M.O. 371.

The Meteorological Magazine

Air Ministry: Meteorological Office

Vol. 69

Oct. 1934

No. 825

LONDON: PRINTED AND PUBLISHED BY HIS MAJESTY'S STATIONERY OFFICE
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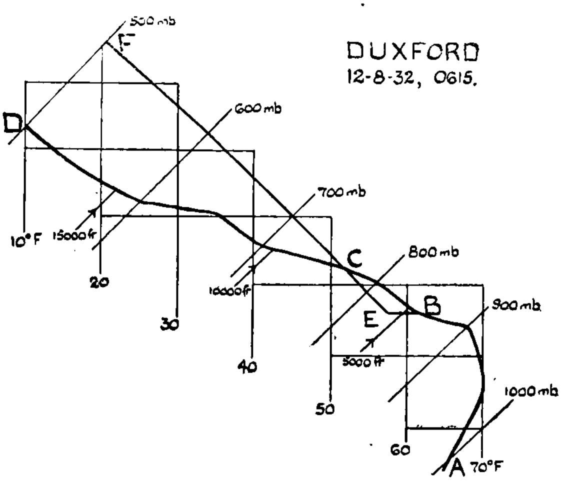
A Note on Frontal Thunderstorms

THE principles of frontal thunderstorms can be most easily discussed by means of a particular case. The cold front storm on the early morning of August 12th, 1932, is very suitable, since the Duxford aeroplane ascent was made just in front of it, and the pilot had to land further east at Martlesham so as to avoid flying back through it. In the accompanying diagram (a tephigram, with temperature as abscissa and potential temperature as ordinate, the horizontal lines being dry adiabatics) the curve A B C D represents the observed state of the atmosphere, while B E C F is a theoretical curve followed by an air mass starting with the observed temperature, pressure, and humidity at B, and ascending under adiabatic conditions. The curve is horizontal to E, the point of saturation, and then follows the saturated adiabatic E F, crossing the other curve at C. The pressure at E, namely 830 mb., agrees exactly with the observed cloud base,* and if we started from any lower point in the observed curve, the area B E C would be increased. Up to the point C the air would be colder than the undisturbed air and would have to be forced upwards, the necessary energy being presumably supplied by the

* The actual observations by the pilot were "Turreted cumulus with nimbus base, base 830 mb., tops 570 mb., to westward, amount nine-tenths; fracto-cumulus 660 to 610 mb., six-tenths, mammato-cumulus, ten-tenths, base 500 mb." The mammillated upper layer was the forward extension of the anvil, and the turreted clouds were no doubt growing up and feeding the storm.

horizontal temperature difference. At 900 mb. temperature fell 6° F. between 6h. and 12h. Above C the rising air would be warmer than its environment and inherently buoyant. The large area between C D and C F, which probably extended to the base of the stratosphere, shows that much energy was available, and it is not surprising that the storm was locally very violent and that large hail fell.*

Although the area B E C is small in comparison with that between C F and C D, it does not follow that it is unimportant. It implies that the rising air was colder than the adjacent air through a layer nearly 2,000 feet thick, the difference exceeding 1° F. for over 1,000 feet. There is no real proof as to exactly what happened on this occasion, but there is no doubt that forced ascent of this kind does often take place, sometimes to a greater extent than that indicated by B E C, and that sometimes the rising air has warmer air all round it, not on one side only. I have noted many clouds to be colder than their environment, including some in thundery weather. As an extreme example, I quote the following extract from a lengthy description of the clouds over Berck at 18h. on August 23rd, 1918. "The alto-cumulus castellatus clouds at 8,000 feet were 5° F. colder than the surrounding air, at 10,000 feet 1° F. colder. The clouds at 15,000 feet were 1° F. warmer than the surrounding air." (These had a stratified base at 14,000 feet, and high cumulo-nimbus tops.) Thunder occurred a few hours later, though high up and of no great intensity. Further investigation is required on these problems.



An excellent example of the practical importance of this trigger action is that of August 27th to 29th, 1930. According to the figures for Kew given by F. H. Dight,† this was the most notable spell of damp heat during the present century. The lapse-rate on all three days was very exceptional, the difference between the afternoon temperature at the ground and the temperature at 17,000 feet in the morning being about 73° F. There were no afternoon ascents, but one can estimate that there was probably a very thin stable layer at

* See *Meteorological Magazine* **67**, 1932, p. 186.
† *Meteorological Magazine* **69**, 1934, p. 112.

3,000 feet which checked convection. At all events the three days passed with practically no cloud and no thunder in the south-east of England, but on the night of the 29th a feeble cold front advanced and there was a memorable storm, in which S. C. Russell* noted sixty-three flashes per minute, the highest rate he ever recorded.

