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## British Wind-Direction Periodicities

By JOSEPH BAXENDELL

Previous to the Great War, investigators of meteorological periodicities devoted little or no attention to the important element wind direction, although soundly based hints that it would probably prove a not unfruitful field in that connexion had been published by my father so long ago as in the eighteen-sixties, and repeated later. The subject was doubtless neglected partly because observations of the direction of the wind are not so easily handled as air pressure and temperature means and rainfall totals, and partly in view of the harmful effects which the large proportion of calms in the wind entries seemed likely to exert on any results that might be, or ought to have been, obtainable from them. How to deal most fairly with the numerous cases of calm which long and reliable records of direction were found to contain, was a more difficult problem than commonly supposed, and was, indeed, thought to be a more serious matter than subsequent experience has shown it to be.

However, on the erection of my first recording anemoscope at Marshside, Southport, I determined to endeavour to eliminate calms at their source, by, (a) making the instrument as sensitive as possible, (b) giving it a very elevated exposure, and (c) adopting as the hour's direction when free movement of the vane had been virtually absent, the mean position which the pen had occupied during the hour. The Hartnups had long acted very similarly at Bidston; and the late Mr. William Ellis had striven, while he could,

to greatly reduce the number of hourly entries of calm at the Royal Observatory, Greenwich.

On looking through the summarised records so obtained at Marshside since 1898, I noticed, some years ago, that if the durations of all winds from NW., N. and NE. were grouped together, the periodicity of 5.1 years which I had previously found in much (especially Lancashire) rainfall and other meteorological data, stood out with singularly isolated clearness and quite surprising amplitude. The series of nearly a century of hourly records of wind direction at the Royal Observatory was therefore examined, and notwithstanding the very numerous entries of calms that it contains in many (especially the later) years, the same or 5.1 year cycle was found to be unmistakably in evidence, practically throughout, and, in general, of substantial amplitude\* ; although this periodicity does certainly seem to be distinctly more pronounced in Lancashire than at Greenwich. Subsequent examination, by Dr. C. E. P. Brooks and Miss T. Hunt,† of a laborious general collection which they had made of London wind-direction data extending over about  $1\frac{1}{2}$  centuries, resulted in very satisfactory confirmation of my principal conclusions. We, however, found that while the oscillation was normally a nearly north to south (very slightly east of north to west of south) one, there had been a spell, of approximately 24 years' duration, mainly in the seventies and eighties of last century, during which it was a much more nearly east to west swing, and this interval contained several 5.1 year periods of outstanding amplitude.

But much of Great Britain is affected also by three other very noteworthy wind-direction periodicities of the order of a few years, viz., (a) Dr. Brooks' and Miss Hunt's 3 year, chiefly an east to west one (a cycle frequently found in other meteorological data in south-eastern England, and weakly present in Lancashire, but said to vanish in Scotland) ; (b) Dr. Goldie's most interesting recurrence of 3.8 years in W. wind frequency in northern Britain,‡ persisting there almost continuously from as far backwards as the records he examined extend, but virtually inoperative in London ; and (c) a very marked cycle of 1.9 years (and therefore apparently an exact second harmonic of the nearly 3.8 year term), which I recently found in the duration of N. and NE. winds at Marshside, Southport. Some considerably longer fluctuations also exist.

On the appearance of Dr. Goldie's elaborate and stimulating paper,‡ it seemed desirable to examine the Southport wind-direction data further, and, on doing so, it quickly became evident that a periodicity of nearly 3.8 years had been in regular operation in the frequency of W., NW. and N. winds (W. ones forming the bulk of the group) ever since the War. Pronounced maxima occurred at

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\* *London, Quart. J.R. met Soc.*, 51, 1925, p.371.

† *London, Met. Mag.*, 68, 1933, p.155.

‡ *London, Quart. J.R. met Soc.*, 62, 1936, p.81.

the following times (as will be readily seen from the accompanying smoothed diagram of the monthly durations of those wind currents, prepared from hourly tabulations of autographic records) :—

DATES OF MAXIMA OF  $3\frac{3}{4}$  YEAR OSCILLATION OF FREQUENCY OF W., NW. AND N. WINDS, AT MARSHSIDE, SOUTHPORT

Beginning of August, 1919.

Middle of December, 1930.

Beginning of August, 1923.

Beginning of July, 1934.

Middle of January, 1927.

Rather curiously and suggestively, the intervals have been alternately about 4 and  $3\frac{1}{2}$  years.

It is very interestingly significant that the phases of this cycle at Southport are practically the reverse of those over northern Britain, a fact largely explained by the average air-pressure diagrams given in Goldie's Paper.

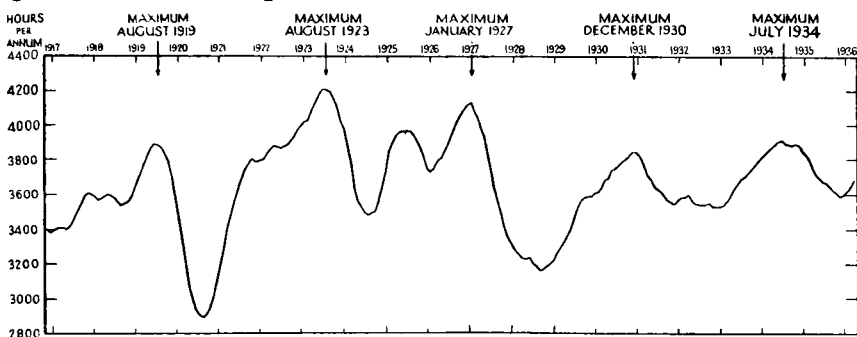


FIG. 1.—DURATION OF W., NW. AND N. WINDS AT MARSHSIDE, SOUTHPORT; SMOOTHED AS DESCRIBED ON P. 132 TO EXHIBIT THE NEARLY 3·8 YEAR CYCLE.

Previous to the War, this nearly 3·8 year fluctuation of W. wind frequency had been weak south of the Border ; it invaded northern England in a very energetic form about 20 years ago, and since then the mean amplitude of its first harmonic component at Southport, as determined by accurate analysis, shows that the full range from minimum to maximum of the sine curve (after Mr. E. G. Bilham's useful corrections for the effects of the grouping and smoothing of the data, have been applied), expressed in hours per annum, has averaged 16 per cent of the mean annual duration of the affected winds. This is not a small amount ; but, owing to the unsymmetrical shape of the observed curve, the actual range is considerably larger—quite materially so even after much smoothing.

I have now, at Dr. F. J. W. Whipple's suggestion, further examined the nearly 1·9 year periodicity in Southport's NE. and E. winds, and have found that, although the phase angle has not appreciably altered as between the earlier and later halves of the 20 periods' data available, the amplitude of this oscillation has been greatly increased ever since the War—in fact decidedly more than doubled, the full range (i.e., twice the amplitude) of the first harmonic component having, during the last 10 periods, averaged no less than

29 per cent of the mean annual duration of those winds. And this notwithstanding that the actual times of maxima and minima of this oscillation are extremely irregular (probably largely owing to "interference").

There can be little doubt that these two periodicities are liable to be affected by somewhat abrupt forms of periodicity action-centre migration, the last of which occurred at about the time when several of the oldest and best authenticated meteorological cycles, in various countries, sustained staggering blows, of one kind or another.

The observers of those most interesting celestial objects, the long-period variable stars, are prepared for striking unexpected dislocations; and some of these changes, moreover, take the form of phase-reversals, of which it now remains for me to mention an interesting instance in meteorology.

I originally detected the nearly 1.9 year cycle a number of years ago, in Southport and other Lancashire rainfall statistics; and then, on analysing the hundred years' records of that element at Bolton (where the long early series at "The Folds", and the subsequent observations at Queen's Park, together constitute a continuous—believed fairly homogeneous—record), I found that this periodicity had been unmistakably operative there the whole time. On, however, dividing the observations into three successive "blocks", of approximately a third of a century apiece, the first block yielded a phase angle practically opposite to those of the two later blocks (which latter were virtually identical). Looking through the data in detail, but smoothed to eliminate the annual and semi-annual terms, which are large, it quickly became apparent that approximate phase reversal occurred about the year 1867, since which there has been no appreciable change in the angle. The amplitude had been materially larger prior to the reversal than it was subsequently, until the War; after that it was, until recently, larger than ever.

So far as I have been able to determine it, the average length of Dr. Goldie's cycle lies between 3.75 and 3.80 years. That of mine seems to be between 1.87 and 1.90 years. It is therefore possible that the two may be, respectively, a third, and a sixth, of the sunspot period. These are, roughly, east to west oscillations. The north to south swing, of 5.1 years, and its associates, do not appear to bear any relation to solar physical phenomena.

The diagram accompanying this article has been produced by taking running 12 monthly totals (of the westerly, etc., affected winds), in order to eliminate the annual and semi-annual terms, and then further smoothing by forming running means of tens of those totals, so as to diminish the disturbing effects upon the curve of the large and very irregular second-order component.

I should like to say, with emphasis, that I by no means maintain that anything approaching full justice can be done to these and other noteworthy meteorological recurrences, by mathematical analysis.

The diagram shows that the rise from minimum to maximum of the 3·8 year period generally occupies much more time than the fall from maximum to minimum, and that a "hump" occurred during the rise, in four out of the five cases shown; but it is obvious that little or no predictive value would attach to the coefficients of any computed higher harmonic than the first. And, similarly, it would be very disingenuous, and frequently quite misleading, to apply strictly mathematical tests (of the usual kind) for reality, to even the first harmonic component of such meteorological cycles. As Dr. Goldie has well expressed it, in a letter from which he kindly permits me to quote:—"These are cases where mathematical criteria of reality cannot from a physical point of view have an application, because the assumptions underlying such criteria are not likely to be justified".

