction frequency at all three places and in the E. component at London, agree very closely. At Edinburgh and Dublin the E. component is very small. The pressure data gave less concordant results, confirming a statement by Mr. Baxendell

* *London, Quart. J.R. met. Soc.*, 59, 1933, p. 375.

that the periodicity is much more clearly shown in the frequency of northerly winds than in pressure. At Edinburgh the pressure data for the years from 1772–1816 and 1907–36 showed no evidence of a periodicity of about five years, but the period 1817–1906 showed a periodicity of 5·06 years very clearly.

From these results it appeared that over two centuries or more the most probable length of the oscillation was not 5·1 or 5·09 years as previously supposed, but more nearly 5·05 years. The detailed study of the plotted phase angles for the N. component shows, however, that it has varied from time to time. At London it was 5·09 years from 1715 to 1797, 5·03 years from 1802 to 1887 and again 5·09 years from 1887 onwards. At Edinburgh there were breaks about 1840 and 1860, while at Dublin the length was about 5·0 years from 1726 to 1765 and 5·1 years from 1831 to 1936.

Assuming, however, a length of 5·05 years throughout in all series we have the following sine terms, with zero at January 1st, 1931. The amplitudes of the wind components are expressed as percentages of all observations, those of the pressures in millibars. The last column gives the standard deviations of the seasonal resultants or means in the same units.

TABLE II—SINE TERMS OF 5·05 YEAR PERIODICITY.

			S.D.
London 1715–1936 ...	... N. component ...	1·4 sin (t + 108)	14
	E. component ...	1·0 sin (t + 87)	16
London 1772–1936 ...	... N. component ...	2·0 sin (t + 98)	...
	E. component ...	1·3 sin (t + 77)	...
Edinburgh ...	... N. component ...	3·0 sin (t + 67)	13
	E. component ...	0·8 sin (t + 49)	15
Dublin	... N. component ...	1·7 sin (t + 47)	11
	E. component ...	0·4 sin (t + 74)	15
Stykkisholm ...	... Pressure	0·77 sin (t + 39)	4·0
Edinburgh ...	... Pressure	0·31 sin (t + 73)	2·7
London	... Pressure	0·18 sin (t + 154)	2·8
Paris	... Pressure	0·13 sin (t + 185)	2·9
Valentia (1867–1936)	... Pressure	0·21 sin (t + 108)	3·6

Mr. Baxendell places a maximum in the five year cycle of frequency of N. and NE. winds at Southport at the end of April 1926, which gives the phase on January 1st, 1931 as 63°, in good agreement with Edinburgh and Dublin. The results of the early series (1715–44) in London do not fit in very well with the later observations, so the sine terms were re-calculated for the interval 1772–1936.

A comparison of the phase angles of the N. and E. components throws some light on the nature of the wind oscillation. At all three stations the difference between the two components is less than 30°. Hence at each station these two components reach their positive values at nearly the same time, become zero and then again reach their greatest negative values almost simultaneously. In other words, a component from NNE. reaches its maximum, dies away and is replaced by a component from SSW. The resultant wind direction oscillates without veering or backing appreciably.

The sine terms for pressure are of great interest. The amplitude increases progressively from Paris to Iceland, and the phase angle decreases. This strongly suggests a wave of pressure advancing from south-south-east to north-north-west and increasing in amplitude as it does so. Measuring approximate distances along a line from Paris to Stykkisholm, we have the following data for the wave :

	Paris.	London.	Dublin.	Edinburgh.	Stykkisholm.
Distance (Km)	0	420	665	910	2340
Time (yrs)	0	0·44	1·08	1·58	2·08
Amplitude (mb) ...	0·13	0·18	0·21	0·31	0·77

It occurred to me that traces of this curious wave of pressure might be shown in the frequencies of occurrence of different types of anomalies of monthly mean pressure distribution as classified by myself and Miss W. A. Quennell*. I accordingly analysed the frequencies of each type and sub-type for a 5-year periodicity, using the data for 1873–1900 and 1910–35 inclusive. I found that types II D 6 and II E both showed a well-marked 5-year periodicity, with a much smaller reverse effect in the opposite types I D 6 and I E. The frequencies, expressed as percentages of all types, are as follows, the figures entered to year 1 being the sums of the frequencies in 1876, 1881, 1886, etc., those entered to year 2 the sums of 1877, 1882 and so on.

Year.	1	2	3	4	5
Type II D 6	9	4	3	8	11
„ II E	4	3	7	10	5
„ I D 6	2	5	3	5	1
„ I E	5	5	3	2	4

None of the other types or sub-types showed a noticeable 5-year periodicity. Now II D 6 is characterised by a deficit of pressure centred north of Iceland, and II E by a deficit of pressure over the Arctic Ocean generally. The two types are fairly similar, and a combination of them is shown in Fig. 1. The values assigned to the isopleths are arbitrary and inserted merely for illustration.

If the sums of II D 6 and II E in the table are expressed as a sine series, the phase angle (zero at January 1st, 1931) is found to be 150°. These types reach their maximum frequency approximately

* *London, Geophys. Mem.* 4, No. 31, 1926.

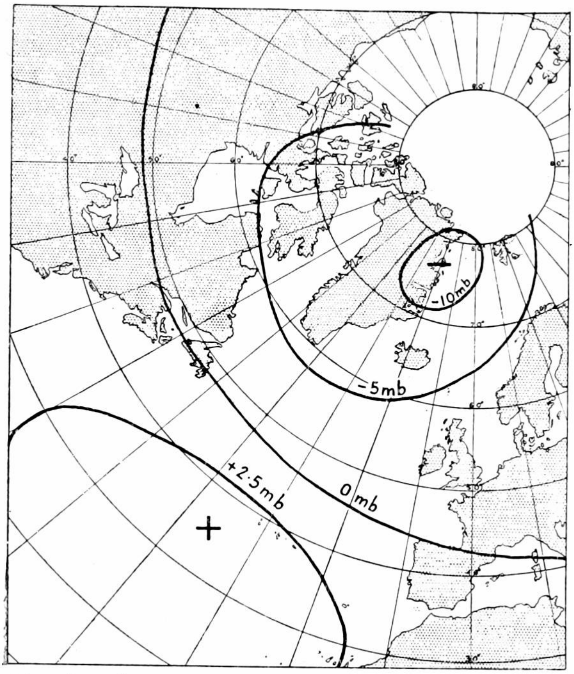


FIG. 1.—COMBINATION OF TYPES II D 6 AND II E.

a year after the 5-year pressure wave at Stykkisholm reaches its minimum. This lag is about equal to that to be expected from the rate of progression of the pressure wave from Paris to Stykkisholm. In other words, about the time that the minimum of the wave would be expected to reach north-east Greenland, there is a greater tendency for the deviations from normal to take the distribution shown in Fig. 1 than at other times.

The variations of the resultant winds in the 5·05 year cycle fit in excellently with the variations of pressure distribution. This was shown by constructing a series of generalised charts from the sine terms in Table II putting $t = 0, 1, 2, 3$ and 4 years. The map for $t = 0$ (*i.e.* January 1st, 1931 and multiples of 5·05 years before or after) is reproduced in Fig. 2 as a specimen. Here the direction of the arrows represents the direction of the resultant wind and the length of the arrows their constancy. The figures represent deviations of pressure in hundredths of a millibar and isopleths of pressure deviation have been drawn. A wind arrow for Southport has been added from Mr. Baxendell's data.