The storm on the night of July 9th, 1923, was probably the most notable night storm of the present century in south-east England, as the lightning and thunder were of a severe type, even though the frequency did not quite equal that of the 1930 storm. Its interest for our purpose lies in the fact that it was associated with a rather feeble warm front. A cold front which crossed England on the 7th became stationary over Holland and eastern France, and subsequently came back as a warm front, owing to the development of an anticyclone over Scandinavia. There were no observations of upper air temperature, but surface temperature showed a rise in the extreme south-east on the 10th, and subsequently over most of England, 90° F. being reached at many places. The upper wind on the evening of the 9th and on the morning of the 10th was ESE. at 2,000 feet and SSE. at 6,000 feet, indicating rising temperature between the two levels. There was little variation above 6,000 feet. It is only in special conditions that instability up above accompanies warm fronts, but warm front storms of fair severity may occur almost anywhere in the British Isles, and in the south-east they average about one in two years. There was a good example on the night of May 26th, 1929.

I have observed large banks of cumulus, associated with local or general fronts, often feeble, with a temperature in the cloud lower than in the air on both sides of the cloud bank through a considerable range of height, but these never gave thunder, and only occasionally even showers. One cannot rule out the possibility of thunder being occasionally due entirely to the horizontal temperature difference, for example in a severe winter line-squall, but there is no doubt that the vast majority of storms derive most of their energy above the condensation level, and that both fronts and surface heating† only serve to start the disturbance. The rising of saturated air through its environment cannot accurately be described as a "convectional over-turning," since it is almost certain that the surrounding dry air only sinks slowly. The only downrush of air is that due to the precipitation, but though the out-flowing cold air helps to maintain the storm, it is a secondary effect and cannot be given primary importance. Even during the night heavy squalls with thunderstorms are usually due to the precipitation, which evidently cools the air above the surface inversion.

Most diurnal convectional storms have some frontal characteristics, especially really severe storms, which are normally of the type first

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* *Meteorological Magazine* **65**, 1930, p. 185.

† This of course refers to one day's heating, not to prolonged heating.

investigated by J. Fairgrieve,* developing along belts of the order of 40 or 50 miles in length and 10 miles in width. The surface winds (after allowing for any general motion) conform to the general rules found by Fairgrieve. During development there is convergence into the belt, but later on the cold air mass formed by the rain spreads out laterally, with divergence in the middle but convergence at its boundaries. Sometimes the storm belt splits into two before it finally breaks up. As a rule there is some general drift at the cloud level, which as a first approximation may be superposed on the movements due to development.

The recent heavy storm over south London on July 22nd, 1934,† illustrated these features. There were large cumulus clouds from noon onwards, but they only became threatening in the evening, when they gathered over south London in an enormous darkening mass. The clouds drifted slowly south-east, but development in the rear made the edge of the dark mass stationary. There was marked wind convergence during development, the wind being WSW. at Croydon and NNE. at Kingsway. The storm was some miles south of Kingsway, but the outflowing air arrived at 20h. G.M.T., and temperature quickly fell 5° F. The wind remained S. to SE. for some time afterwards.

The "surface heating" and "frontal" types of thunderstorms form overlapping rather than sharply defined categories, and the classification refers only to the lower layers, leaving out of account the main source of the thunderstorm energy. A classification which took into account both the lower and the upper layer would inevitably be rather clumsy, and the simple classification is probably the most practically useful, but it is important to keep its limitations in mind. True knowledge of the atmosphere consists not in forming simple generalisations, but rather in following out the actual processes of nature in all their complexity.

C. K. M. DOUGLAS.

Wind Pressures on Buildings

During recent years the investigations into the wind pressure on buildings, which were initiated by Sir Thomas Stanton at the National Physical Laboratory, have been pursued further by the measurement of pressures on buildings and the comparison with the pressures found on small scale models in the wind tunnels at the N.P.L. A paper on Wind Pressures on Buildings by A. Bailey‡ gives the

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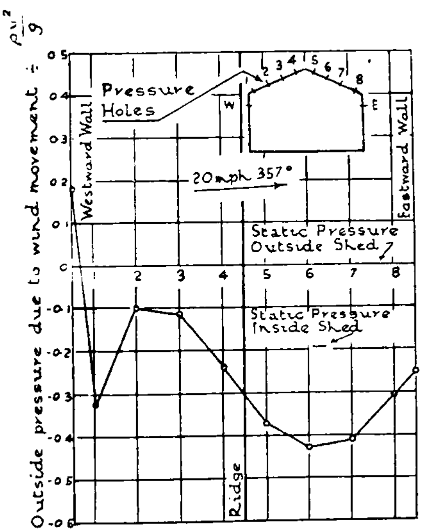
* See *British Rainfall*, 1911 and 1914. Also *London Q.J.R. Meteor. Soc.* **44**, p. 245.