We are dealing with oscillations resembling, by their quasi-periodic character, the light changes of many of the long-period variable stars, and the course of our own sun's spot curve. In meteorological data, the smoothness of the run of the mean curve derived from many periods of a given cycle; the repetition, in general form, of the oscillation numerous times in immediate succession; the accord of the phase angles obtained from the separate earlier and later halves of records of some length, or of such portions of those records as contain no phase reversals; and the finding of virtually identically situated periodogram peaks in records of different meteorological elements, at places far apart; lie the strongest evidences of reality. Experienced astronomers frequently feel justified by vastly less proof, in placing a comparatively recently discovered fluctuating star in their official catalogues of known, long-period variables. Nor have they any hesitation in conventionally styling as "periodic", persistent variations which are obviously, in reality, of only a quasi-periodic character, and therefore never susceptible of exact prediction.

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## Royal Meteorological Society

The monthly meeting of the Society was held on Wednesday, June 16th at 49, Cromwell Road, South Kensington. Dr. F. J. W. Whipple, F.Inst.P., President, was in the Chair.

The following papers were read and discussed:—

*F. Loewe, Ph.D.—A period of warm winters in western Greenland and the temperature see-saw between western Greenland and central Europe.*

Particulars are given regarding the big rise in winter temperatures in Greenland and its more oceanic climate during the last fifteen years. Observations covering sixty years show a marked negative correlation of simultaneous temperatures between western Greenland and the regions around the Baltic Sea. This temperature see-saw

can be explained by the simultaneous pressure anomalies over Iceland and the Norwegian Sea and the changes of the meridional pressure gradient over the northern Atlantic.

*Lt.-Col. E. Gold, D.S.O., F.R.S.—Modifications of the float of the Dines anemometer to increase or decrease the range of velocity.*

The range of velocity which can be recorded by the Dines anemometer can be increased by putting weights on the float. The maximum range of the Dines anemometer with a float of normal weight is 122.5 m.p.h.; this can be increased to 137 m.p.h. by weighting the float so that its maximum height will be 15.4 cm. (6 in.) above its zero level. These limitations are due to the fact that at these velocities air from the inside of the float begins to bubble through to the space in the container outside. If the float is weighted so that it does not rise at all above the zero level, air begins to bubble through at a wind speed of 178 m.p.h. If an anemometer is required which will record on a linear scale velocities higher than 122.5 m.p.h., the dimensions of the float must be changed. This change can be made by altering the shape of the interior of the float and an increase of the range up to 150 m.p.h. can be obtained in this way without increasing the height of the container. If a greater range is required it is necessary not only to alter the shape of the float, but also to increase its length. The length of the existing float is approximately 47 cm. If this length is increased to 91 cm. and the necessary change of shape is also made, velocities up to 200 m.p.h. can be recorded. The exact numerical dimensions of the float for these cases and for cases of a more open scale also have been calculated.

*C. J. Boyden, B.A.—A method of predicting night minimum temperatures.*

A simple general relationship, which appears to be applicable in any climate, is found connecting monthly mean values of maximum and minimum dry-bulb temperatures with mean wet-bulb temperatures. The formula is extended for predicting individual minimum temperatures on nights when there is no appreciable change of air mass between the times of maximum and minimum temperature, allowance being made for wind speed, cloudiness and fog formation.

*J. S. Farquharson, M.A.—Haboobs and instability in the Sudan.*

The dust storms of the Sudan, called "haboobs," are shown to be associated with thunder squalls. Several haboobs are discussed, with particular reference to upper winds and upper air temperatures. Conditions associated with instability in the Sudan are indicated, a unique series of upper air temperatures being of value in this connexion. A series of photographs taken with the co-operation of the R.A.F. illustrates the conditions in some of the haboobs.

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The Council of the Royal Meteorological Society has awarded the Howard Prize for 1937 to Cadet Ralph Wills of H.M.S. *Conway*

School Ship. The subject of the competition was an essay on "The meteorology of the voyages of discovery to America and to South Africa."

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## Correspondence

To the Editor, *Meteorological Magazine*

### Optical Phenomena observed in Pembrokeshire

Mr. William Phelps, Rock Cottage, Amroth, Pembrokeshire, has sent details of optical phenomena he observed at 9.45 a.m. B.S.T. on June 24th. The phenomenon consisted of the halo of  $22^\circ$ , parhelic circle, and brightly prismatic parhelia at the intersections. The halo was coloured. In the south-east the parhelic circle was invisible owing to low cloud. Mr. Phelps states also that inside the parhelic circle and the halo were faint indications of another circle, also coloured. I cannot explain this last observation.

S. E. ASHMORE.

11, Percy Road, Wrexham, Denbighshire, North Wales, July, 4th, 1937.

[A similar phenomenon is described in the article on "The Halo phenomena of May and June, 1935," published in the *Meteorological Magazine* for July, 1935, p. 133. Ed. M.M.]

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### Solar Haloes in May

With reference to Mr. J. Edmund Clark's letter, and the appended note of observations by Mr. G. A. Clarke, which appeared in the June number of the *Meteorological Magazine*, I find that a number of solar haloes were seen here during the last fortnight of May this year. During these two weeks haloes were noted on the 20th, 23rd, 27th, 28th, 29th, and 30th. On the 30th a  $22^\circ$  halo appears to have persisted throughout the day, otherwise they do not seem to have been in any way remarkable.

It is interesting to note that the period of their occurrence falls during one of the months found by C. Visser on statistical analysis to show a maximum frequency for halo phenomena in Holland, namely April and May.

C. STUART BAILEY.

Longbridge, 76, Woodcote Valley Road, Purley, Surrey, June 30th 1937.

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### Searchlight Rainbow at Aldershot

As I was leaving Rushmore Arena, Aldershot about 0015 on June 6th, 1937, at the conclusion of the Aldershot Tattoo, I witnessed what I believe to be a very remarkable phenomenon.

Continuous moderate rain was falling at the time and to enable the audience to clear the arena powerful searchlights, situated from 50 to 100 ft. above the ground, were concentrated upon the exits. These searchlights were some 300 yards immediately behind me and reflected a brilliant artificial rainbow, apparently 100 ft. in diameter

and approximately 150 ft. ahead, the ends disappearing abruptly into masses of spectators. Rain could be distinctly seen falling through the arc giving it a glimmering sheen, and as the searchlight moved, which it occasionally did, backwards and forwards, up and down, it gave a very curious effect especially when another searchlight with its attendant rainbow crossed or intermingled with it.

G. F. HILLMAN.

*Meteorological Station, South Farnborough, Hampshire, June 22nd, 1937.*

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### Midsummer Frosts

In the September, 1934, issue of this magazine it was reported that the latest "spring" frost registered in the screen since the establishment of the Rickmansworth climatological station in 1929 had been on June 10th, 1932, and the earliest "autumn" frost on August 26th, 1934. There had thus been an interval of 76 days during which the air temperature did not once fall to the freezing point. It may be of interest to mention that the length of this frost-free period has now been reduced to 56 days by the occurrence of a minimum of  $31\cdot0^{\circ}$  F. in the screen at 4h. G.M.T. on June 30th, 1937. As there were readings of  $33\cdot9^{\circ}$  F. on July 19th, 1932,  $32\cdot8^{\circ}$  F. on July 27th, 1936, and  $32\cdot2^{\circ}$  F. on July 31st, 1935, it appears probable that the notably "continental" climate of the enclosed valley in which the Rickmansworth meteorological station is situated is capable of producing an occasional frost even at the height of summer.

E. L. HAWKE.

*Ivinglea, Dagnall, Bucks., July 6th, 1937.*

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### Snow on the Grampians

On June 9th, 1937, a considerable snowbank was found on the Grampian Hills near Montrose. The situation was at 1,500 ft. above sea level in an entrenched gully, some 80 ft. below the general level of the hillside, on the southward-facing slope above Water of Tarf, Glen Esk. The aspect of the snowbank was south-east, well shielded by the wall of the gully from the late afternoon and evening sun. The drift was about 25 yards long by 15 yards up-slope; and the depth varied from 1 to 4 ft. at the most sheltered end. The snow was melting slowly at the base and along the upper edges; but the drift was firm in texture and consisted of rather big grains. Steps were kicked in the surface which held well for climbing.

There is little snow left on the hills in spite of the heavy falls of March. Some other small patches were seen in the same gully and in other sheltered spots; but the summits have been clear of snow for more than a month, and the open northern faces of the hills are also bare of snow.

H. H. LAMB.

*Meteorological Station, Montrose, Forfar, June 12th, 1937.*

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### Intense Gloom at Rotherham

The weather of the past month has shown no unusual features with the exception of the unusual period of intense gloom which afflicted this district for a number of hours on the 24th. The present writer has no recollection of any similar visitation outside the winter months.

The forenoon was overcast with slight mist but about 14h. G.M.T., the sky began to darken and at 14h. 30m. artificial light was necessary and had to be used until 20h. when the gloom dispersed and a ground mist developed.

With the exception of a very slight shower at 15h. 30m. and a further shower from 18h. 45m. to 19h. 20m., no rain fell. These two showers gave a total of only 0.02 in. Wind was calm to variable in the forenoon and early afternoon, but by 17h. a NNE. breeze of force 2 sprang up.

The colour of the light which reached the surface was of a reddish-brown tint which rather indicated that the light had been filtered through a dense mass of overhead fog and that only light of long wave length was capable of penetrating the cloud layer.

Information which reached me later showed that in the centre of the town, the darkness between 16h. and 17h. was almost complete, an affliction which we, in this district two miles out of the town, were fortunately spared.

LESLIE ATKINSON.

187, Broom Lane, Rotherham, July 1st, 1937.

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### Resident Observer Wanted

In the *Meteorological Magazine* for 1922, p. 66, you recorded the circumstances in which the Royal Meteorological Society took over the lease of 62, Camden Square, as a gift from the Trustees of the British Rainfall Organization, on condition that the Society undertook the maintenance of the meteorological observations. These observations were begun by Mr. G. J. Symons in 1858 and form a remarkably homogeneous and accurate series. They are, moreover, of special value because they represent very fairly the conditions existing in a closely built-up area in London.