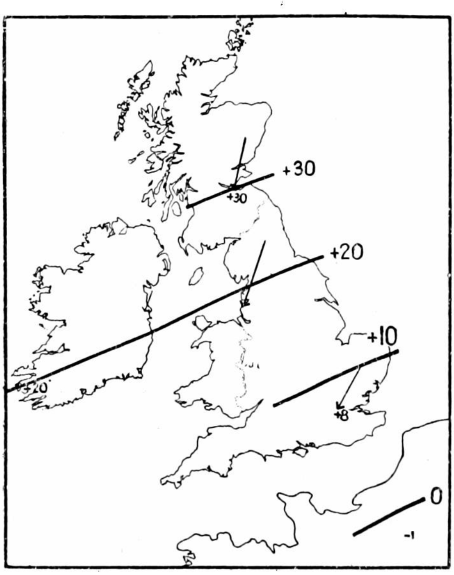


FIG. 2.—5·05 YEAR CYCLE, STAGE t=0. DEVIATIONS OF PRESSURE AND RESULTANT WIND FROM NORMAL.

The result of this investigation is to show that the 5·05 year cycle in the resultant wind direction in the British Isles is in some way associated with the advance northwards of a series of pressure waves, which are very small in France and southern England but increase rapidly in amplitude as they approach Iceland. The focus towards which these waves are directed apparently lies in the Arctic regions near the north of Greenland. I have termed them " waves " but this does not imply that they necessarily take the form of sine curves. Fig. 3 shows the average variations of pressure at Edinburgh and Stykkisholm in the cycle of 5·05 years. The curves are constructed from seasonal means, unsmoothed. At Edinburgh

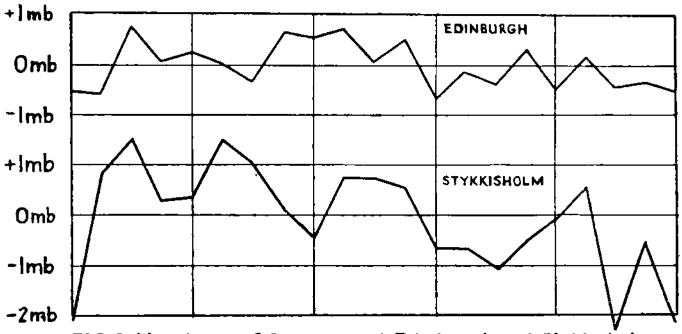


FIG 3 Variations of Pressure at Edinburgh and Stykkisholm in 5·05 year cycle.

the curve though irregular is fairly symmetrical, but at Stykkisholm the variation is more of the " saw-tooth " type, a rapid rise from minimum to maximum being followed by a slow oscillating fall from maximum to minimum. The change is curiously suggestive of the passage of a tide of the open sea into the tidal bore of a river, but whether the analogy has any significance is another matter.

OFFICIAL PUBLICATIONS

The following publications have recently been issued :—

Annual Report *of the Director of the Meteorological Office presented by the Meteorological Committee to the Air Council for the year ended March* 31, 1937.

The year under review was a period of planning and preparation in the Meteorological Office with the object of providing the greatly extended meteorological services required by the expanding Royal Air Force and the increased flying on civil air routes both in Great Britain and overseas. Additional officers were recruited and trained to staff the many new meteorological stations required on service and civil aerodromes in Great Britain and in connexion with the Empire Air Routes, both trans-Atlantic and eastwards. The Office also has been called upon to provide officers to take up appointments created by other services to meet the needs of Empire Air Routes.

In order to carry out a special programme of meteorological observations and investigation over the North Atlantic an officer has been attached to the s.s. *Manchester Port* for a year, *i.e.* to make eight round voyages between England and Canada.

Much attention has been given to the problem of the issue of warnings of the formation of ice on aircraft, which has been brought to the fore by the increased amount of flying within clouds now carried out by all types of aircraft.

PROFESSIONAL NOTES

No. 77. Variations of temperature at Oxford 1815–1934. By LILIAN F. LEWIS, B.Sc. (M.O. 336*q*.)

The paper contains a comprehensive analysis of the mean monthly and annual temperatures at Oxford from 1815–1934. An examination of the data shows that variations of temperature from the normal are considerably greater in the winter months, December, January and February than in any other month.

The second part of the note is concerned with an investigation of the records with regard to the secular trend of temperature. A curve, representing the variations in the twenty-year averages of mean annual temperature, is found to be definitely periodic. It has been suggested that the climate in middle latitudes of the northern hemisphere is tending to become somewhat milder and if the statistics for Oxford were available only since 1870, the curve would give some support to this suggestion, but the complete curve shows that similar mild periods have occurred previously. A curve representing approximately the annual range of temperature indicates that conditions were unusually equable during the first quarter of the twentieth century.

Discussions at the Meteorological Office

The subjects for discussion for the next two meetings are—

November 1st, 1937. *The evaporation of water from plane and cylindrical surfaces.* By R. W. Powell and E. Griffiths. (London, Trans. Instn. chem. Engrs., 13, 1935, pp. 175–98.) *Opener*—Mr. E. Ll. Davies, M.Sc.

November 15th, 1937. *The mean transport of air in the Indian and South Pacific Oceans* and *Outlines of Philippine frontology.* Both by C. E. Deppermann. (Manila Weather Bureau 1935 and 1936.) *Opener*—Mr. R. A. Watson, B.A.

Correspondence

To the Editor, *Meteorological Magazine*

Snowfall at Nottingham

May I suggest that the work of the British Group of the International Snow Commission would be appreciably helped if meteorological observers were to give more attention to the incidence and depth of snow.

During the past twenty-two years I have kept a record of snow days, days with snow lying, and depth of snowfall at Nottingham, and the following table gives the average values for each month over this period. No snow occurred in the four months June to September.

	Jan.	Feb.	Mar.	Apr.	May	Oct.	Nov.	Dec.	Year
Days with snow ...	4·7	5·2	4·9	2·6	0·3	0·3	1·5	3·4	22·9
Days with snow lying	4·1	4·5	3·0	0·8	0·0	0·1	1·0	3·5	17·0
Depth of snowfall in inches	2·3	3·2	2·2	0·5	0·0	0·0	0·4	1·3	9·9

In my records a day with " snow lying " is a day on which snow is definitely lying during the period and not merely at the hour of the morning observation. Days on which the ground may be whitened for a brief period by a snow shower are not counted as days with snow lying. The " morning observation " rule for snow lying is open to some objection. The ground might be free from snow at 9 a.m. on a certain day, but it might be covered by 10 a.m. and remain so all day. If a mild wind set in clearing the snow before the next morning's observation, no record would be made of " snow lying ", although actually it had been lying for hours. In keeping my record of " depth of snowfall " I have entered the actual depth of snow falling and lying each day as accurately as possible. I adopted the depth of $\frac{1}{4}$ inch as a minimum amount in much the same way that ·01 inch is used as the unit of rainfall. Depths under, say about one-eighth of an inch, I entered as trace, but such days were counted as days with " snow lying ", provided that at least half of the ground was covered. In very cold weather a mere sprinkling of snow may cover the ground for a day or two. The term " depth of snow " in my record excludes snow and sleet which thaws as it reaches the ground. In most registers, I imagine, no record is kept as to depth of snow falling beyond notes of the amount in considerable falls.

Systematic records of depths of snow all over the country on a basis such as I have outlined would produce interesting and useful data. The value of such records would be greatly increased were they standardised by rules formulated by the Meteorological Office.

ARNOLD B. TINN.

Kenilworth, Calstock Road, Woodthorpe, Nottingham, August 30th, 1937.

Lowest Rainfall for August, 1937

From the *Meteorological Magazine* I find that no station showed a lower rainfall total in August than the 0·18 in. recorded here. The closest approach was the return from Hodsock Priory, Worksop, 61 miles east-south-east from here, where 0·20 in. was measured. At Wath-upon-Dearne, 6 miles north, 0·27 in. fell.

Through the courtesy of the Borough Engineer for Rotherham

I am able to give herewith a selection of the readings of his gauges :—

Kimberworth Central School	... ...	0·17 in.
Aldwarke Sewage Works	... ...	0·13 in.
Spurley Hey Central School	... ...	0·12 in.

In view of these figures is it possible that a very circumscribed area in and about Rotherham has had the meteorological distinction of being the driest part of the British Isles in August, 1937 ?

A partial drought of 52 days started on July 22nd and ended on September 12th, during which period the total rainfall amounted to 0·36 in.