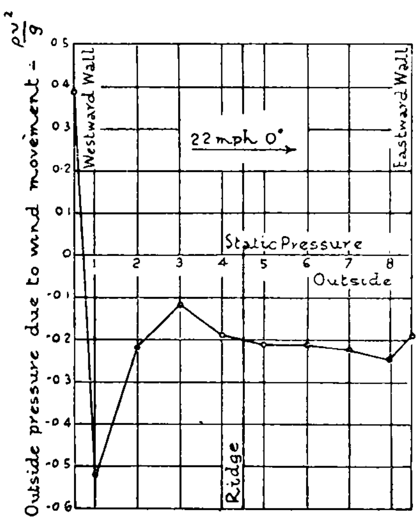
† *Meteorological Magazine* **69**, 1934, p. 163.

‡ "Wind Pressures on Buildings," by Alfred Bailey, M.Sc., Assoc.M.Inst.C.E. *London Inst. Civ. Engin., Selected Engin. Papers, No.* 139.

results of one such investigation, that on a large shed belonging to the Metropolitan-Vickers Electrical Manufacturing Co., at Manchester. Other investigations on similar lines are being carried on at a bridge over the Severn and on a hangar at Manston. The latter is an even more elaborate investigation than that conducted at Manchester and when it is completed it will be of great interest to compare its results with those which are given in the present paper. The problem is (*a*) to discover qualitatively how wind pressure (or suction) is exerted on the different parts of the roof and sides of a building; (*b*) to determine quantitatively the scale effects produced in models, the ultimate objective being to be able to predict from the examination of a model in a wind tunnel to what strains the full size building will be subjected. The method used in the Manchester experiment was briefly as follows:—Pressure holes at a number of points on the roof and sides of the building were connected with a multimanometer gauge which the observer photographed when he estimated that suitable wind conditions were in operation. The measurements from these photographs were then compared with measurements of pressure made at similar holes in a small model in the wind tunnel. The type of result obtained is best seen from an example such as that shown in the figure below in



Wind pressure on Shed



Wind pressure on Model

which the right-hand diagram refers to the full scale measurements, the left-hand to those on the small model. The points at which measurements were made are shown by numbers corresponding to those on the section of the shed. In this case the wind was normal to the roof ridge. The points that stand out are (*a*) there are two positions where suction is great, one just behind the windward eves (at point 1) and the other over the lee slope of the roof; (*b*) the latter area is subjected to greater suction on the full scale than would be expected from the model experiment; (c) pressure on the windward wall is greater on the model than on the full scale shed. The ratios of the suctions have been determined for the Manchester shed as 1·51 and for the pressures as 0·64. The physical process to which this discrepancy between full scale and model is due is not understood. It may be due to differences between the structure of the wind in the tunnel and that in nature.

From the practical point of view the suction effect on the lee side of the roof is of considerable importance, a statement which is brought home in this paper by photographs of damage to buildings in Birmingham by wind in which the roofs of houses were lifted off and gable walls were pulled outwards.

This same effect of the *outward* falling of buildings when struck by tornadoes has been explained as an explosive action of the air inside the building owing to the sudden reduction of pressure in the core of the tornado (*vide* Gregg's Aeronautical Meteorology, p. 228). It would seem to the writer of this note that this view may need modification in the light of these investigations on wind pressure, and that the outward falling of the buildings is due rather to the creation of lee eddies than to the explosion of air prisoned in the building.

C. S. DURST.

Meteorological Observations in central Greenland

Previous to the winter of 1930–1, meteorological observations in Greenland were restricted to those of coastal stations and occasional observations by sledge parties traversing the inland ice during the warmer months. Inferences about conditions in central Greenland during the "winter" had not been checked by observation.

During the period mentioned, however, two meteorological stations were being maintained on the ice cap and a recent Geophysical Memoir* gives a summary of some seven months' observations at a station in lat. 63° 3′ N., long.41° 49′ W., at an altitude of 8,000 ft., manned by members of the British Arctic Air Route Expedition. This expedition was led by H. G. Watkins, who unfortunately lost his life while leading a subsequent expedition to Greenland. In addition to the extensive programme of exploration and surveying, meteorological work was also carried on at the base camp of the expedition, near Angmagssalik, in east Greenland, and a summary of almost a complete year's observations at the Base is given.