In order to provide as far as possible for the maintenance of the station in perpetuity the Society has recently purchased the freehold of the property and the Council has given much thought to the arrangements for taking the observations. The house will shortly become vacant and it is the Council's desire to find, if possible, a new tenant interested in meteorology who would undertake the rôle of "resident observer". The Council hopes, therefore, that you will be good enough to bring this matter to the notice of readers of the *Meteorological Magazine*. I shall be pleased to furnish full

details in response to a communication addressed to the Society at 49, Cromwell Road, London, S.W.7.

E. L. HAWKE,

Hon. Secretary.

*Royal Meteorological Society, 49 Cromwell Road, London, S.W.7, June 23rd, 1937.*

## NOTES AND QUERIES

### **Thunderstorm at the Aerological Station, Vacoas, Mauritius**

From February 10th to 24th, 1937, owing to the presence of low pressure centres to the south, Mauritius experienced a spell of hot, humid weather with very light northerly winds. For this period the mean temperature was  $80\cdot6^{\circ}$  F., the mean relative humidity 82 per cent and the mean wind velocity  $3\cdot9$  m.p.h., with comparatively small variations from these mean values.

This unpleasant type of weather was terminated on the 25th through the extension north-eastwards of an anticyclone centred to the south-west. With the arrival of this "cold" front cooler easterly winds began to establish themselves during the morning of the 25th and there resulted a violent thunderstorm of short duration which was directly overhead at the Vacoas aerological station from about 12h. 0m. to 12h. 30m. (local standard time).

During this time four lightning flashes struck at or near the station damaging telephonic and lighting circuits. One hit an electric light pole near the entrance. In the office the lighting wires fused and the shades and lamps that they were carrying fell to the floor and shattered. Next, the overhead telephone wires were hit, fusing 18 inches of S.W.G. copper wire and leaving marks on the outside office wall that indicated sparking of at least 1 foot. A fuse-box lid blew off and hit a workman who was sheltering nearby. A third flash struck and tore off the vane of a Dines anemometer. The vane, at a height of 100 ft., is the highest point in the immediate vicinity. The vane was badly damaged as shewn by the photograph on the opposite page.

The rainfall during the storm was torrential, 76 mm. being recorded in 90 minutes, with a maximum rate of fall of  $42$  mm. in 23 minutes. The rainfall chart shews that this intense fall was perfectly recorded by the Casella natural-syphon gauge. Two funnels are used with this gauge, one of 8 in. diameter for ordinary records and one of  $5\frac{1}{16}$  in. diameter during heavy falls, but on this occasion the smaller funnel had not been substituted.

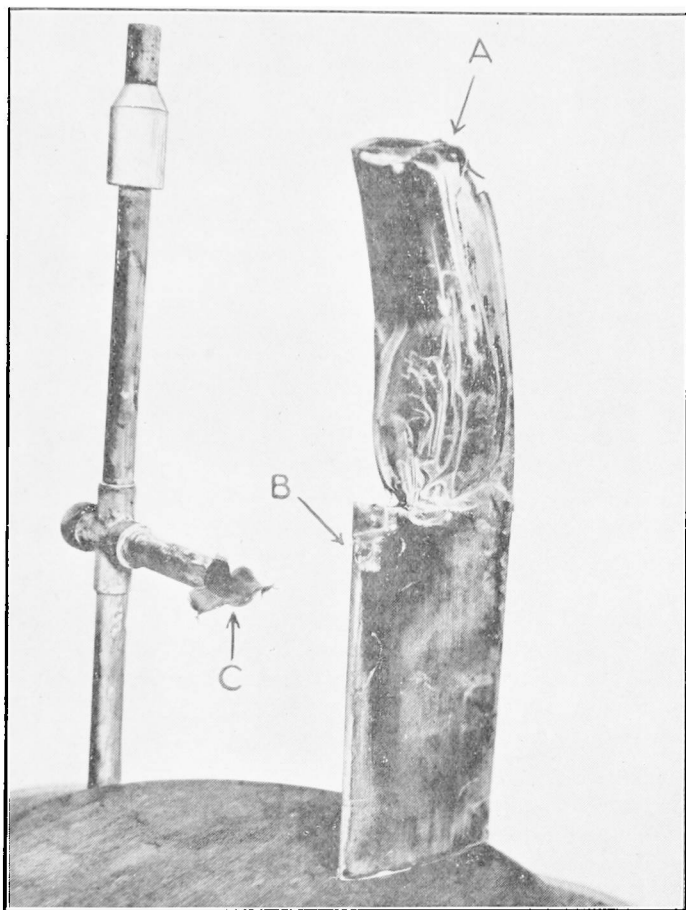
N. R. MCCURDY.

M. HERCHENRODER.

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### **Thunderstorms of June 10th, 1937**

Severe thunderstorms were experienced in many parts of south-east England on the evening of June 10th. The following accounts bring out special features of interest in connexion with these storms.



DINES ANEMOMETER VANE STRUCK BY LIGHTNING, MAURITIUS,  
FEBRUARY 25TH, 1937

- A. Highest point of vane where lightning struck.
- B. Hole made of about  $\frac{1}{2}$  in. length.
- C. Path taken by lightning through the head, as indicated by a number of pitted marks, and thence down the mast to earth.



Mr. C. J. P. Cave of Stoner Hill, Petersfield, writes that "The thunderstorm of June 10th was not particularly severe here, the rainfall amounting to only 0.24 in., but it was very remarkable for the extraordinary darkness and for the great rapidity with which it came on. An interesting point at a late stage in the storm was the length of time the thunder lasted. I timed a number of peals; few lasted less than one minute, several lasted 80 seconds, one 95 seconds, and two 100 seconds. This would imply a length of some 20 miles for the longer flashes, which were of course from cloud to cloud. The great length of the flashes was seen later on when the storm had passed away so far that no thunder could be heard; occasional flashes were seen above the horizon to the north and north-west; one of these subtended an angle of about  $90^\circ$  along the horizon. Since the thunder was quite inaudible the very nearest point of the lightning must have been at least 12 miles away giving a minimum length of some 24 miles for the flash."

Mr. D. Schove of St. David's College, South Eden Park Road, Beckenham, Kent, writes that "A peculiar form of lightning was observed in the storm of June 10th, 1937, in which what was apparently some secondary effect travelled—relatively slowly—from the 'stem' to the 'branches' of the main flash. It thus appeared as if the lightning itself was moving or rather uncoiling, so that we were tempted to christen it the 'Uncoiling Rope' flash.

This flash was observed four times directly over Langley Park, West Wickham, Kent, about 9 p.m. (Summer Time), and the wave in at least three cases moved from a northerly to a southerly point. As far as I know this is the only record of such a flash\*, and while the cause seems obscure, it may prove significant to mention the other peculiarities of that particular storm.

At 8.15 p.m. an unusually regular and well marked cloud front stretched from north-west to south-east, and stratus clouds approaching the storm from the east were sucked under, and rolled in rapidly-whirling masses of mummified cloud, suggesting tornado formation. Neither the rain nor the thunder was remarkable, but the lightning showed an unusual 'ability for bending' and 'looped' and 'crossed' flashes appeared again and again."

Mr. B. Mannoeh of Kuchbewani, 19 Hythe Road, Worthing, writes that "At about 18h. 35m. G.M.T. on June 10th, while I was watching the rather active thunderstorm which passed over Worthing that evening, I noticed a discharge almost directly overhead, which gave a peculiar sound about eight seconds later. Instead of the usual noise, there was a distinct note of a frequency about 100c/sec., which lasted for perhaps  $\frac{1}{2}$  sec. while being interrupted by intervals of reduced intensity. The only plausible explanation that has occurred to me is that a resonance between two layers of air at different

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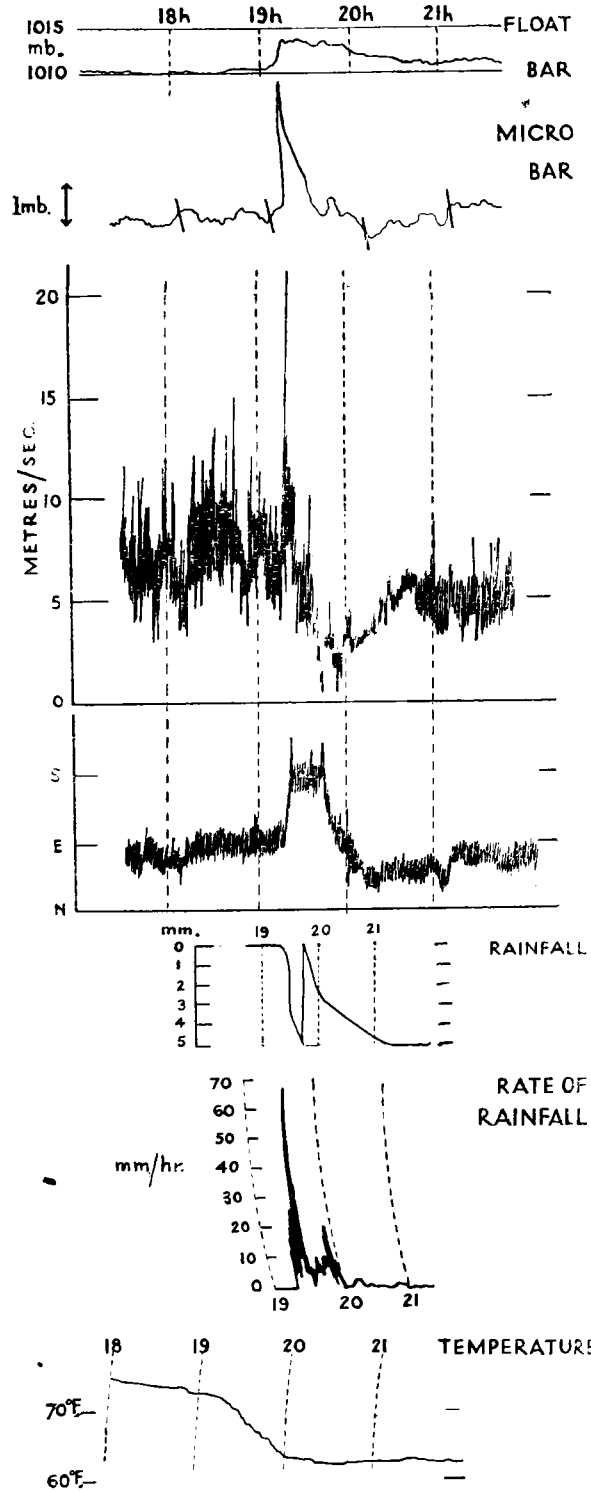
\* This form of lightning is described from personal observation by Sir George Simpson under the heading "Rocket Lightning" in the Thirty-second Robert Boyle Lecture, Oxford, 1930, pp. 10-1. Ed *M.M.*

temperatures may have been set up by internal reflection, and this seems possible in view of the fact that, so far as I could judge, the note was free from harmonics. This seems to me to be a very curious and unusual phenomenon."