L. ATKINSON.

136, Broom Lane, Rotherham, Yorkshire, September 24th, 1937.

Remarkable Gloom in Dyffryn Clwyd

A spell of gloom occurred at Trefnant, in the Clwyd Valley, this afternoon, that I think should be recorded. After two or three cold days, the air this morning became warmer and felt humid, with a light NNE. wind. At 3 p.m. B.S.T. it became gloomy and the aspect of the sky caused me to prepare to record a thunderstorm. However, nothing came except a few drops of rain at 3·5 p.m. The darkness increased and after a few minutes it was impossible to see indoors without artificial light. Very heavy rain occurred from 3·28 p.m. to about 4·10 p.m., the gloom steadily growing thicker, and it was at its worst at 5 p.m., when the sky was practically indistinguishable. Even the gardeners had to stop work through inability to see, and rooks and jackdaws congregated at 4·55 p.m. and began to roost. This is an extraordinary happening in an area such as ours, so far remote from industrial areas.

Gradually after 5 p.m. the light got better until 5·35 p.m. when it was normal for a dull wet autumn day. It was dead calm throughout at the surface, with a very slow cloud drift from north-north-east. At the thickest of the gloom the colour was strongly yellow. I imagine from the appearance of things that an inversion was present and the wind, not being strong enough to dispel factory smoke, drifted slowly along charged with soot, and that we actually had Lancashire smoke fog in North Wales.

S. E. ASHMORE.

Llannerch Gardens, St. Asaph, Flintshire, North Wales, September, 13th, 1937.

Aurora at Boscombe Down on September 11th, 1937

A good auroral display was observed this morning (September 11th) as I was cycling from Salisbury to Boscombe Down aerodrome (in a northerly direction) from 2h. 45m. G.M.T., to 3h. 30m. G.M.T. The glow when first seen extended upwards from about 5° or 10° above the horizon and consisted of diffuse streaks of white light. After about 4 or 5 minutes it assumed a dull pinkish hue and streamers were observed upwards to an elevation of 30° to 40°

approximately. Subsequently the intensity of the display varied considerably; the light increased to a maximum which lasted for 10 to 12 minutes and then faded to a diffuse patch of light up to about 15° to 20° elevation, finally disappearing almost completely. After 5 or 6 minutes the phenomenon reappeared and the same sequence was repeated. The sky was cloudless, visibility 8 to 12 miles, wind northerly, 5 to 6 m.p.h., temperature 39° F.

W. A. A. KINGE.

Meteorological Station, R.A.F., Boscombe Down, Wilts., September 11th, 1937.

NOTES AND QUERIES

The Daily Range of Temperature

In the article entitled " The Unequal Heating of Land and Water " in the August issue of the *Meteorological Magazine,* some estimates are given of the mean daily range of temperature over land surfaces. The estimates are derived from values of mean daily maximum and mean daily minimum temperatures. That is a very common method of studying questions related to the diurnal variation of temperature, but it is as well to remind ourselves occasionally that it gives an extremely inaccurate idea of the true diurnal range of temperature, that is to say the average amount by which the temperature in the afternoon exceeds that in the early morning.

The proper method of examining this question is to study averages of hourly values, such as those which are available for the principal observatories. That is the only method that would occur to anyone who wanted to study the diurnal variation of pressure, of wind, or of almost any other element. In the case of temperature it happens to be the custom to tabulate daily extremes—mainly because it happens to be very easy to observe the daily extremes. We have acquired the habit of referring to the maximum temperature as the " day temperature " and the minimum temperature as the " night temperature ", and of regarding the " mean daily range ", as measured by the average difference between these quantities, as an approximation to the average daily rise of temperature due to insolation.

That is a mistaken idea, as we may see at once by a study of the data for Kew Observatory. The averages of hourly values for the period 1871–1915 are given in *Hourly Values from Autographic Records* 1915, 1916 and 1917. They are in degrees on the absolute tercentesimal scale; when converted to degrees Fahrenheit we find that the range of the hourly mean varies from 3·9° F. in December to 13·7° F. in June. Actually, the true diurnal range slightly exceeds the value found in this way because the highest and lowest points on the curve may not occur at exact hours, but the error is very small. We do not possess averages of daily extremes for the same period, but we have the values for 1881–1915 published in the " Book of Normals ", Section I. These give us " mean daily ranges " varying from 8·5° F. in January to 16·8° F. in June. Thus the daily range derived from readings of maximum and minimum thermometers is about double the true diurnal range in winter, and 23 per cent greater than the true diurnal range in summer. On the average for the whole year the range of daily extremes exceeds the true diurnal range by about 40 per cent at Kew.

The explanation of these discrepancies lies, of course, in the fact that solar radiation is not the only factor in causing the reading of the maximum thermometer to exceed that of the minimum thermometer. If we could expose self-registering thermometers at a point out at sea where there is no appreciable diurnal variation of temperature, we should still find substantial differences between the maximum and minimum daily readings, due to the casual and non-periodic changes arising from variations in the source of the air supply. A small daily range would also arise from the seasonal variation. In the neighbourhood of the British Isles the daily range due to such causes would appear to be 3° F. to 5° F., the variation being smaller in summer than in winter.

I do not wish to suggest that the author of the article was unfamiliar with the facts outlined above. I venture to think that the magnitude of the error made by the common method of determining the diurnal range of temperature may not, however, be fully appreciated by some of your readers. That is my excuse for troubling you with this note.

E. G. BILHAM.

Rainfall experienced during 1937

The incidence of rainfall so far experienced during 1937 over the British Isles, and more especially over England and Wales, is worthy of special comment. The early part of the year was abnormally wet, and details of the persistent rains of January to February were given on pp. 42–3 and of January to March on pp. 70–1 of this magazine.

Over the British Isles as a whole the rainfall of each of the first five months of the year, viz., January to May, exceeded the average. Over England and Wales all five months were also wetter than usual, but over Scotland only the first two and over Ireland only the first four months gave more than usual. Details of the general rainfall January to May, 1937 and the average values are given in Table I. The total experienced over England and Wales as a whole was comparable with that over Scotland and Ireland, although on the average England and Wales are appreciably drier. The total of 21·2 in. exceeds the average amount by as much as 8·6 in., and is greater than that of any similar period back to before 1870. The next wettest first five months of the year back to 1870 were those of 1920, 1877 and 1872 with 17·5 in., 18·4 in., and 17·6 in., respectively.

Table I also gives details of the rainfall June to September, 1937. The total was again most striking over England and Wales, being

TABLE I

	England and Wales	Scotland	Ireland
	in.	in.	in.
January–May, 1937	21·2	21·2	21·8
January–May. Average*	12·6	19·1	16·5
June–September, 1937	8·1	15·1	14·3
June–September. Average* ...	11·2	15·1	13·5

* For the period 1881–1915.

3·1 in. less than the average, whereas over both Scotland and Ireland the rainfall approximated closely to the average. The total of 8·1 in. over England and Wales compares with 8·0 in., 8·2 in., and 7·0 in. for similar periods during 1933, 1929 and 1921, respectively.

In spite of the fact that the total rainfall over England and Wales for January to September, 1937 is as much as 5·5 in. above the average, the incidence of four consecutive dry months, June to September, has resulted in the ground at the beginning of October being generally dry with only small storages of water for supply in many localities.

J. GLASSPOOLE.

REVIEW

The climates of the continents. By W. G. Kendrew, M.A., 3rd edition. Size 9 in. × 5½ in., pp. xii + 473. *Illus.* Oxford. At the Clarendon Press, 1937. 21*s*. net.

Mr. Kendrew's book has become a classic of English climatology. Published first in 1922 to " fill a gap in the sources available for the study of the earth " it rapidly went out of print; a second edition which appeared in 1927 was reprinted in 1930, and a third edition has now followed in 1937.