The observations at the Base fit in with what was already known

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* *London, Meteor. Office, Geophysical Memoirs, No.* 61. Meteorological results of the British Arctic Air Route Expedition. By S. T. A. Mirrlees, M.A. (M.O.356d).

of the climate of the Greenland fjords : the prevailing winds blow up and down the fjords, and fog is rare within them, though it is common on the outer coasts in summer. Where the air flow is suitably concentrated by the topography the wind blowing off the ice-cap may at times attain hurricane velocity; force 12 (Beaufort Scale) was observed on 11 days and wind velocities up to 129 m.p.h. were recorded. Temperature varied between extremes of 63°F. and – 6°F.

From the point of view of aviation the main feature of the observations at the station on the ice-cap was the fact that drifting snow may cause the horizontal visibility near the surface to fall below 1 kilometre at nearly 50 per cent. of the observation hours. Often it seems to be the case that the snow of the surface is whirled along in a shallow layer, but at times blizzard conditions may prevail up to a considerable height. The prevailing direction of wind was from between N. and NW., *i.e.*, downhill, but gales were experienced from both downhill and uphill directions. The temperature varied between extremes of 8°F. and – 64°F., the mean for October–February was about – 25°F., the same as the normal for Jakutsk. The coldest month at Jakutsk, however, has a normal temperature of – 46°F., and the coldest month at the Ice-cap station averaged –33°F. Presumably the drainage of cold air from the ice-cap is free enough to prevent the occurrence of any remarkable extremes of temperature such as are experienced at enclosed valley stations in northern Siberia. On the ice-cap in quiet conditions a large inversion of the temperature lapse rate forms near the surface and any increase of wind disturbs this, so that an increase of wind may be associated with a rise in temperature of 30° or 40°F. in a few hours.

Apart from their bearing on the question of whether an air-route across Greenland is practicable these observations are of interest in regard to the more general question of the atmospheric circulation over Greenland. Discussion of this point has been limited owing to the fact that only part of the simultaneous observations from other stations in Greenland has as yet been available and the following conclusions are given tentatively.

It appears that outflowing winds from Greenland may in suitable circumstances attain hurricane force, but such outflow is limited in extent, appears to have no direct influence for disturbed weather in the north-east Atlantic, and is probably not on a large enough scale to provide motive power for the atmospheric circulation. (Somewhat similar localised outflows have been observed on the margin of the Antarctic Continent). The semi-permanent " central cold zone " is a statistical production ; the setting-in of strong winds either from east or west may bring " plus " temperatures to the Ice-cap station even in the coldest months.

At the Ice-cap station the changes of wind and barometric pressure are often those appropriate to the passage of a depression with centre to the southward; less frequently to the passage of a depression with centre to the northward. Isobaric charts drawn from observations at coastal stations could frequently be used to forecast wind and weather at the Ice-cap station, but there are also occasions when the M.S.L. isobars could not be so used. Some evidence for the existence of " fronts " of a kind crossing the inland ice is found. The difference between the temperatures of air at the Ice-cap and Base stations corresponds remarkably closely with a " saturated adiabatic " lapse rate when strong winds blow uphill between the two stations, and less closely with a " dry adiabatic " lapse rate when they blow downhill.

From what has been published of the results of the observations made by the German expedition, under the leadership of the late Alfred Wegener, at a station on the ice-cap 275 miles farther north during the same winter, it appears that the observations at the British station may be representative only of conditions on the southern part of the ice-cap. Tables and diagrams of the observations are given, therefore, for use in further investigations.

S. T. A. MIRRLEES.

OFFICIAL NOTICES

Discussions at the Meteorological Office

The series of meetings for the discussion of recent contributions to meteorological literature, especially in foreign and colonial journals, were resumed at the Meteorological Office, South Kensington, for the session 1934–5, on Monday, October 15th. The subject for this meeting was a paper by H. U. Sverdrup, entitled " The Norwegian North Polar Expedition with the 'Maud,' 1918–25, Scientific Results, Vol. II, Meteorology." The discussion was opened by Dr. G. C. Simpson, C.B., F.R.S.

The meeting are held on alternate Mondays at 5 p.m. The subjects for the next two meetings are :—

October 29th, 1934. *A survey of the air currents in the Bay of Gibraltar, 1929–30.* By J. H. Field and R. Warden (London, Meteor. Off., Geophys. Mem. Vol. 7, No. 59, 1933). *Opener*—Mr. J. S. Dines, M.A.

November 12th, 1934. (1) *Aerological investigations of atmospheric disturbances with special reference to processes in the stratosphere.* By E. Palmén (Helsingfors, Mitt. Met. Inst. Univ., No. 25, 1933) (in German), and (2) *On the distribution of temperature in the stratosphere and its influence on the dynamics of weather.* By E. Palmén (Meteor. Zs., Braunschweig, **51,** 1934, pp. 17–23) (in German). *Opener*—Mr. C. K. M. Douglas, B.A.