Mr. A. E. Moon of 39, Clive Avenue, Clive Vale, Hastings, writes that "On June 10th an unusually severe thunder squall occurred here. Conditions at 18h. (G.M.T.) were cloudy and warm with a moderate NNE. wind.....The first thunder was heard to the south at 18h. 32m. at a considerable distance. By 18h. 42m. lightning was seen and the distance then was about 7 miles. By this time the clouds to the south were intensely black. The vanguard cloud passed overhead at 18h. 45m. accompanied by a sudden squall of wind from the south-south-west and it was sufficiently dark to make it difficult to read out of doors. The upper winds were from  $155^{\circ}$  at 5,000 ft. approx. at 18h. and from  $170^{\circ}$  at 1,500-2,000 ft. at 18h. 45m. After the passage of the front of the squall cloud lightning and thunder occurred at frequent intervals. Rain of large drops began at 18h. 33m. but this ceased for a short time. Rain began again suddenly and heavily at 18h. 46m. becoming torrential by 18h. 52m. followed a minute later by large hailstones. At 18h. 55m. the rain was driven along like smoke before a SE. wind which almost reached gale force in gusts and visibility at this time was reduced to 200 yards..... All lightning flashes were decidedly pink in colour and were in majority cloud to cloud discharges. It was particularly noted that on numerous occasions 2 or 3 distinct flashes followed the same path in rapid succession. Rainfall amounted to 0.77 in. from 18h. 33m. to 19h. 30m. There was evidence of minor damage, such as fallen trees. A 'tidal wave' is reported to have occurred at Hastings at 18h. 45m."

Mr. Webb, the resident observer at Kew Observatory, writes that "An occlusion crossed the observatory between 19h. and 20h. G.M.T. on June 10th and was accompanied by a fairly severe thunderstorm lasting from 19h. 15m. to 21h. 30m. Weather during the afternoon had been partly cloudy with dry air, a steady falling barometric pressure and a maximum temp. of  $77^{\circ}$  F. at 16h. 20m. Traces of altocumulus castellatus were observed during the afternoon.

Soon after 19h. the sky became very dark and turbulence was apparent with the development of some very well-defined mammato cumuli at 3,000-4,000 ft. to the south of the observatory. At 19h. 10m. these clouds were moving almost due north while the surface wind was as yet E. At 19h. 20m. the wind record shows a pronounced line squall with a maximum gust of 21.4 m./sec. (48 m.p.h.) and a sudden veer in direction from E. to S'E. (see diagram opposite). The pressure rose sharply from 1010 mb to 1013 mb, a rise of 3 mb in as many minutes. The wind velocity fell away to 2 m./sec. at 19h. 45m. Lightning and thunder were first observed at 19h. 15m., 2 miles to the south-south-east, the storm being apparently centred in the south-east and moving northwards. Temperature fell fairly rapidly from  $72^{\circ}$  F. at 19h. 10m. to  $63^{\circ}$  F. at 20h. At 19h. 45m. the wind



backed from S'E. to E. once again and then to NE. at 20h. 10m., velocity 5m./sec. The cloud was now a higher uniform sheet with fractonimbus below and the storm covered a very wide front in the east moving westwards. Heavy rain fell from 19h. 20m. to 20h. and moderate rain 20h. to 21h. Almost all the lightning was from cloud to cloud and some flashes spanned great distances, one at 19h. 59m. started in the north-west, passed within 1 mile to the east of the observatory and continued to the south-east. Another noteworthy flash occurred at 20h. 17m. one mile to the north of the observatory and appeared to hang in the air for an appreciable time and then split into a line of beads as it died away. Lightning occurred mainly in the east and north and eventually passed to the north-west, the last flash being observed in the north-west at 21h. 30m. Altogether 10mm. of rain were recorded, the maximum rate being 67 mm./hr. at 19h. 30m."

### **A Useful Atlas for Meteorologists**

The new "University Atlas," edited by George Philip and H. C. Darby, and published by George Philip and Son, Ltd. at the price of half a guinea, gives unusual prominence to climatic characteristics. The introduction is followed by seven pages of graphs showing for each month the mean daily maximum and minimum temperature, and the average pressure and rainfall, while inset figures give the height of the station in feet, the mean annual range of temperature and the annual rainfall. Each sheet is headed by a map showing the positions of the stations—a very useful feature. This section includes data for no fewer than 206 stations, 30 of which are in the British Isles. The sources of the data and periods covered by the averages are not given but it is stated that many of them refer to an interval of 35 years. The world maps, which are a modification of the "Mollweide Interrupted Homolographic" projection, include temperature (January, July, Year and annual range), isobars and winds (January, July), rainfall (Winter, Summer, Year, rainfall regimes), cloudiness, climatic regions and sea surface temperature, while the orographical map of each continent (and of the British Isles) is accompanied by a set of more detailed climatic maps. The printing and colouring of all the maps reaches a high standard of excellence.

C. E. P. BROOKS.

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### **The Wettest Place in the British Isles**

Hugh Walpole, in "A Prayer for my Son," published recently, writes:—"For now on the rocky and uncertain path to Seathwaite, Rockshaw drove them at snail's pace. They tumbled into the wettest place in Great Britain . . .". It is time that Seathwaite, in Borrowdale, should no longer be referred to as the wettest place. Actually there are several small areas very nearly twice as wet. This common error has apparently been perpetuated because meteorological literature has supplied no precise statement to replace it. Salter, in his "Rainfall of the British Isles," gives a map which shows that the average rainfall exceeds 150 in. in Snowdonia, the English Lake District, on Ben Nevis, and over a small area at the head of the River Garry, in the western Highlands of Scotland. These are definitely the four wettest areas in the British Isles. Mill, in the preface to the Rainfall Atlas, refers to an area near Llyn Llydaw on Snowdon as "one of the wettest spots in the British Isles, where the average probably exceeds 200 inches".

This lack of precision in meteorological literature has been due mainly to the absence of direct observations at spots most likely to be the wettest, viz., the summits of the highest mountains in these four areas. From a consideration of the records now available and a study of the general relation of the average rainfall to the con-

figuration of the land, estimates can be made of the maximum rainfall in each of these four localities.

Snowdonia provides the most detailed series of observations. The rain-gauges were set up on the eastern flank of Snowdon by Mr. Gethin Jones for the North Wales Power Co. The steady increase in the rainfall from Cwm Dyli westwards to the summit is shown in the table below :—

					<i>Altitude.</i>	<i>Average annual rainfall.</i>
					ft.	in.
Cwm Dyli	...	...	...	...	310	112
Wenallt	...	...	...	...	1,050	141
Delta	...	...	...	...	1,435	154
Llyn Llydaw	...	...	...	...	1,450	171
Copper Mine	...	...	...	...	1,480	180
Glaslyn	...	...	...	...	2,500	198

The summit of Snowdon (3,560 ft.) is only about 500 yds. to the south-west of Glaslyn and the record at Glaslyn probably gives very nearly the maximum rainfall on Snowdon. It is concluded therefore that the average annual rainfall over a small area near the summit of Snowdon reaches a maximum of 200 in.

From Seathwaite to Scafell Pikes (3,210 ft.) and Sca Fell (3,160 ft.) we have the following records :—

					<i>Altitude.</i>	<i>Average annual rainfall.</i>
					ft.	in.
Seathwaite	...	...	...	...	423	129
Stockley Bridge	...	...	...	...	585	138
Stye Head	...	...	...	...	1,100	150
Styehead Tarn	...	...	...	...	1,472	153
Sprinkling Tarn	...	...	...	...	1,985	159

The average rainfall probably exceeds 150 in. over an area including Sca Fell, Scafell Pikes and Great End and extending eastwards to Bow Fell and Allen Crag. In view of the isolated position of Sca Fell and Scafell Pikes the maximum rainfall is considered to be no more than 185 in.

Although Ben Nevis is loftier than Snowdon (attaining an altitude of 4,406 ft.) it is more isolated and therefore offers less obstruction to the SW. winds which may slide round without being forced to ascend. All the rainfall records show that Ben Nevis is not as wet as Snowdon at similar distances from the summits. The computed average for the record, maintained at Ben Nevis Observatory, is 165 in., which, although greater than that at Seathwaite Farm, is appreciably less than that recorded in the other three localities.

It is of interest to recall that the Rev. R. P. Dansey in an article in this magazine for March, 1905, suggested that a corrie just below

the summit of Ben Nevis and at the head of Allt-a-Inhuilinn might well prove to be the wettest spot in the British Isles. Actually, however, this contention was based on his knowledge that snow was swept off the summit and accumulated in such corries, to form a more or less permanent snowbed. In this note, however, we are dealing with precipitation, without being concerned with what happens to it subsequently.