The general arrangement of the volume is identical with the earlier editions, but nevertheless the changes are considerable even though they are chiefly concerned with details only. The whole of the text has been reset, the tables have been revised and many of the maps and diagrams have been redrawn in order to incorporate the most recent information. This applies especially to the maps of temperature, rainfall and wind; most of these are new and take into consideration much of the vast amount of information published in the climatological atlases of the several countries that have recently appeared. The new edition carries a much enlarged bibliography which now appears at the end of the book instead of at the beginning and is classified geographically according to the continents.

The whole is a very readable volume. Statistics are there for those who like them, but they are kept apart from the text which is amply illustrated by no less than 160 charts and diagrams. The text is not confined to a description of the data, the reader of a chapter is left with a vivid conception of the type of weather that is experienced and this is due very largely to the number of quotations interspersed in the text giving descriptions by local residents of some of the notable happenings of the weather.

To criticise the details of the facts presented would require a reviewer of encyclopaedic knowledge and is beyond the capacity of the present writer. One point however may be noted. Recent memoirs on the depressions of eastern Asia by Father Gherzi of the Zi-ka-wei Observatory and by members of the staff of the Nanking Research Institute have shown that in the winter and spring months the precipitation in these depressions differs very notably from that of the depressions of western Europe in that it falls almost entirely in the rear of the depression after the passage of the cold front. It is apparently carried by the E. and SE. winds as Mr. Kendrew suggests but it falls only after these winds have been undercut by the cold northerly winds in the rear; according to the old Chinese proverb "Rainfall bearers are the north-easters". A summary of the main facts of these depressions would form a useful addition to the volume; their characteristics are comparatively little known to western meteorologists and they have an important influence on the climate of eastern Asia.

One of the facts which the reading of the volume brings home is the importance of orographic features and of ocean currents in determining the climate of any locality; they are referred to in almost every chapter. As the one refers to the land and the other to the sea a single chart of the world would carry them both, and might well form a frontispiece even on small scale to any new edition that may be called for.

The index runs to some 13 pages. It is limited almost entirely to geographical names, though the names of certain local winds are also included; it appears however to be adequate to its purpose. For anyone accustomed to revised editions the necessity of checking the entries against the final text is illustrated; a chance reference revealed the fact that entries for page 313 were assigned to 312 apparently on account of a transposition of the pages in the proof stage.

The title of the book is itself a challenge. Mr. Kendrew has provided English speaking peoples with an excellent volume on "The Climates of the Continents" will he, or any other enterprising meteorologist, provide a companion volume on the corresponding features of the oceans.

E. E. Austin.

BOOKS RECEIVED

Estudios Meteorologicos de Colombia, 1931–1935. Bogota, 1936.

Mysore Meteorological Memoirs No. XI. Monthly and annual means of hourly values of weather elements, Bangalore Observatory, 1915–1929. Bangalore, 1935.

OBITUARY

Richard Inwards.—We regret to learn of the death on September 30th of Mr. Richard Inwards. Mr. Inwards was born at Houghton Regis on April 22nd, 1840, and so lived to within three years of his century. From an early age he was interested in meteorology and astronomy, joining the Royal Meteorological Society in 1862 ; his work as a mining expert and mine manager carried him into many distant parts of the world, and he accumulated a great fund of knowledge concerning the various weather beliefs current in the form of proverbs in various countries. In 1893 he published a collection of these " proverbs, sayings and rules concerning the weather " under the title of " Weather Lore." This well-known book went through three editions, the last appearing in 1898, and is still a valuable source of information.

Mr. Inwards took a very active part in the work of the Royal Meteorological Society. He served as President in 1894 and 1895, taking as the subjects of his addresses " Weather Fallacies " and " Meteorological Observatories." He also served as Treasurer and for twenty years he took a large share in editing the *Quarterly Journal.* In his later years he was a well-known figure in Highgate, and in the early 1920's he was often to be seen walking in Parliament Hill Fields. He also played chess and retained his faculties so well that long after his 80th birthday he could hold his own with much younger men. He was by many years the Senior Fellow of the Royal Meteorological Society and the Council sent him telegrams of congratulation on each successive lustrum that he completed. Mr. Inwards never married, but his loss will be felt by a wide circle of friends among the older meteorologists.

NEWS IN BRIEF

We learn that Dr. Heinrich v. Ficker, Professor of Meteorology at the University of Berlin has been appointed Professor of Geophysics at the University of Vienna and Director of the Zentralanstalt für Meteorologie und Geodynamik.

With effect from July 1st, 1937, the newly established independent Meteorological Service of Burma took over the duties of issuing weather reports and forecasts for air routes in Burma, work which was previously performed by the Calcutta Office of the India Meteorological Department.

The Weather of September, 1937

In the northern hemisphere pressure was lowest (1000 mb.) over Iceland where it was 6–8 mb. below normal, and highest (1,024 mb., 4 mb. above normal) west of the Azores. There was thus an unusually steep gradient for westerly winds over the Atlantic, west of the British Isles, continuing as a gradient for south-westerly winds over Scandinavia and the eastern Baltic. The Azores anticyclone was continued as a narrow ridge of high pressure (1,016 mb.) along the Alps, broadening out eastwards into a weak anticyclone (1,019 mb., 3–4 mb. above normal) north of the Caspian. Over most of Asia and North America pressure was rather uniform, between 1015 and 1018 mb., and the deviations from normal were small.

The mean temperature for 18 days at the north pole was 9°F., but most of the Arctic coasts of Asia and America were about 35° F., rising to 39° at Spitsbergen and Bear Island. In Europe temperature increased from 45° F. in the north of Norway to 50° in the Shetlands, central Scandinavia and Finland, 60° south of the English channel and across the Alps and central Europe and 70° from Gibraltar across southern Italy, Greece and the Black Sea and north of the Caspian; upper Egypt was still above 90° F. Most of central Siberia lay between 40° and 50° F., but on the Pacific coast temperature increased from 58° F. in 50° N. to 75° F. at Shanghai and 82° F. at Hongkong. In America and northern Canada temperature was below 40° F., rising to 50° F. from central Alaska to south of Hudson Bay, 60° F. in about 45° N., 70° F. in 35° N. and 80° F. on the Gulf Coast of the United States. Temperatures were generally above normal, especially north of the Black Sea and Caspian, where the excess was 8°–10° F.; in Alaska, north-west and west Canada, excess 4°–6° F., and the coast of Newfoundland and Nova Scotia, excess 5° F. The British Isles were 1° F. above normal in the north-west and 1° F. below normal at Kew. The eastern United States, the Alps and central Siberia were also slightly below normal.

Precipitation was heavy (4–8 in.) on the coast of north-west Europe, where it was generally about 1½ times the normal, decreasing rapidly eastwards ; it was also abnormally heavy in parts of southern Europe. In America the falls of 1–2 in. were generally somewhat below normal.

In Australasia pressure was highest (1020 mb.) between New South Wales and New Caledonia and west of Perth (West Australia) while a large area below 1010 mb. extended from French Indo-China across the Philippines. Most of Australia was about 1016–1019 mb., New Zealand 1012–1014 mb. The deviations from normal were generally small, but reached +4 mb. at Sydney. Temperature decreased from 80° F. over Indo-China, Siam, Malaya, the Philippines and the Northern Territory of Australia to 70° F. in about lat. 21° S, 60° F. in lat. 28° S. in the west and 35° S. in eastern Australia and 50° F. south of Tasmania. In New Zealand temperature decreased from 53° F. in the north to 47° F. in the south. The deviations from normal were generally small but Victoria and Tasmania were about 2° F. above normal and central Australia 3° F. below normal. Much of Australia was rainless but about an inch fell in New South Wales and 1–3 in. on the south coast. In New Zealand and Tasmania the rainfall was heavier (3–6 in.) but in both countries the falls were generally below normal.