The dates for subsequent meetings are as follows :—

November 26th and December 10th, 1934 ; January 14th and 28th; February 11th and 25th; and March 11th, 1935.

The Director of the Meteorological Office wishes it to be known that visitors are welcomed at these meetings.

Course of Training for Observers

Provided enough applications are received, an elementary course of training for meteorological observers and deputy observers at climatological stations in connexion with the Meteorological Office (including stations that come under the Health Resort Scheme) will be held at the Meteorological Office, Exhibition Road, South Kensington, on Tuesday and Wednesday, November 27th and 28th, 1934. The Course is intended primarily for beginners, and for those who have not yet taken observations in accordance with official regulations.

There will be no fee. Travelling and other incidental expenses incurred by observers attending the Course will not be paid by the Meteorological Office. Applications for admission to the Course should be made before November 1st to The Director (M.O.7), Air Ministry, Kingsway, London, W.C.2.

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 ending March* 31*st*, 1934.

Much of the work of the Meteorological Office deals with the rapid collection of observations of weather on and above a large part of the earth's surface, both land and sea, and the marshalling of the information so obtained to give a picture of the conditions existing at any moment. This information is used for answering inquiries about " weather " as well as forming the basis for a large variety of forecasts. The efficient performance of this work, involving the interchange of weather information by wireless telegraphy over most of the northern hemisphere, requires an elaborate international organisation, which is described in detail in the first part of this report, together with a summary of the use made of the information for forecasting and otherwise. The demands for information continue to grow, and the number of " weather " inquiries rose from 8,705 in 1932–3 to 10,166 in 1933–4, these figures being exclusive of inquiries relating to aviation and climate.

Other features of the report describe the various special investigations which were in progress during the year, especially a series of researches at Kew Observatory into problems of atmospheric electricity, airwaves from gunfire, and visibility. The report also refers to the various activities in connexion with the International

Polar Year 1932–3, which were described in greater detail in the preceding report. In October 1933 the British party returned safely from Fort Rae in Canada with complete records of work in all branches of meteorology, and these records are now being tabulated and analysed.

PROFESSIONAL NOTES

No. 66. *Lightning and Aircraft.* By G. C. Simpson, C.B., F.R.S. (M.O. 336f).

There is always some electrical force in the earth's atmosphere, especially near the surface, and the first part of this paper describes the electrical effects which may be expected to accompany various types of weather. The generation of lightning and the ways in which the presence of aircraft may influence an electric discharge are then discussed and lastly the dangers to, and the measures of protection that can be adopted for aeroplanes, airships and kite balloons, are considered separately. The general conclusion is that " on aeroplanes without aerials there is practically no danger to the personnel .... the position, however, is much more serious if the machine has a trailing aerial .... the most important thing, therefore, to be done when it is known that the plane is in a danger area or is about to enter a danger area is to withdraw the aerial." Even though not actually struck, an aeroplane including metal parts not connected by conductors may collect charges able to give unpleasant though not dangerous shocks.

No authentic case is on record of an aeroplane having been wrecked as the result of being struck by lightning, and since January, 1925, when the first report of a British aeroplane being struck by lightning was made, only ten cases have been reported. A short account of each of these occurrences is given in the first appendix and a second appendix contains the report of the committee which examined the problem of the protection of R.101 from the risks of lightning.

Correspondence

To the Editor, *Meteorological Magazine*

Waterspout seen from Pentonwarra

At 8h. 55m. G.M.T. (9h. 55m. B.S.T.) on September 25th 1934, a waterspout was seen about two miles north-north-east of Pentonwarra Point, Trevone, Padstow, Cornwall. There was a fairly thick but partially broken up layer of fracto-cumulus moving north-east and from a dark portion of this, but by no means a stormy looking portion, there descended a thin pencil, almost straight, of tube-like structure, the sides darker than the centre and hanging down to near the edge of the cloud below which was clear sky. It was only noted because the clouds were being looked at at the time for the purpose of the 9h. meteorological record. As soon as its nature was realised a look at the sea revealed the other end in the shape of a small dish-shaped disturbance estimated at 12 to 15 feet in height and perhaps 20 feet in diameter. It was rather like the shape shown by an instantaneous photograph of the formation of a splash made by a drop of water on a water surface, but of course there were no sharp edges but rather a splash of water more intense at the edges than the centre. It moved at perhaps 12 m.p.h. towards the north-east, i.e., with the wind which was force 4 from the south-west. No connexion between the cloud and sea ends was seen except a slight rainbow coloured band for a few seconds above the sea but about 4 times as wide at least as the spout. No funnel shape widening of the spout at the cloud end was noted. It was quite a delicate structure and during the 7 minutes or so of its visibility partially disappeared at times and then reformed. The cloud spout was ahead of the water spout but did not point in its direction.