The rainfall increases steadily westwards up the River Garry from Invergarry on Loch Oich towards the main mountain ridge where an altitude of 3,140 ft. is attained on Sgurr na Ciche. The only records at the head of the valley are at Glenquoich, Kinlochquoich and Loan at altitudes of 569, 580 and 650 ft. respectively. Loan and Kinlochquoich with 163 and 125 in., are at distances from the main summit of  $2\frac{1}{2}$  and  $4\frac{1}{2}$  miles, while at corresponding distances from Snowdon the values are 146 and 130 in. It is inferred from these records and the general distribution of the average rainfall in relation to the configuration of the land that the rainfall on Sgurr na Ciche, at the head of the River Garry, is comparable with that on Snowdon, reaching over a small area a maximum of 200 in. a year.

It is clear therefore that appreciable areas in Snowdonia, the English Lakes, on Ben Nevis and at the head of the River Garry in Inverness-shire are wetter than Seathwaite (with 129 in.). The average rainfall probably reaches 200 in. over small areas near the summit of Snowdon and on Sgurr na Ciche at the head of the River Garry, and these two areas rank as the wettest in the British Isles. Seathwaite Farm does not even rank as the wettest habitation, for Pen-y-Gwryd Hotel (to the east of Snowdon) and Kinlochquoich Lodge (at the head of the River Garry) are equally wet, while Ben Nevis Observatory, which was occupied for a few years, is much wetter.

J. GLASSPOOLE.

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## REVIEW

*Introduction à l'étude dynamique du climat.* By George Canellopoulos, Athens, 1936.

The term "dynamical climatology" was proposed in 1930 by Bergeron\* for the study of collective processes, suitable examples for these latitudes being quasi-stationary weather types. This principle forms a logical extension of the ideas of masses and fronts to the catalogues of isobaric types, of which several have been drawn up for the use of the forecaster, and promises to give some addition to precision in forecasting when more regional studies are available. So far, only a few studies on these lines have been published, and the present work is designed to examine the possibility of making a dynamical study of the climate of Greece.

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\* Richtlinien einer dynamischen Klimatologie. *Met. Z. Braunschweig*, 47, 1930, pp. 246-62.

Since there are no available data of upper-air temperature in Greece, it is necessary to choose a control station where disturbing effects such as topography and radiation are too small to prevent the ordinary observations of temperature from being representative. The station chosen is the small island of Lemnos, and an examination is made of the temperature data for the winter periods of the years 1927-34.

Five types of air mass are distinguished, the two principal being :—

(i) H—masses of air reaching the Ægean Sea from north, when pressure is high over the Balkans and low to south,

(ii) M—Mediterranean masses travelling to north or north-east. The properties of each type are discussed and tables are given showing the mean temperature associated with each. Further studies are proposed in which other seasons and other districts of Greece will be considered. This work forms a useful addition to the literature of the dynamical study of climate.

S. T. A. MIRRLEES.

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### BOOKS RECEIVED

*Las "temperaturas sentidas" en la Península Ibérica.*—By Dr Walter Knoche. Publicaciones de la Sociedad Geográfica Nacional, Series B, No. 75, Madrid 1936.

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### NEWS IN BRIEF

Mrs. J. H. Field of Hoath, Lonesome Lane, Reigate, Surrey, has for sale several volumes of meteorological publications formerly belonging to Mr. J. H. Field, whose death is referred to in the June, 1937, number of this magazine. The books include the *Meteorological Magazine*, March, 1866, to date; *British Rainfall* complete; the *Quarterly Journal of the Royal Meteorological Society* bound, 1906-19, unbound, 1920-2, April to October 1923, 1926, January 1927, 1928-9, 1931-6; "Manual of Meteorology" by Sir Napier Shaw, Vols. 2 and 4; "Scientific papers of Lord Rayleigh" 4 vols.; "Climatic atlas of India" and "The Earth" by H. Jeffreys. Any readers interested should write direct to Mrs. Field.

We learn that Prof. Wladimir Köppen, the eminent Graz meteorologist, has been awarded the shield of nobility by the German Chancellor.

A Leverhulme Research Fellowship has been awarded to Mr. G. Seligman, Chairman of the British Group of the International Commission of Snow whose subject will be "To examine the transition of firn snow into glacier ice"; and a Leverhulme Research Grant has been awarded to Mr. G. Manley, M.A., B.Sc., Senior lecturer in Geography at Durham University, whose subject will be "A study of the Helm wind of the northern Pennines."

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## The Weather of June, 1937

For the first time the broadcast climatic data for June include stations in India, Australia, New Zealand and the western Pacific. The chart for mean pressure shows an anticyclone exceeding 1020 mb. over the Azores extending as far as Valentia in Ireland, pressure decreasing northwards to 1005 mb. at Spitsbergen, and slowly eastwards across Europe to below 1010 mb. in Siberia. South-eastwards the decrease was more rapid to a minimum below 995 mb. in north-west India, rising again to 1005 mb. over Burma. Another anticyclone (above 1015 mb.) extended from Hawaii to the Pacific coast of North America with a small outlier south of the Great Lakes; a depression (below 1010 mb.) occupied Alaska. An intense anticyclone, above 1025 mb., lay south of Tasmania, the isobar of 1015 mb. including nearly the whole of Australia and New Zealand. Pressure was 5 mb. above normal west of Ireland and in central Russia, 10 mb. above normal over Tasmania, and more than 5 mb. below normal over most of the Arctic, including Alaska, Spitsbergen and Jan Mayen and the Taimyr Peninsula.

Mean temperature was still below freezing point on the Taimyr Peninsula and Fridtjof Nansen Land and only 33° F. in Resolution Island, Baffin Bay. In America temperature increased rapidly southwards to 60° from the interior of Alaska to the Great Lakes and the south of Nova Scotia, 70° in latitude 40° N., and 80° in latitude 34° N., but the Pacific coast was below 60° as far south as Victoria, B.C. In the British Isles temperatures rose from 50° at Lerwick to 61° at Kew; most of Europe was between 60° and 70°, the latter figure being exceeded from the Riviera to Greece. Most of Siberia south of 60° N., was above 60° F. In the Nile Valley temperatures varied from 80° at Cairo to 93° at Khartoum and Kareima, decreasing again southwards. Shaibah in Iraq gave a mean of 96° F. In India temperatures were everywhere above 80° and exceeded 90° in the north and north-west. In the southern hemisphere temperatures were 80° F. in New Guinea and the Solomon Islands and 79° at Darwin and Samoa; most of Australia was between 50° and 60°; Tasmania and most of New Zealand were between 40° and 50°. Temperature was more than 5° F. above normal over northern Canada, 2–5° above over most of Europe and more than 5° above normal near the White Sea, but elsewhere deviations were generally small.

Rainfall was 1–2 in. over the British Isles, 2–4 in. over most of Europe, 1–2 in. over Siberia and more than 3 in. over most of the United States, reaching 9 inches at New Orleans. Some heavy totals were reported from India, nearly 20 in. at Bombay and Calcutta and 30 in. at Port Blair. In Australia there was no rain in the north and less than an inch over most of the south, Perth being an exception with 9 in. Totals in New Zealand varied but were mostly 3–4 in.

Rainfall was generally somewhat below normal in Europe and the British Isles (except parts of Scotland). In America the coastal regions were above normal, the interior generally below. India was generally near the normal except at Port Blair, 5 in. above. In Australia and New Zealand the rainfall was generally deficient except at Perth.

The outstanding features of the weather of June over the British Isles were the warm sunny spell during the first part of the month in south and east England, the frequency of thundery conditions in England, the deficiency of sun in parts of Ireland and the number of gales in the extreme north of Scotland. Rainfall was for the most part below average. During the 1st and 2nd quiet cool anticyclonic weather prevailed mainly, with considerable sunshine, 12·7 hrs. at Ventnor on the 1st and at Eastbourne on the 2nd—ground frosts occurred at several inland places but in the Shetland Isles north-westerly gales were experienced on both days. By the evening of the 2nd the ridge of high pressure had passed eastwards to the North Sea and from then to the 8th pressure was low to the north and west. Rain fell frequently except in the south and east until the 6th, 4·43 in. at Festiniog (Merioneth) in the 48 hours ending 9h. on the 4th, and 1·32 in. at Hawkshead (Lancashire) on the 3rd, but after this date there were showers and much sunshine. Thick fog was experienced at times from the 4th to 6th along the south-west coasts and at Eskdalemuir and on the 5th in north Scotland. In the south-east this was a warm sunny period; the 5th and 6th were the sunniest days with 15 hrs. bright sunshine at many places, while temperature rose generally over 70° F. and on the 6th exceeded 80° F. in parts of London. The 8th was a cooler day in the south with some rain; in north and central Ireland thunderstorms were experienced. On the 9th a ridge of high pressure developed across England moving northwards and for 3 days temperature rose again, exceeding 80° F. on the 11th at many places in the south and reaching 85° F. at Greenwich and Camden Square and 82° F. at Tunbridge Wells. Severe thunderstorms were widespread in England on the nights of the 10th\* and 11th. Meanwhile the weather was cool in the north and west with south-westerly gales in north Scotland on the 10th. Some mist or fog developed locally at times but sunshine records were good over the whole country, 16·1 hrs. at Inchkeith on the 10th. On the 12th pressure was high over the Shetlands but a depression off our south-west coasts brought rain in that neighbourhood on that day. Heavy rain was also experienced in eastern and northern England on the 13th and 14th owing to a shallow depression which was developing over the North Sea, 2·47 in. at Driffield (Yorkshire) on the 14th and 1·56 in. at Troutbeck (Cumberland) on the 13th. Thunderstorms were experienced in the Midlands and northern England on the 13th. From the 15th to 20th the depression to the east moved slowly southward and cool northerly

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\* See p. 138.

winds and unsettled weather prevailed but with considerable sunshine especially in the west. Thunderstorms were experienced in south Scotland and north England on the 16th and in England on the 17th to 20th. Ground frost occurred locally inland in the north on the 18th and 21st. After some fog in the early morning the 21st was a brilliantly sunny day 10 to 15 hrs. being recorded generally except in parts of the Irish Free State where there was slight local rain. After this another depression over Denmark moved away north-westwards while the anticyclone over the Atlantic gradually extended across the British Isles. Rain occurred generally on the 22nd with thunderstorms in the south but from then to the 26th the weather was fair to cloudy with occasional slight local mist or drizzle, though the depression centred to the north caused gales in north Scotland on the 25th and 26th. From the 27th to 30th the depressions to the north moved on a more southerly course bringing unsettled weather with rain at times mainly in the west and north but long periods of sunshine. Gales were again felt locally in Scotland on the 27th to 29th. The distribution of bright sunshine for the month was as follows :—

	Total	Diff. from		Total	Diff. from
	(hrs.)	normal		(hrs.)	normal
		(hrs.)			(hrs.)
Stornoway ...	154	— 13	Chester ...	162	— 33
Aberdeen ...	187	+ 6	Ross-on-Wye ...	184	— 23
Dublin ...	113	— 69	Falmouth ...	209	— 18
Birr Castle ...	104	— 56	Gorleston ...	230	+ 21
Valentia... ..	165	— 8	Kew ... ..	208	+ 5

Kew, Temperature, Mean  $60.7^{\circ}$  F., Diff. from normal +  $0.8^{\circ}$  F.