Over the British Isles during September temperature was above the average at the beginning and end of the month but below the average in the middle of the month. Both rainfall and sunshine were in general about the average except that rainfall was considerably in excess in south Ireland and sunshine in the Midlands and east Scotland, while there was a marked deficiency of sunshine in Ireland. There was also much early morning mist or fog. From the 1st to 6th a deep depression centred to the north-west of the British Isles caused generally unsettled warm weather with frequent rain in the north and west, 2·06 in. at Inagh (Co. Clare) on the 4th and 1·56 in. at Troutbeck (Cumberland) on the 5th. In the south some rain occurred in most parts on the 1st, 2nd and 7th, but otherwise until the 9th conditions there were mainly dry and sunny, 11·1 hrs. bright sunshine were experienced at Point of Ayre on the 2nd and over 10 hrs. at many places in the south on the 3rd to 6th and in north England and Scotland on the 5th. On the 7th to 9th the depression to the north moved away eastwards but on the 9th a deepening depression moved south-east across the south-western districts to France causing rain in most parts except the north. Gales were experienced in the north-west and north on the 5th to 9th. After the 8th there was a general drop in temperature with the change to northerly winds, maxima had reached 80° F. at Cambridge, Norwich and Oxford on the 7th, but a maximum of 51° F. was reported from Waterford on the 9th and of 52° F. at Cullompton on the 10th. From the 10th to 12th cold anticyclonic weather prevailed with much sun on the 10th and 11th, but overcast skies on the 12th. From then to the 22nd pressure was generally low over the country except on the 14th and 21st when ridges of higher pressure passed across. During this period the weather was unsettled. Thunderstorms were frequent, being reported from some part or other of the country on each day from the 13th to 20th inclusive—they were most widespread on the 17th—while hail was recorded at a few places and a gale in north-west Ireland on the 21st. Morning mist or fog occurred locally, becoming more general on the 19th, 21st and 22nd when it was thick in places. Temperature continued low for the time of year—on a few nights screen minima as low as 30° F. to 35° F. were recorded—though between about the 15th to 18th maxima approached nearer the average. With the change to southerly winds veering south-west on the 22nd, temperature rose again generally reaching 70° F. at a few places. On the 23rd and 24th dry sunny anticyclonic conditions with morning mist or fog prevailed in the south but the north and west came under the influence of a depression to the north which was moving eastwards. Gales were reported from the north-west on the 24th. A trough of low pressure extending from this depression passed across the south on the 25th causing the wet weather to spread south followed by cold northerly winds. In the north the 25th was a sunny day, Aberdeen had 10·2 hrs. bright sunshine. On the 26th there was a return to warm sunny conditions in the south and east owing to the influence of the anticyclone extending from Scandinavia to the Mediterranean while a depression lay to the west. This depression brought slight rain to the north and south on the 27th, while central districts had considerable sunshine. From the 28th to 30th the south came under the influence of an anticyclone passing from the Atlantic to the continent while the north and, from the evening of the 29th, Ireland were influenced by deep depressions to the north moving eastwards which caused considerable rain at times. In the south there was much mist or fog on the mornings of the 29th and 30th, but much sunshine on all three days which extended at times to the north as well. The distribution of bright sunshine for the month was as follows :—

	Total (hrs.)	Diff. from normal (hrs.)		Total (hrs.)	Diff. from normal (hrs.)
Stornoway ...	102	− 8	Chester ...	138	+ 8
Aberdeen ...	160	+34	Ross-on-Wye ...	153	+17
Dublin	113	−17	Falmouth ...	160	+ 2
Birr Castle ...	92	−27	Gorleston ...	152	− 6
Valentia... ...	100	−27	Kew	153	+ 7

Kew, Temperature, Mean 57·5° F., Diff. from normal − 1·0° F.

Miscellaneous notes on weather abroad culled from various sources.

Severe gales were reported on all coasts of France on the 11th and 12th. A sudden cold spell was experienced in Switzerland and Austria about the 13th, snow falling down to the 3,000 ft. level. Thunderstorms accompanied by torrential rains swept the Riviera on the night of the 13th and floods were experienced in the Rhone Valley about the 20th. Persistent heavy rain for a fortnight caused the waters of Lake Como to rise so much on the 20th that the town of Como was partly flooded—most of the rivers in northern Italy were in flood by the 20th and the mountains covered with snow (*The Times*, September 13th–22nd).

After many months of drought abundant rain fell in southern Morocco about the 16th. Twenty Algerians and many cattle were swept away by flooded rivers as the result of heavy rains in the Department of Oran about the 27th (*The Times*, September 17th–28th).

A typhoon which formed east of Manila at the end of August passed across Hongkong during the early hours of September 2nd—this was followed by a tidal wave which swept ¼ mile inland and overwhelmed two villages, Taipo and Taipo Market. About 400 people were killed or drowned and much material damage was done both on land and sea. Floods occurred in the Honan province and also along other parts of the Yellow River about the 9th. A typhoon swept across south-west Japan on the 11th killing 18 people and injuring 119, while many houses were damaged and flooded (*The Times*, September 3rd–13th).

A severe storm swept across Nova Scotia about the 12th and a hurricane on the 15th, destroying nearly half the apple crop (*The Times*, September 14–16th).

Daily Readings at Kew Observatory, September, 1937

Date	Pressure, M.S.L. 13h.	Wind, Dir., Force 13h.	Temp. Min.	Temp. Max.	Rel. Hum. 13h.	Rain.	Sun.	REMARKS. (see vol. 69, 1934, p. 1).
	mb.		°F.	°F.	%	in.	hrs.	
1	1013·8	SW.4	59	73	66	—	1·1	d_0 21h.–23h.
2	1015·4	SW.3	58	72	71	0·12	5·6	PR 14h. r_0–23h.–24h.
3	1018·8	WSW.3	59	71	47	trace	9·0	r_0 0h.–2h.
4	1024·9	S.2	48	70	49	—	10·3	w early.
5	1020·3	SW.3	48	72	53	—	9·7	w early.
6	1018·5	SW.3	53	75	52	—	7·6	w early.
7	1019·0	SW.3	61	76	63	—	7·3	
8	1025·2	N.2	57	68	44	0·03	8·2	r_0–r 4h.–6h.
9	1021·0	WNW.1	48	60	82	0·25	0·6	r–r_0 12h.–17h. r_0 19h.–
10	1020·6	NNW.3	45	60	49	—	6·0	w early. [21h.
11	1020·2	N.4	45	57	57	—	5·7	
12	1019·3	N.2	47	58	56	0·03	1·2	r–r_0 17h.–23h.
13	1002·0	N.1	51	60	69	0·55	1·2	r_0 1h.–4h. tlR 15h.–
14	1003·7	NW.2	47	62	51	—	7·0	[16h.
15	993·4	SSW.4	53	66	68	0·07	3·5	r_0–r 2h.–5h., 14h.–16h.
16	990·3	SSE.2	43	62	71	0·07	4·3	pr 10h.–17h. tl 14h.
17	988·0	S.3	50	63	75	0·57	2·1	R 7h.,9h.–10h., tl 10h.
18	999·5	SW.3	48	64	55	—	9·9	w early and late.
19	1001·9	N.3	45	57	88	0·16	0·0	wf early R–r 12h.–15h.
20	1009·1	N.3	46	58	64	0·04	3·4	pr 13h., 14h., 16h.
21	1016·6	SW.2	41	58	71	—	1·3	w early.
22	1013·7	S.3	50	65	60	—	4·3	w early.
23	1022·4	WSW.1	41	66	63	—	7·5	Fe early.
24	1021·1	SW.3	43	65	65	—	5·4	Fe early.
25	1020·8	NE.1	55	57	91	0·13	0·0	r_0–r 2h.–11h., 14h.–
26	1018·8	SSE.3	56	71	66	—	9·3	w early. [19h.
27	1014·8	E.1	52	71	75	0·01	0·1	f to 10h., r_0 11h., 18h.
28	1019·0	W.3	55	65	57	—	6·4	w late.
29	1022·0	SW.2	44	67	65	—	8·4	Fe early. f late.
30	1016·0	S.3	45	66	59	—	6·7	Fe early.
*	1013·7	—	50	65	63	2·04	5·1	* Means or Totals.