W. M. Lindley.

Pentonwarra, Trevone, Padstow, Cornwall, September 25th, 1934.

Cloudburst in Vallay

On Saturday, September 1st, about 5 p.m., there was a cloudburst in the island of Vallay. It came down for 10 minutes in torrents and all who were out in it where it fell were soaked to the skin. The curious thing is that it did not fall on the south side of my house where I keep the rain-gauge, and on the following morning the rain taken was only ·05 in. The distance from the rain-gauge to where the rain fell was only 70 yards. It fell to the north of the gauge close to the back door of the house. This seems a curious enough occurrence to record to you.

George Beveridge.

Vallay, Lochmaddy, North Uist, Hebrides, September 7th, 1934.

Rainfall in Westmorland

The enclosed figures for the rainfall here for some days in September may interest you :—

September 22nd 1·7 inches.
,, 26th 1·1 ,,
,, 30th 1·88 ,,

In the last case heavy rain began about noon and lasted till midnight, accompanied by a strong south wind.

The total rainfall, September 23rd–30th was 5·8 inches, as measured in my own gauge. Windermere Lake is very full, the piers for motor-boats being completely under water. Thirlmere, however, is still very much below its normal level.

E. M. Bullock.

St. Rule, Windermere, Westmorland, October 1st, 1934.

Halo Phenomenon seen from Grayshott

While at Grayshott, Hindhead, on August 24th, I observed the halo phenomenon here described. At 8h. 46m. G.M.T. there were small areas of the sky occupied by very thin cirro-stratus. Directly above the sun was a perfectly straight spectral band, its length subtending an angle of about 30° at the observer's eye. Its colours were red nearest the sun and blue outside. Its nearest approach to the sun was about 22° and consequently I took it for an upper arc of contact to the 22° halo, which had not yet appeared. The band justifies mention on account of its straightness. There was no sign of curvature even at the point where one could imagine it to touch the absent 22° halo. Another interesting feature was the fact that it was not horizontal—the left hand end was appreciably lower than the right. Mr. A. Moon describes a similar occurrence in the *Meteorological Magazine* for January, 1931, pp. 287–9.

As time went on the band slowly curved down, by reason of the growing altitude of the sun. This change of the shape of the tangent arc is discussed fully by Dr. Whipple in the *Meteorological Magazine,* June, 1932, pp. 109–11. At 9h. 30m. the arc had become very faint, and not until it had completely vanished did the 22° halo appear.

All the observations were made with the aid of spectacles of Crookes glass, which I find invaluable in the study of optical displays.

S. E. ASHMORE.

19, *Vicarage Road, Handsworth, Birmingham. August 26th,* 1934.

Anti-Solar Rays

The rays referred to by Mr. W. L. Baxter in the June issue of the *Meteorological Magazine* were presumably the anti-solar or crepuscular rays described (with an accompanying sketch) by Mr. G. A. Clarke in the *Meteorological Magazine* for February, 1923. The phenomenon is mentioned in the following issues of this publication :—

June, 1923 ; September and December, 1925 ; January and September, 1926.

Also in the April, 1923, issue, Mr. C. F. Talman refers to the voluminous literature on the subject.

These rays are quite often seen during the summer months in the hilly regions of the North-west Frontier Province and Kashmir. The irregularities in the western horizon, the almost daily formation of cumulus clouds on the mountain ranges and the frequent dustiness of the atmosphere, all favour the appearance of this phenomenon.

I observed these rays myself at Gulmarg on August 15th and 16th, and on September 12th and 16th, 1931 ; at Thandiani on August 22nd, and September 4th, 5th, 6th and 7th in 1932, and on August 18th, 1933. This year I had the good fortune to see the rays on eleven consecutive days, from July 14th to 24th inclusive, at Ganderbal in the vale of Kashmir. On each occasion the visibility at Ganderbal was good, and the sky was clear except for a little detached cumulus over very high peaks to the north. The rays appeared to occupy the same positions every evening but to vary in intensity. By climbing an adjacent hill it was possible, owing to the uneven spacing of the rays, to identify one or two of the most prominent peaks which produced the most conspicuous shadows. The rays extended well beyond the zenith, lasted from ten to twenty minutes and varied from purple to pink in colour.