*Miscellaneous notes on weather abroad culled from various sources.*

A heat wave was experienced in Austria and Poland early in the month and extended later to Germany. By the 11th serious fires had broken out in several villages in Poland, and at Berlin on the 11th temperature rose to  $97^{\circ}$  F. a record there for June since at least 1830. On the 12th temperature fell generally. A violent storm swept Bordeaux about 8 p.m. on the 9th causing considerable damage to property. Lourtier, Canton Valais, in which 65 houses and barns were badly damaged by a flow of mud, was evacuated about the 17th owing to a threatened landslip. In consequence of the melting of the snows the level of the Swiss lakes rose considerably about the middle of the month and Lower Zug and Lucerne overflowed their banks at several points. In Carinthia a period of heavy rain succeeded the great heat of the early part of the month. A severe hailstorm lasting about  $\frac{1}{4}$  hour did much damage in Venice on the night of the 20th. (*The Times*, June 11th–22nd.)

Rain showers, the prelude to the monsoon occurred in Bombay and Poona on the 12th. Severe storms were experienced near Akyab about the 18th. (*The Times*, June 14th–19th).

Drought prevailed in southern Saskatchewan about the middle of

the month. Dense fog occurred off the coast of New Jersey on the 3rd and off north Newfoundland on the 26th. In the United States, temperature was above normal along the western and eastern coasts, the Ohio Valley and Lake Region during the first half of the month becoming cooler later while in the Mississippi-Missouri Valley and Mountain Region temperature was low early in the month, becoming much above normal during the week ending the 22nd. The rainfall distribution was irregular (*The Times*, June 5th-28th and *Washington, D.C., U.S. Dept. Agric., Weekly Weather and Crop Bulletin*.)

### Daily Readings at Kew Observatory, June 1937

Date	Pressure, M.S.L. 13h.	Wind, Dir., Force 13h.	Temp.		Rel. Hum. 13h.	Rain.	Sun.	REMARKS. (see vol. 69, 1934, p. 1).
			Min.	Max.				
	mb.		°F.	°F.	%	in.	hrs.	
1	1018.1	NNW.4	49	62	52	—	8.3	w early.
2	1022.0	NNW.2	47	63	51	—	7.2	
3	1018.8	WSW.3	46	65	55	—	8.2	r <sub>0</sub> 19h.-20h.
4	1017.8	SW.3	56	72	62	—	4.0	w evening.
5	1018.3	WSW.3	55	74	56	—	9.8	
6	1016.0	S.4	51	79	47	—	14.3	w early.
7	1014.2	SW.3	59	77	59	—	12.4	
8	1017.9	SSW.3	52	67	78	0.06	6.7	r <sub>0</sub> -r 11h.-14h.
9	1016.1	S.2	47	71	50	0.02	7.0	r <sub>0</sub> -r 15h.-18h.
10	1012.9	NE.4	54	77	54	0.41	6.7	TLR 19h.-22h.
11	1014.5	WSW.2	59	81	60	—	11.4	l 22h.
12	1019.7	WSW.3	62	77	61	trace	8.4	pr <sub>0</sub> 1h.-2h.
13	1020.3	SSE.3	59	70	82	0.52	4.4	rR 7h.-11h.
14	1024.8	W.2	54	71	64	—	5.0	
15	1026.2	NE.3	57	64	72	0.02	3.4	pr <sub>0</sub> during day.
16	1025.2	WNW.3	51	63	61	0.01	1.2	pr 17h., r <sub>0</sub> 19h.-22h.
17	1021.9	NNW.4	49	61	67	—	4.1	pr <sub>0</sub> 13h.
18	1017.6	NW.3	49	63	48	0.41	6.2	r 20h., TLR 21h.-22h.
19	1013.8	NE.2	48	61	55	0.02	5.3	r-r <sub>0</sub> 0h.-5h.
20	1015.7	N.2	50	63	69	0.19	3.3	r 1h.-7h., TLR 17h.
21	1020.0	W.2	47	68	52	—	11.4	w early.
22	1015.6	WNW.3	53	72	43	0.13	10.7	r <sub>0</sub> 18h.-24h.
23	1015.8	NNW.2	53	67	49	—	11.0	r <sub>0</sub> 0h.-1h.
24	1015.5	NE.3	54	66	53	—	5.0	
25	1019.9	SW.2	49	69	56	—	4.3	d <sub>0</sub> 7h.
26	1020.6	NNW.2	52	68	64	—	2.4	
27	1017.9	NNW.2	57	72	56	—	7.6	
28	1011.0	SW.3	53	74	53	—	8.3	pr <sub>0</sub> 21h.
29	1011.3	NNW.3	55	62	61	0.01	7.8	pr 12h., 14h., 17h.
30	1017.6	SW.4	47	64	63	—	2.7	pr <sub>0</sub> 12h., 17h.
*	1017.9	...	53	69	58	1.81	6.9	* Means or Totals.

### General Rainfall for June, 1937

England and Wales	...	71	} per cent of the average 1881-1915
Scotland	...	103	
Ireland	...	78	
British Isles	...	81	

## Rainfall : June, 1937 : England and Wales

Co.	STATION.	In.	Per cent of Av.	Co.	STATION.	In.	Per cent of Av.
<i>Lond.</i>	Camden Square.....	1.49	74	<i>War.</i>	Birmingham, Edgbaston	.82	35
<i>Sur.</i>	Reigate, Wray Pk. Rd..	1.95	94	<i>Leics.</i>	Thornton Reservoir ...	.62	29
<i>Kent.</i>	Tenterden, Ashenden...	1.84	97	"	Belvoir Castle.....	.56	29
"	Folkestone, Boro. San.	1.71	...	<i>Rut.</i>	Ridlington .....	1.12	58
"	Margate, Cliftonville...	1.83	104	<i>Lincs.</i>	Boston, Skirbeck.....	1.92	105
"	Eden'bdg., Falconhurst	2.57	117	"	Cranwell Aerodrome...	1.19	71
<i>Sus.</i>	Compton, Compton Ho.	1.01	41	"	Skegness, Marine Gdns.	1.58	88
"	Patching Farm.....	.96	48	"	Louth, Westgate.....	1.26	58
"	Eastbourne, Wil. Sq....	1.35	73	"	Brigg, Wrawby St.....	1.57	...
<i>Hants.</i>	Ventnor, Roy. Nat. Hos.	.85	46	<i>Notts.</i>	Worksop, Hodsock.....	1.33	67
"	Fordingbridge, Oaklands	.81	43	<i>Derby.</i>	Derby, The Arboretum	.89	38
"	Ovington Rectory.....	1.74	75	"	Buxton, Terrace Slopes	1.74	54
"	Sherborne St. John.....	1.62	76	<i>Ches.</i>	Bidston Obsy.....	1.81	82
<i>Herts.</i>	Royston, Therfield Rec.	2.89	129	<i>Lancs.</i>	Manchester, Whit. Pk.	1.19	45
<i>Bucks.</i>	Slough, Upton.....	1.99	97	"	Stonyhurst College.....	3.74	122
"	H. Wycombe, Flackwell	1.49	74	"	Southport, Bedford Pk.	1.87	86
<i>Oxf.</i>	Oxford, Radcliffe.....	1.56	70	"	Ulverston, Poaka Beck	3.04	94
<i>N'hant.</i>	Wellingboro, Swanspool	1.41	69	"	Lancaster, Greg Obsy.	2.68	105
"	Oundle .....	1.23	...	"	Blackpool .....	2.25	103
<i>Beds.</i>	Woburn, Exptl. Farm...	1.49	76	<i>Yorks.</i>	Wath-upon-Deane.....	1.55	70
<i>Cam.</i>	Cambridge, Bot. Gdns.	1.52	72	"	Wakefield, Clarence Pk.	1.39	65
"	March.....	1.34	68	"	Oughtershaw Hall.....	3.20	...
<i>Essex.</i>	Chelmsford, County Gdns	2.31	120	"	Wetherby, Ribston H..	...	...
"	Lexden Hill House.....	2.25	...	"	Hull, Pearson Park.....	1.32	64
<i>Suff.</i>	Haughley House.....	.96	...	"	Holme-on-Spalding.....	1.62	74
"	Rendlesham Hall.....	1.32	70	"	West Witton, Ivy Ho.	1.33	65
"	Lowestoft Sec. School...	.66	36	"	Felixkirk, Mt. St. John.	1.45	66
"	Bury St. Ed., Westley H.	1.79	85	"	York, Museum Gdns....	1.74	84
<i>Norf.</i>	Wells, Holkham Hall...	1.34	68	"	Pickering, Hungate.....	1.01	48
<i>Wilts.</i>	Porton, W.D. Exp'l. Stn	1.49	77	"	Scarborough.....	1.22	66
"	Bishops Cannings.....	1.50	62	"	Middlesbrough.....	1.69	90
<i>Dor.</i>	Weymouth, Westham.	.57	32	"	Baldersdale, Hury Res.	1.35	57
"	Beaminstor, East St....	1.36	60	<i>Durh.</i>	Ushaw College.....	1.47	68
"	Shaftesbury, Abbey Ho.	.76	33	<i>Nor.</i>	Newcastle, Leazes Pk...	2.85	135
<i>Devon.</i>	Plymouth, The Hoe.....	1.33	62	"	Bellingham, Highgreen	1.11	48
"	Holne, Church Pk. Cott.	1.78	62	"	Lilburn Tower Gdns....	1.49	72
"	Teignmouth, Den Gdns.	.93	48	<i>Cumb.</i>	Carlisle, Scaleby Hall...	1.71	68
"	Cullompton .....	.75	35	"	Borrowdale, Seathwaite	8.75	143
"	Sidmouth, U.D.C.....	.70	...	"	Thirlmere, Dale Head H.	3.63	88
"	Barnstaple, N. Dev. Ath	1.03	58	"	Keswick, High Hill.....	2.12	73
"	Dartm'r, Cranmere Pool	2.40	...	<i>West.</i>	Appleby, Castle Bank...	1.30	57
"	Okehampton, Uplands.	1.30	47	<i>Mon.</i>	Abergavenny, Larchfd	1.27	52
<i>Corn.</i>	Redruth, Trewirgie.....	2.09	84	<i>Glam.</i>	Ystalyfera, Wern Ho....	4.02	107
"	Penzance, Morrab Gdns.	1.21	55	"	Treherbert, Tynywaun.	3.87	...
"	St. Austell, Trevarna...	1.77	68	"	Cardiff, Penylan.....	1.10	44
<i>Soms.</i>	Chewton Mendip.....	1.66	56	<i>Carm.</i>	Carmarthen, M. & P. Sch.	2.43	82
"	Long Ashton.....	1.41	56	<i>Pemb.</i>	St. Ann's Hd, C. Gd. Stn.	.86	43
"	Street, Millfield.....	.74	...	<i>Card.</i>	Aberystwyth.....	1.88	...
<i>Glos.</i>	Blockley .....	2.08	...	<i>Rad.</i>	Birm W.W. Tyrmynydd	1.59	49
"	Cirencester, Gwynfa....	1.30	54	<i>Mont.</i>	Lake Vyrnwy .....	...	...
<i>Here.</i>	Ross-on-Wye.....	1.06	49	<i>Flint.</i>	Sealand Aerodrome.....	1.22	...
<i>Salop.</i>	Church Stretton.....	1.48	61	<i>Mer.</i>	Blaenau Festiniog .....	6.84	114
"	Shifnal, Hatton Grange	.88	39	"	Dolgelly, Bontddu.....	3.20	92
"	Cheswardine Hall.....	.94	38	<i>Carn.</i>	Llandudno .....	1.09	57
<i>Worc.</i>	Malvern, Free Library...	1.22	92	"	Snowdon, L. Llydaw 9..	11.25	...
"	Ombersley, Holt Look.	.92	41	<i>Ang.</i>	Holyhead, Salt Island...	2.35	109
<i>War.</i>	Alcester, Ragley Hall...	.79	35	"	Lligwy .....	2.74	...