General Rainfall for September, 1937

England and Wales ...	97	per cent of the average 1881–1915.
Scotland	85	
Ireland	133	
British Isles	101	

Rainfall : September, 1937 : England and Wales

Co.	Station.	In.	Per cent of Av.
Lond .	Camden Square..........	1·54	85
Sur .	Reigate, Wray Pk. Rd..	1·99	96
Kent .	Tenterden, Ashenden...	2·72	127
,, .	Folkestone, Boro. San.	3·11	...
,, .	Margate, Cliftonville....	2·50	127
,, .	Eden'bdg., Falconhurst	2·16	95
Sus .	Compton, Compton Ho.	2·19	79
,, .	Patching Farm..........	2·09	87
,, .	Eastbourne, Wil. Sq....	2·62	105
Hants.	Ventnor, Roy.Nat.Hos.	2·72	110
,, .	Fordingbridge, Oaklnds	2·70	126
,, .	Ovington Rectory.......	1·73	76
,, .	Sherborne St. John......	2·15	105
Herts .	Royston, Therfield Rec.	1·91	102
Bucks.	Slough, Upton............	2·44	139
,, .	H. Wycombe, Flackwell	3·24	165
Oxf .	Oxford, Radcliffe.........	1·98	116
N'hant	Wellingboro, Swanspool	1·27	71
,, .	Oundle	1·27	...
Beds .	Woburn, Exptl. Farm...	1·46	82
Cam .	Cambridge, Bot. Gdns.	2·37	147
,, .	March.......................	1·22	68
Essex .	Chelmsford, County Gdns	1·28	74
,, .	Lexden Hill House......	1·89	...
Suff .	Haughley House.........	1·13	...
,, .	Rendlesham Hall.........	2·54	132
,, .	Lowestoft Sec. School...	2·17	111
,, .	Bury St. Ed., WestleyH.	1·70	85
Norf. .	Wells, Holkham Hall...	1·19	63
Wilts .	Porton, W.D. Exp'l. Stn	2·16	123
,, .	Bishops Cannings........	3·14	143
Dor .	Weymouth, Westham.	2·13	101
,, .	Beaminster, East St....	3·30	129
,, .	Shaftesbury, Abbey Ho.	3·48	143
Devon.	Plymouth, The Hoe....	2·32	91
,, .	Holne, Church Pk. Cott.	3·02	84
,, .	Teignmouth, Den Gdns.	2·23	114
,, .	Cullompton	2·71	120
,, .	Sidmouth, U.D.C.........	2.34	...
,, .	Barnstaple, N. Dev.Ath	4·44	164
,, .	Dartm'r, Cranmere Pool	4·90	...
,, .	Okehampton, Uplands.	3·12	96
Corn .	Redruth, Trewirgie......	3·71	119
,, .	Penzance, Morrab Gdns.	4·05	138
,, .	St. Austell, Trevarna...	3·99	125
Soms .	Chewton Mendip.........	2·48	81
,, .	Long Ashton............	2·11	88
,, .	Street, Millfield..........	4·00	180
Glos .	Blockley	2·65	...
,, .	Cirencester, Gwynfa....	1·82	83
Here .	Ross-on-Wye.............	2·30	120
Salop .	Church Stretton.........	3·25	160
,, .	Shifnal, Hatton Grange	2·92	151
,, .	Cheswardine Hall........	2·20	108
Worc .	Malvern, Free Library...	2·46	127
,, .	Ombersley, Holt Lock.	2·80	158
War .	Alcester, Ragley Hall...	2·49	140
War .	Birminghm, Edgbastor	1·99	111
Leics .	Thornton Reservoir ...	1·86	99
,, .	Belvoir Castle............	·97	52
Rut .	Ridlington	1·35	70
Lincs .	Boston, Skirbeck.........	1.41	80
,, .	Cranwell Aerodrome...	·75	42
,, .	Skegness, Marine Gdns.	1·17	65
,, .	Louth, Westgate.........	·96	48
,, .	Brigg, Wrawby St.......	·97	...
Notts .	Mansfield, Carr Bank...	1·63	89
Derby.	Derby, The Arboretum	1·58	92
,, .	Buxton, Terrace Slopes	1·50	46
Ches .	Bidston Obsy.............	2·09	87
Lancs.	Manchester, Whit. Pk.	1·02	43
,, .	Stonyhurst College......	2·64	69
,, .	Southport, Bedford Pk.	2·02	73
,, .	Ulverston, Poaka Beck	4·25	99
,, .	Lancaster, Greg Obsy.	2·68	79
,, .	Blackpool	2·02	71
Yorks.	Wath-upon-Dearne......	1·65	104
,, .	Wakefield, Clarence Pk.	1·36	85
,, .	Oughtershaw Hall.......	4·26	...
,, .	Wetherby, Ribston H..	1·12	62
,, .	Hull, Pearson Park......	1·29	75
,, .	Holme-on-Spalding......	·90	52
,, .	West Witton, Ivy Ho.	1·52	71
,, .	Felixkirk, Mt. St. John.	1·21	66
,, .	York, Museum Gdns....	1·06	65
,, .	Pickering, Hungate......	1·61	84
,, .	Scarborough..............	1·49	83
,, .	Middlesbrough...........	1·52	92
,, .	Baldersdale, Hury Res.	2·60	104
Durh .	Ushaw College...........	1·76	88
Nor .	Newcastle, Leazes Pk...	1·67	84
,, .	Bellingham, Highgreen	3·38	141
,, .	Lilburn Tower Gdns....	1·01	43
Cumb.	Carlisle, Scaleby Hall...	2·69	100
,, .	Borrowdale, Seathwaite	11·00	117
,, .	Thirlmere, Dale Head H.	7·78	123
,, .	Keswick, High Hill......	5·08	120
West .	Appleby, Castle Bank...	2·38	94
Mon .	Abergavenny, Larchf'd	1·26	54
Glam .	Ystalyfera, Wern Ho....	4·48	103
,, .	Treherbert, Tynywaun.	4·58	...
,, .	Cardiff, Penylan.........	1·94	64
Carm .	Carmarthen, M. & P. Sch.	4·28	119
Pemb .	Pembroke, Stackpole Ct.	3·45	111
Card .	Aberystwyth	3·36	...
Rad .	BirmW.W.Tyrmynydd	3·22	83
Mont .	Lake Vyrnwy	2·19	62
Flint .	Sealand Aerodrome......	1·59	...
Mer .	Blaenau Festiniog	5·86	82
,, .	Dolgelley, Bontddu......	4·17	98
Carn .	Llandudno	2·60	122
,, .	Snowdon, L. Llydaw 9..	9·60	...
Ang .	Holyhead, Salt Island...	2·99	112
,, .	Lligwy	2·62	...