An examination of the observations made at stations to the west of Ganderbal (e.g. Peshawar, nearly 200 miles away) showed that there was considerable dust-haze every day from July 14th to 24th and also occasional dust-storms. The monsoon over the extreme north of India was very weak during this period. Similar conditions prevailed on the days when I observed the rays in 1931–3, but on these occasions, except for the four consecutive days in September, 1932, the effect was apparently due to broken belts of cumulus cloud lying very low on the western horizon.

R. G. VERYARD.

No. 1 (Indian) Group Headquarters, R.A.F., Peshawar, August 26th, 1934.

Remarkable Cloud Movements

The article in the May *Meteorological Magazine* on the above and especially the references, p. 85, to a warm front effect, and p. 86, to possible wave motion, makes me wonder whether a " cloud ripple," which I observed on December 23rd,* 1883, and which I was puzzled how to explain, may have any bearing on the subject. A description and sketch will be found on p. 44, vol. I, " History and Work of the Warner Observatory, Rochester, N.Y. (1883–1886)," in a paper by me on " The Recent Sky-glows." After referring to Kiessling's correlations between them and abnormally high temperatures at Säntis, north-east Switzerland, at 3,300 feet I continued :—

" The following confirms independently the existence of such marked lines of contact. On December 23rd,* 1883, the writer observed at 2.45 p.m. a ripple of clear sky $\frac{1}{4}$° to $\frac{3}{4}$° broad, traversing a beautifully marked lofty cirrus above the sun, travelling 90° in 10 minutes, ending 40° to 50° long. The cloud, as this passed along, melted entirely except in its densest portions, which turned from opaque dark to transparent white. Evidently the crest of a lofty warm wave penetrated right through the cirrus cloud, which was fringed with exquisite bands."

The last point is a significant indication of its great height. By

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*As below the figure ; 25th in the text is a printer's error.

the sketch and my diary I see that the base of the cloud was twice the height of the sun from south by west to west-south-west; the upper margin was about six times the sun's height; the extremes at south and west about five times. There was a background of clear sky and the ripple is described as blue. The upper edge was from 30° to 40° altitude. The ripple began at the west ending due south at its top, convergent all through below by perspective. There was a slight brief rose glow at 2.52 p.m. The sun, golden, touched the horizon at 3.34. Similar clouds, forming between 2.30 and 3, joined the former cloud up to the zenith in the west; "now again dissolving and changing to (and ? being obscured by) cirro-stratus and cumulus at lower level, rosy tipped by sun."

No record is entered as to a glow or after-glow. On the 22nd there was a fair glow at 4.50 to 5.5 up to 60°. On the 25th it was bright, small print legible at 4.35; the after-glow pronounced at 4.55 but Porrs' comet visible at 4.57, when the smallest print of the Weekly Report of the Meteorological Office was still legible at the window.

J. EDMUND CLARK.

Street, Somerset. May 25th, 1934.

Peculiar Features of the Summer of 1934

Although superficially the summer of 1934 has borne a good deal of resemblance, especially in the early part, to that of 1933, its detailed meteorological topography, so to speak, has been very distinct. Two very unusual features call for comment. The first was the geographical distribution of great heat during the first half of July. Ordinarily London and the south-east are as hot as any part of the country during a heat wave, and often hotter. In July, 1934, however, a very vigorous easterly wind off the North Sea prevented the temperature from rising much above 80° F. anywhere on the eastern side of England, notwithstanding cloudless skies. On the western side of England, on the contrary, from Lancashire to Devonshire, the temperature frequently rose to the vicinity of 90°.

The second remarkable feature was the persistent high winds of the last week in July and first three weeks in August. The strong westerly winds with cool temperature made August a more bracing month inland than it often is, but their strength at times was a little disconcerting to campers and others on holiday. Besides a number of more or less widespread gales or semi-gales there was a good deal of rather puzzling local high wind. Thus at Handcross, on the forested Wealden heights of Sussex, where I happened to be, there sprang up suddenly during the night of August 7th, a high NE. wind which lasted about two hours and then quite suddenly subsided to be followed by a calm and sultry day. The weather chart for the morning of the 8th showed a light gradient for northerly winds, and there did not appear to be thunderstorms anywhere near such as might account for the local gale during the night. On the 10th at the same place a SW. gale from the channel blew all day accompanied by a heavy driving drizzle, probably in part of " orographic " origin.

L. C. W. BONACINA.

35, Parliament Hill, London, N.W.3, August 28th, 1934.