## Rainfall : June, 1937 : Scotland and Ireland

Co.	STATION.	In.	Per cent of Av.	Co.	STATION.	In.	Per cent of Av.
<i>I. Man</i>	Douglas, Boro' Cem....	3·04	126	<i>R&amp;C</i>	Achnashellach .....	4·10	103
<i>Guern.</i>	St. Peter P't. Grange Rd.	·62	33	"	Stornoway, C. Guard Stn.	3·43	...
<i>Wig</i>	Pt. William, Monreith.	2·93	125	<i>Suth</i>	Lairg .....	2·27	109
"	New Luce School .....	3·33	115	"	Tongue .....	...	...
<i>Kirk</i>	Dalry, Glendarroch .....	3·00	108	"	Melvich .....	2·96	153
<i>Dumf.</i>	Dumfries, Crichton R.I.	2·56	107	"	Loch More, Achfary....	4·50	122
"	Eskdalemuir Obs .....	3·94	125	<i>Caith</i>	Wick .....	2·77	154
<i>Rozb</i>	Hawick, Wolfelee .....	1·24	53	<i>Ork</i>	Deerness .....	2·70	147
<i>Peeb</i>	Stobo Castle .....	1·49	64	<i>Shet</i>	Lerwick .....	4·29	241
<i>Berw</i>	Marchmont House .....	1·45	63	<i>Cork</i>	Dunmanway Rectory...	1·57	45
<i>E. Lot</i>	North Berwick Res .....	1·70	102	"	Cork, University Coll...	...	...
<i>Mid</i>	Edinburgh, Blackfd. H.	1·00	50	"	Mallow, Longueville....	·96	44
<i>Lan</i>	Auchtyfardle .....	2·05	...	<i>Kerry</i>	Valentia Observatory...	2·00	63
<i>Ayr</i>	Kilmarnock, Kay Park	3·25	...	"	Gearhameen .....	3·00	60
"	Girvan, Pinmore .....	3·16	109	"	Bally McElligott Rec...	1·06	...
"	Glen Afton, Ayr San .....	3·00	100	"	Darrynane Abbey .....	1·06	34
<i>Renf</i>	Glasgow, Queen's Park	2·17	94	<i>Wat</i>	Waterford, Gortmore...	1·65	63
"	Greenock, Prospect H.	2·96	90	<i>Tip</i>	Nenagh, Castle Lough.	1·44	59
<i>Bute</i>	Rothsay, Ardenraig .....	4·53	148	"	Roscrea, Timoney Park	2·19	...
"	Dougarie Lodge .....	3·38	124	"	Cashel, Ballinamona...	1·04	46
<i>Arg</i>	Loch Sunart, G'dale .....	4·10	127	<i>Lim</i>	Foynes, Coolnanes .....	...	...
"	Ardgour House .....	7·94	...	<i>Clare</i>	Inagh, Mount Callan....	2·74	...
"	Glen Etive .....	8·67	184	<i>Wexf</i>	Gorey, Courtown Ho...	1·44	59
"	Oban .....	4·12	...	<i>Wick</i>	Rathnew, Clonmannon.	1·11	...
"	Poltalloch .....	4·80	157	<i>Carl</i>	Bagnalstown, Fenagh H.	1·58	64
"	Inveraray Castle .....	7·01	177	"	Hacketstown Rectory...	...	...
"	Islay, Eallabus .....	3·72	142	<i>Leix</i>	Blandsfort House .....	2·20	85
"	Mull, Benmore .....	15·20	193	<i>Offaly</i>	Birr Castle .....	2·05	89
"	Tiree .....	2·49	98	<i>Kild</i>	Straffan House .....	1·60	70
<i>Kinr</i>	Loch Lervin Sluice .....	2·42	111	<i>Dublin</i>	Dublin, Phoenix Park..	1·31	66
<i>Fife</i>	Leuchars Aerodrome...	1·93	116	<i>Meath</i>	Kells, Headfort .....	1·95	73
<i>Perth</i>	Loch Dhu .....	4·60	110	<i>W.M.</i>	Moate, Coolatore .....	...	...
"	Crieff, Strathearn Hyd.	2·00	76	"	Mullingar, Belvedere...	2·57	99
"	Blair Castle Gardens ...	1·41	71	<i>Long</i>	Castle Forbes Gdns .....	1·89	73
<i>Angus</i>	Kettins School .....	1·49	72	<i>Gal</i>	Galway, Grammar Sch.	2·09	82
"	Pearsie House .....	1·75	...	"	Ballynahinch Castle....	3·30	93
"	Montrose, Sunnyside...	1·95	118	"	Ahascragh, Clonbrock.	1·97	70
<i>Aber</i>	Balmoral Castle Gdns..	·73	43	<i>Rosc</i>	Strokestown, C'node....	...	...
"	Logie Coldstone Sch .....	1·07	55	<i>Mayo</i>	Blacksod Point .....	2·79	100
"	Aberdeen Observatory.	1·26	74	"	Mallaranny .....	4·92	...
"	New Deer School House	1·72	86	"	Westport House .....	1·82	67
<i>Moray</i>	Gordon Castle .....	2·26	111	"	Delphi Lodge .....	6·72	117
"	Grantown-on-Spey .....	...	...	<i>Sligo</i>	Markree Castle .....	1·83	62
<i>Nairn</i>	Nairn .....	1·83	104	<i>Cavan</i>	Crossdoney, Kevit Cas..	1·87	...
<i>Inw's</i>	Ben Alder Lodge .....	2·38	...	<i>Ferm</i>	Crom Castle .....	2·23	82
"	Kingussie, The Birches.	1·32	...	<i>Arm</i>	Armagh Obsy .....	2·15	85
"	Loch Ness, Foyers .....	1·31	59	<i>Down</i>	Fofanny Reservoir .....	2·59	...
"	Inverness, Culduthel R.	1·52	80	"	Seaforde .....	2·54	92
"	Loch Quoich, Loan .....	10·41	...	"	Donaghadee, C. G. Stn.	2·44	105
"	Glenquoich .....	...	...	<i>Antr</i>	Belfast, Queen's Univ...	...	...
"	Arisaig House .....	4·25	130	"	Aldergrove Aerodrome.	2·99	124
"	Glenleven, Corroul .....	...	...	"	Ballymena, Harryville.	2·80	96
"	Fort William, Glasdrum	4·92	...	<i>Lon</i>	Garvagh, Moneydig....	2·20	...
"	Skye, Dunvegan .....	3·79	...	"	Londonderry, Creggan.	2·51	86
"	Barra, Skallary .....	2·00	...	<i>Tyr</i>	Omagh, Edenfel .....	2·83	100
<i>R&amp;C</i>	Alness, Ardrross Castle.	1·09	48	<i>Don</i>	Malin Head .....	2·06	...
"	Ullapool .....	1·77	75	"	Dunkineely .....	2·21	...