Rainfall: September, 1937: Scotland and Ireland

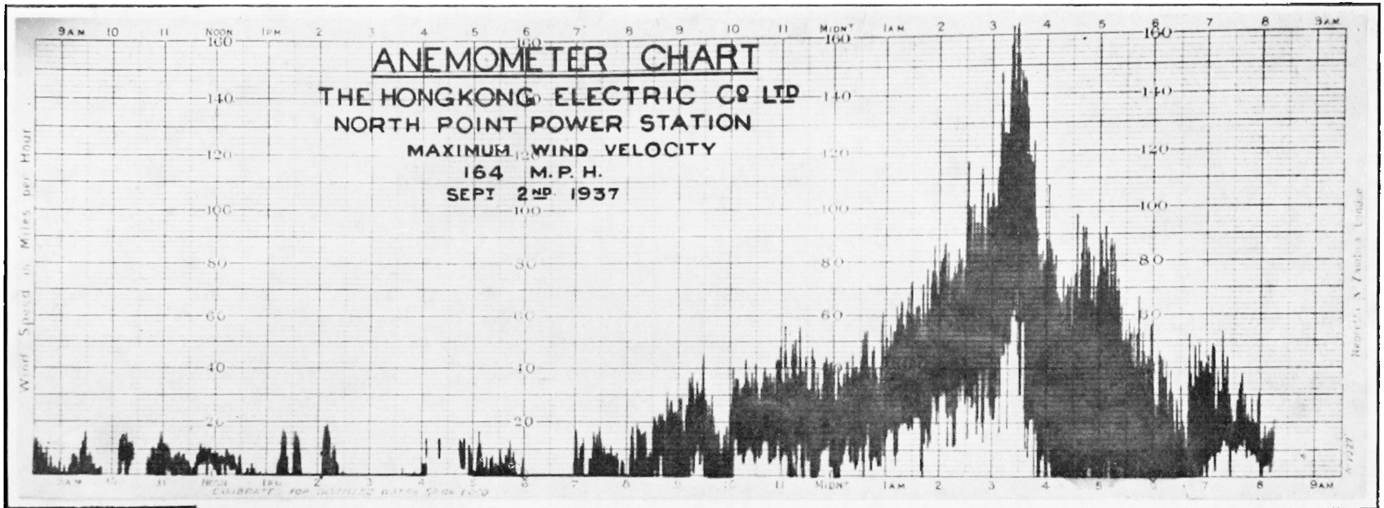
Co.	Station.	In.	Per cent of Av.	Co.	Station.	In.	Per cent of Av.
I. Man	Douglas, Boro' Cem....	2·50	77	*R&C* .	Achnashellach	6·62	91
Guern.	St.Peter P't.Grange Rd.	3·33	128	,, .	Stornoway,C.GuardStn.	4·41	118
Wig .	Pt. William, Monreith.	2·36	81	*Suth* .	Lairg........................	2·06	73
,, .	New Luce School.........	3·23	90	,, .	Skerray Borgie............	2·78	...
Kirk .	Dalry, Glendarroch......	2·56	70	,, .	Melvich.....................	2·12	76
Dumf.	Dumfries, Crichton R.I.	2·60	102	,, .	Loch More, Achfary....	5·93	103
,, .	Eskdalemuir Obs........	4·80	130	*Caith* .	Wick	1·75	70
Roxb .	Hawick, Wolfelee........	2·38	93	*Ork* .	Deerness	3·12	108
Peeb .	Stobo Castle..............	...	...	*Shet* .	Lerwick	2·59	93
Berw .	Marchmont House......	1·52	63	*Cork* .	Dunmanway Rectory...	...	...
E.Lot .	North Berwick Res.....	1·03	49	,, .	Cork, University Coll...	3·01	112
Midl .	Edinburgh, Blackfd. H.	1·64	80	,, .	Mallow, Longueville....	3·58	149
Lan .	Auchtyfardle	2·48	...	*Kerry*.	Valentia Observatory...	6·55	158
Ayr .	Kilmarnock, Kay Park	2·55	...	,, .	Gearhameen...............	8·70	143
,, .	Girvan, Pinmore.........	2·88	75	,, .	Bally McElligott Rec...	...	...
,, .	Glen Afton, Ayr San. ...	3·31	85	,, .	Darrynane Abbey.......	6·12	172
Renf .	Glasgow, Queen's Park	3·53	127	*Wat* .	Waterford, Gortmore...	3·89	143
,, .	Greenock, Prospect H..	4·48	94	*Tip* .	Nenagh, Castle Lough.	...	...
Bute .	Rothesay, Ardencraig...	3·34	82	,, .	Roscrea, Timoney Park	...	...
,, .	Dougarie Lodge..........	2·54	66	,, .	Cashel, Ballinamona....	3·07	127
Arg .	Loch Sunart, G'dale....	...	...	*Lim* .	Foynes, Coolnanes......	3·78	131
,, .	Ardgour House..........	11·70	...	*Clare* .	Inagh, Mount Callan....	10·49	...
,, .	Glen Etive..................	8·55	111	*Wexf* .	Gorey, Courtown Ho...	3·79	153
,, .	Oban.........................	6·25	...	*Wick* .	Rathnew, Clonmannon.	3·16	...
,, .	Poltalloch..................	5·22	114	*Carl* .	Bagnalstown,Fenagh H.	3·17	128
,, .	Inveraray Castle.........	9·45	147	,, .	Hacketstown Rectory...	3·48	124
,, .	Islay, Eallabus............	4·19	100	*Leix* .	Blandsfort House.......	2·96	109
,, .	Mull, Benmore............	8·40	73	*Offaly*.	Birr Castle...............	4·00	175
,, .	Tiree	4·53	122	*Kild* .	Straffan House	2·26	101
Kinr .	Loch Leven Sluice.......	1·56	61	*Dublin*	Dublin, Phoenix Park..	1·45	76
Fife .	Leuchars Aerodrome...	1·10	57	*Meath*.	Kells, Headfort..........	4·89	184
Perth .	Loch Dhu..................	6·60	115	*W.M* .	Moate, Coolatore.........	5·33	...
,, .	Crieff, Strathearn Hyd.	2·66	93	,, .	Mullingar, Belvedere...	4·76	178
,, .	Blair Castle Gardens....	2·36	100	*Long* .	Castle Forbes Gdns......	4·85	169
Angus.	Kettins School............	1·02	46	*Gal* .	Galway, Grammar Sch.	5·43	172
,, .	Pearsie House............	1·80	...	,, .	Ballynahinch Castle....	9·60	202
,, .	Montrose, Sunnyside...	1·31	66	,, .	Ahascragh, Clonbrock.	5·42	175
Aber .	Balmoral Castle Gdns..	·96	40	*Rosc* .	Strokestown, C'node.....	...	...
,, .	Logie Coldstone Sch....	·50	21	*Mayo*.	Blacksod Point..........	4·20	108
,, .	Aberdeen Observatory.	1·53	69	,, .	Mallaranny	7·08	...
,, .	New Deer School House	1·79	71	,, .	Westport House.........	4·57	129
Moray	Gordon Castle............	1·09	44	,, .	Delphi Lodge.............	11·10	147
,, .	Grantown-on-Spey	1·11	45	*Sligo* .	Markree Castle...........	4·68	138
Nairn.	Nairn	1·13	51	*Cavan*.	Crossdoney, Kevit Cas..	4·30	...
Inv's .	Ben Alder Lodge.........	4·11	...	*Ferm* .	Crom Castle..............	3·65	131
,, .	Kingussie, The Birches.	2·13	...	*Arm* .	Armagh Obsy............	2·35	96
,, .	Loch Ness, Foyers	4·02	137	*Down*.	Fofanny Reservoir......	3·93	...
,, .	Inverness, Culduthel R.	1·62	69	,, .	Seaforde	3·44	125
,, .	Loch Quoich, Loan......	12·65	...	,, .	Donaghadee, C. G. Stn.	1·85	77
,, .	Glenquoich................	9·63	111	*Antr* .	Belfast,Queen's Univ....	1·92	75
,, .	Arisaig House............	5·83	96	,, .	Aldergrove Aerodrome.	2·00	81
,, .	Glenleven, Corrour......	...	...	,, .	Ballymena, Harryville.	2·38	77
,, .	Fort William, Glasdrum	9·33	...	*Lon* .	Garvagh, Moneydig....	3·23	...
,, .	Skye, Dunvegan.........	7·13	...	,, .	Londonderry, Creggan.	3·98	121
,, .	Barra, Skallary..........	4·05	...	*Tyr* .	Omagh, Edenfel.........	3·84	126
R&C .	Alness, Ardross Castle.	...	...	*Don* .	Malin Head...............	4·41	...
,, .	Ullapool	3·90	104	,, .	Dunkineely................	5·31	...

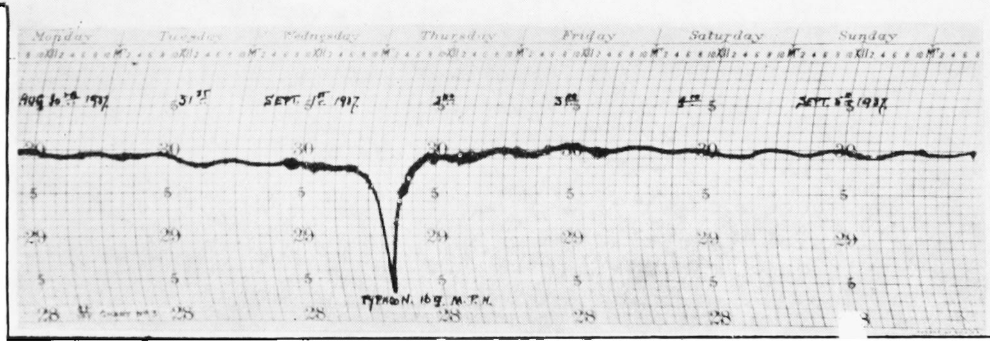
Climatological Table for the British Empire, April, 1937

STATIONS.	PRESSURE.		TEMPERATURE.							Rela-tive Hum-idity.	Mean Cloud Am'nt	PRECIPITATION.			BRIGHT SUNSHINE.	
			Absolute.		Mean Values.				Mean.							
	Mean of Day M.S.L.	Diff. from Normal.	Max.	Min.	Max.	Min.	½ Max. and Min.	Diff. from Normal	Wet Bulb.			Am'nt.	Diff. from Normal.	Days.	Hours per day.	Per-cent-age of possi-ble.
	mb.	mb.	°F.	°F.	°F.	°F.	°F.	°F.	°F.	%	0–10	in.	in.			
London, Kew Obsy.	1010·7	− 3·7	61	31	56·3	43·5	49·9	+ 2·8	44·2	86	8·4	1·98	+ 0·53	16	3·4	25
Gibraltar	1016·8	+ 0·4	71	51	63·9	54·3	59·1	− 1·8	53·8	83	4·7	2·47	...	9	...	...
Malta	1012·6	− 0·8	74	52	67·2	55·3	61·3	+ 0·4	55·6	77	5·1	0·34	− 0·52	5	8·9	68
St. Helena	1011·4	− 1·5	72	61	68·9	62·8	65·9	+ 1·6	64·3	96	9·0	7·09	+ 3·87	26	...	...
Freetown, Sierra Leone	1010·7	+ 1·6	93	73	88·7	76·7	82·7	...	76·7	76	5·5	2·18	− 1·88	6	...	...
Lagos, Nigeria	1010·1	+ 0·7	91	73	88·7	78·9	83·8	+ 1·0	78·1	81	7·1	4·81	− 1·27	5	7·2	59
Kaduna, Nigeria	1009·4	...	101	60	96·5	71·9	84·2	+ 2·7	70·6	64	4·5	1·24	− 1·84	1	8·8	72
Zomba, Nyasaland	1011·9	− 0·6	84	56	79·4	63·0	71·2	+ 1·9	66·3	78	6·0	3·37	− 0·29	8	...	...
Salisbury, Rhodesia	1014·6	− 0·7	84	45	76·9	53·8	65·3	− 0·4	57·9	65	3·9	1·04	...	6	7·3	62
Cape Town	1016·6	+ 0·2	96	49	71·0	54·1	62·5	− 0·7	54·7	83	5·4	2·16	+ 0·29	10	...	...
Johannesburg	1016·1	− 0·2	78	38	69·8	50·1	59·9	− 0·1	50·7	61	3·1	1·75	+ 0·01	7	8·5	74
Mauritius	1012·8	− 1·1	86	65	82·6	70·3	76·5	+ 0·7	73·2	76	5·4	2·63	− 2·49	12	7·6	66
Calcutta, Alipore Obsy.	1006·8	+ 0·5	104	70	96·3	76·8	86·5	+ 0·9	76·1	74	4·3	0·15	− 2·03	1*	...	...
Bombay	1007·9	− 0·9	92	70	88·7	76·4	82·5	− 0·6	75·1	75	2·6	0·01	− 0·04	0*	...	...
Madras	1007·5	− 0·9	94	70	90·0	77·5	83·7	− 1·6	78·0	77	6·3	2·61	+ 1·98	2*	...	...
Colombo, Ceylon	1008·7	0·0	90	70	87·1	75·7	81·4	− 1·3	77·8	79	7·3	10·64	+ 0·91	18	5·7	46
Singapore	1008·0	− 0·9	93	73	86·9	76·5	81·7	+ 0·1	78·3	80	8·3	10·71	+ 3·08	19	4·3	36
Hongkong	1012·9	+ 0·3	86	60	76·4	68·6	72·5	+ 1·7	68·9	84	8·5	2·26	− 3·39	8	4·4	35
Sandakan	1008·5	...	91	74	88·5	76·6	82·5	+ 0·3	78·2	84	7·9	4·01	− 0·48	18	...	...
Sydney, N.S.W.	1016·4	− 2·0	81	49	69·5	56·2	62·9	− 1·8	57·4	73	6·7	5·58	+ 0·06	16	5·5	48
Melbourne	1018·7	− 0·8	83	37	66·3	49·8	58·1	− 1·4	52·7	76	6·8	1·41	− 0·76	16	4·4	39
Adelaide	1020·0	+ 0·2	90	47	71·9	53·9	62·9	− 1·0	55·0	55	6·5	0·66	− 1·06	7	4·7	42
Perth, W. Australia	1016·4	− 2·0	97	52	80·0	59·9	69·9	+ 3·1	60·1	58	3·7	4·05	+ 2·40	10	8·2	73
Coolgardie	1017·3	− 1·0	93	48	79·1	55·1	67·1	+ 2·1	58·1	55	2·4	0·12	− 0·84	2	...	...
Brisbane	1015·0	− 2·6	85	54	79·2	59·3	69·3	− 1·0	61·7	63	2·7	0·92	− 2·85	7	8·5	75
Hobart, Tasmania	1015·7	+ 0·9	81	35	61·0	45·2	53·1	− 2·1	47·1	65	5·6	0·96	− 0·89	12	5·8	53
Wellington, N.Z.	1013·1	− 5·0	73	37	61·3	49·0	55·1	− 2·0	52·0	73	6·6	2·30	− 1·58	14	5·9	54
Suva, Fiji	1010·5	− 0·1	92	72	85·9	75·2	80·5	+ 1·9	76·2	84	6·4	12·13	− 0·08	23	5·6	48
Apia, Samoa	1009·6	− 0·3	89	72	86·0	74·6	80·3	+ 1·4	77·3	80	5·4	9·41	− 0·74	16	7·1	60
Kingston, Jamaica	1013·4	− 0·7	91	69	86·9	71·5	79·2	+ 0·8	69·8	78	2·3	0·58	− 0·66	2	6·8	54
Grenada, W.I.	1011·6	− 0·9	89	71	86	73	79·5	+ 0·6	74	78	5	4·69	+ 2·53	19	...	...
Toronto	1015·1	− 1·0	65	29	49·7	36·8	43·3	+ 1·2	36·7	72	5·8	4·02	+ 1·73	13	5·0	37
Winnipeg	1015·3	− 1·4	61	13	45·7	30·0	37·9	+ 0·2	30·2	85	6·9	2·64	+ 1·24	13	4·6	34
St. John, N.B.	1016·3	+ 2·9	68	23	48·7	31·5	40·1	+ 1·1	35·2	71	6·0	2·61	− 0·90	11	6·3	47
Victoria, B.C.	1015·2	− 2·3	63	37	52·7	42·3	47·5	− 0·4	44·6	83	8·2	2·34	+ 0·82	17	4·1	30

* For Indian stations a rain day is a day on which 0·1 in. or more rain has fallen.

(39051) Wt. 20/31 1125 10/37 Hw. G.377/6





Barogram August 30th to September 5th, 1937

TYPHOON AT HONGKONG, SEPTEMBER 2ND, 1937 (see p. 235)