## Climatological Table for the British Empire, January, 1937

PRESSURE.			TEMPERATURE.							Mean Cloud Am't	PRECIPITATION.			BRIGHT SUNSHINE.		
Mean of Day M.S.L.	Diff. from Normal.	mb.	Absolute.		Mean Values.						Mean.	Wet Bulb.	Diff. from Normal.	Days.	Hours per day.	Per-centage of possible.
			Max.	Min.	Max.	Min.	Max. 1/2 Min.	Diff. from Normal	°F.							
mb.	°F.	°F.	°F.	°F.	°F.	°F.	°F.	°F.	%	0-10	In.	In.				
London, Kew Obsy...	1009.4	- 8.2	54	29	46.9	37.9	42.4	+ 2.0	90	7.7	3.76	+ 2.00	21	1.5	18	
Gibraltar .....	1021.1	- 0.4	62	45	58.5	51.0	54.7	- 0.2	82	6.6	5.43	...	11	...	...	
Malta .....	1020.8	+ 3.8	68	43	59.2	51.0	55.1	- 0.2	75	5.7	2.02	- 1.19	8	5.6	56	
St. Helena .....	1011.0	+ 1.3	74	58	68.8	60.3	64.5	+ 1.1	93	9.7	0.57	- 1.47	9	...	...	
Freetown, Sierra Leone	1010.3	+ 1.2	91	70	87.4	74.8	81.1	...	78	2.2	0.00	- 0.41	0	...	...	
Lagos, Nigeria .....	1009.9	+ 0.3	91	68	87.4	73.1	80.3	- 0.6	85	4.6	0.00	- 1.04	0	6.0	51	
Kaduna, Nigeria .....	1013.7	...	94	50	87.1	56.7	71.9	- 1.5	40	0.9	0.00	0.00	0	8.8	77	
Zomba, Nyasaland ...	1007.0	- 0.6	84	54	80.7	64.8	72.7	- 0.1	69.7	8.0	18.02	+ 6.92	23	...	...	
Salisbury, Rhodesia...	1008.4	- 0.8	87	55	80.7	60.1	70.4	+ 0.7	67	7.3	4.72	...	16	6.9	53	
Cape Town .....	1013.1	- 0.3	90	56	79.4	62.7	71.1	+ 1.2	65	2.1	1.15	- 0.47	5	...	...	
Johannesburg .....	1000.5	- 0.3	86	50	75.7	56.6	66.1	- 0.6	59.4	5.3	8.45	+ 2.28	18	6.5	48	
Mauritius .....	1009.7	- 2.2	88	67	83.8	72.9	78.3	- 1.0	74.8	6.6	10.12	+ 2.36	22	8.2	62	
Calcutta, Alipore Obsy.	1015.0	- 0.2	83	49	77.1	53.5	65.3	- 1.3	53.8	1.3	0.00	- 0.42	0*	...	...	
Bombay .....	1012.7	- 0.9	89	61	82.6	64.8	73.7	- 1.8	62.8	70	2.1	0.00	- 0.10	0*	...	
Madras .....	1013.2	- 0.9	85	64	83.9	68.6	76.3	+ 0.1	60.9	78	6.0	0.07	- 1.07	0*	...	
Colombo, Ceylon .....	1010.7	- 0.1	89	69	85.5	73.0	79.3	- 0.2	73.5	75	5.4	3.43	- 0.18	14	7.7	65
Singapore .....	1009.3	- 1.1	89	70	86.0	74.2	80.1	+ 0.4	75.7	81	7.2	8.16	- 1.73	14	5.9	49
Hongkong .....	1018.1	- 1.6	76	49	66.3	58.0	62.1	+ 1.9	57.3	76	7.0	2.77	- 1.45	5	4.5	41
Sandakan .....	1008.9	...	90	72	85.8	74.8	80.3	+ 0.5	76.8	88	8.9	19.58	+ 0.18	22	...	
Sydney, N.S.W. ....	1008.4	- 4.0	98	61	79.9	66.6	73.3	+ 1.7	66.3	63	6.6	2.12	- 1.55	13	8.2	58
Melbourne .....	1009.6	- 3.3	99	49	75.1	54.6	64.9	- 2.5	59.2	58	7.5	2.54	- 0.65	11	6.3	44
Adelaide .....	1011.5	- 1.5	102	50	80.5	58.9	69.7	- 4.0	57.6	48	6.4	2.42	- 1.70	10	7.7	55
Perth, W. Australia ..	1011.2	- 1.3	98	51	84.0	63.6	73.8	- 0.0	62.6	51	2.2	0.02	- 0.32	1	11.4	82
Coalgardie .....	1009.5	- 1.9	110	52	88.9	63.3	76.1	- 1.3	62.2	52	3.2	1.04	- 0.58	3	...	
Brisbane .....	1009.3	- 2.0	96	64	87.5	70.3	78.9	+ 1.7	70.8	59	4.8	1.57	- 0.88	5	9.7	71
Hobart, Tasmania .....	1005.3	- 5.0	82	44	67.6	51.5	59.5	- 2.5	53.0	50	6.9	3.38	- 1.55	16	7.0	47
Wellington, N.Z. ....	1006.2	- 7.1	73	45	65.8	53.5	59.7	- 2.8	56.2	73	6.5	3.18	- 0.15	12	7.5	51
Suva, Fiji .....	1007.1	- 0.4	94	72	88.9	76.6	82.7	+ 2.8	77.5	78	6.4	8.78	- 2.65	22	7.0	53
Apia, Samoa .....	1007.3	- 0.6	90	71	86.1	75.2	80.7	+ 1.7	77.3	79	6.3	15.20	- 1.85	27	7.1	56
Kingston, Jamaica ...	1014.1	- 1.0	89	65	86.4	68.5	77.5	+ 0.7	66.2	85	3.0	1.13	- 0.17	6	...	
Grenada, W.I. ....	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	
Toronto .....	1022.3	+ 4.4	53	11	37.4	24.9	31.1	+ 8.9	...	...	5.18	- 2.39	15	2.5	27	
Winnipeg .....	1023.7	+ 1.8	15	- 37	- 3.7	- 22.2	- 12.9	- 6.0	...	4.6	1.02	- 0.01	18	3.0	35	
St. John, N.B. ....	1023.1	+ 7.6	47	- 3	34.4	17.1	25.7	+ 6.5	22.0	74	6.9	4.09	- 0.71	11	3.6	39
Victoria, B.C. ....	1018.4	+ 2.4	45	19	34.7	27.6	31.1	+ 7.9	28.4	73	6.7	2.32	- 2.22	16	2.7	31

\* For Indian stations a rain day is a day on which 0.1 in. or more rain has fallen.



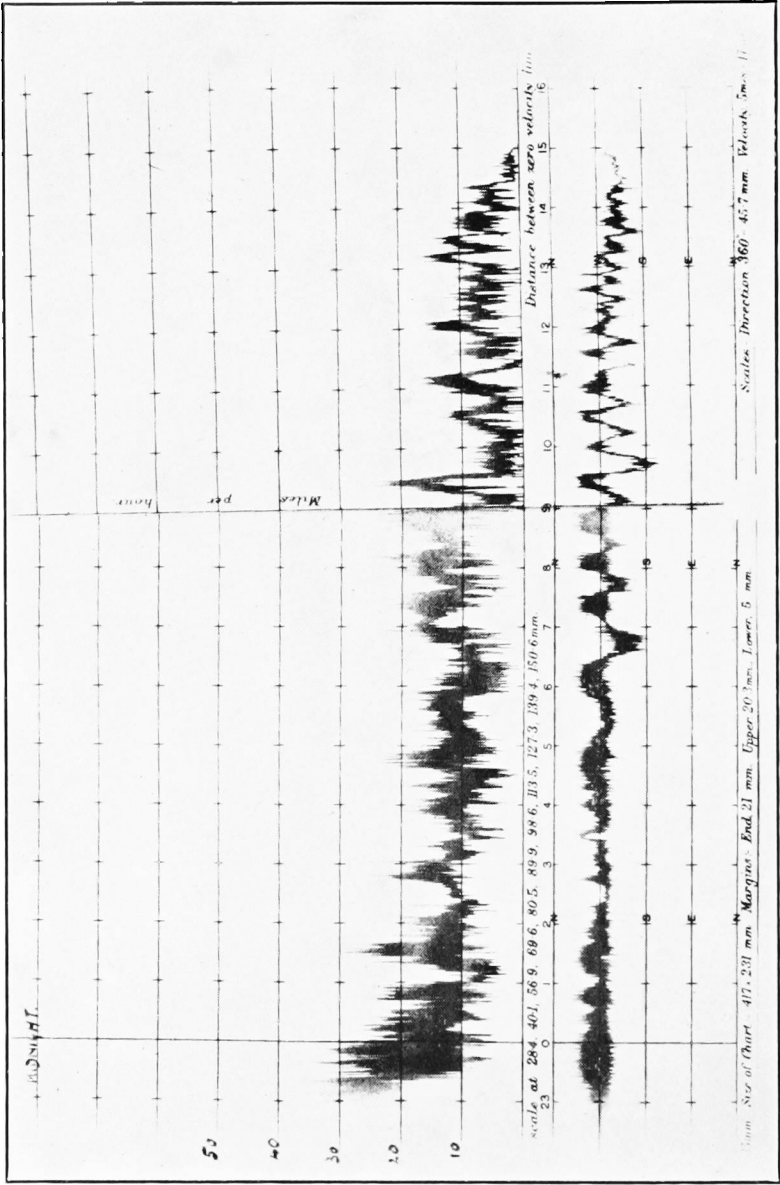


FIG. 1.—ANEMOGRAM, ABBOTSINCH, NOVEMBER 16TH, 1936 (see p. 157)