NOTES AND QUERIES

The Typhoon in Japan

A typhoon, said to be the most severe since 1917, swept across south-west Japan on September 21st, and maintained its intensity there during most of the day. It first struck Nagasaki in the extreme south-west of Japan in the early morning, and then passed north-eastwards to the neighbourhood of Wakasa Bay about 400 miles distant. The velocity of the winds is said to have reached 60 m/s or over 130 m.p.h. In *The Times* of October 2nd, the London representative of the *Asahi* gives the latest figure as 4,232 killed and 36,051 injured, with a total of 8,789 houses completely demolished and 18,405 houses partly demolished. He says " the most striking fact is the great number of schools which collapsed and of school children killed or injured." Some 3,000 ships were damaged. The effect of the typhoon was felt most severely in Osaka, Kyoto and Kobe. In Japan typhoons may be experienced at any time of the year. They are, however, rare in January to March, and most frequent in the relatively calm periods in which no prevailing winds exist, i.e., in August and September, the period of transition of the monsoon. The typhoons which reach Japan originate generally in the Marshall and Marianne Islands, move in a westerly direction at first, then recurve and travel north-east to the neighbourhood of Japan. By the time they are north of the 30° parallel, in the temperate latitudes in which Japan lies, they usually increase in size and diminish in intensity as they move north-east. This recent typhoon was followed as usual by huge tidal waves which penetrated a considerable distance inland. Heavy rain also caused floods in the surrounding country which destroyed bridges, caused damage to the crops and flooded thousands of houses.

REVIEWS

Red-shifts in the spectra of nebulae, being the Halley Lecture delivered on 8 May 1934. By Edwin Hubble. Size 9 × 6 in., pp. 17. *Illus.* Published by Mr. Milford at the Clarendon Press, Oxford, 1934. 2*s*. net.

This Halley Lecture is of absorbing interest to all who follow, even as the veriest amateurs, the most modern science of astrophysics. It is concerned with the attempt to verify the startling theory of an expanding universe, from the observed fact that the dark lines in the spectra of nebulae are shifted towards the red end of the spectrum. Such a "red-shift" is a logical result of rapid motion away from us, and apart from the assumption that some quite new and unrecognised physical principle is in operation, the observations can only mean that the more distant nebulae are rushing outwards at some thousands of miles a second. The investigation is not without its difficulties however, and apart from its cosmological fascination, it has the interest which must always attach to the development of new methods to meet new problems. The study of nebulae is regarded as a gigantic piece of sampling, and the mathematical treatment, which is quite simple, is based on this assumption. That nebulae, like molecules, can be discussed in terms of the law of averages may be obvious, but is none the less unexpected.

Batavia, K. Magn. en Meteor. Observatorium. Verh. No. 26. Further researches into the possibility of long-range forecasting in Netherlands India. By H. P. Berlage. *Jr. Verh.* No. 27. Daily forecast of wind-force on Java. By J. Boerema. Batavia, 1934.

In the first of these papers Dr. Berlage examines the theoretical basis of various ideas of seasonal forecasting. Analysis of Sir Gilbert Walker's "oscillations" shows that they can practically all be expressed as oscillations between a high-pressure centre and a low-pressure centre. Such oscillations differ in character according to whether the high-pressure centre is in colder or warmer regions than the low-pressure centre. If the high-pressure centre is the colder, the equilibrium of the system is stable and any deviations set up a closed cycle. The best example of this is the 3-year "Southern Oscillation" between the sub-tropical South Pacific high and the tropical low centred near Darwin in January and Bombay in July. If on the other hand the high-pressure centre is the warmer, the system is not stable and the oscillations become violent but irregular, as in the Azores-Iceland oscillation.

The 3-year oscillation, however, is not persistent but breaks down from time to time, and studies of tree-rings in Java from 1519 to 1929 shows that its average length is 3·32 years. Nevertheless the author considers that it is a real 3-year period which suffers disturbance by a 7-year oscillation natural to the Pacific and represented by the 7-year recurrence of rainfall in Peru and Ecuador. He regards these, and an oscillation of 2 years, as almost the only natural weather periods of terrestrial origin, and remarks that "of those many weather-periodicities revealed by harmonic analysis most are to be interpreted as compromise phenomena of only a few long-periodic cycles having a clear physical significance." The 3-year oscillation is definitely of tropical origin. It would seem that these oscillations should give a promising basis for long-range forecasting, but the difficulty is that they are probably started and controlled by variations of solar radiation which cannot be foreseen. The author concludes that while "the view of this paper on the practical attempts to forecast the character of coming monsoons is a rather pessimistic one," there are many hopeful pointers for future research.

The second paper, by Dr. J. Boerema, gives an interesting example of a local forecast based purely on statistical considerations. In tobacco-drying it is useful to have an estimate of the wind velocity during the day. At 7h. the surface velocity at Batavia is small, but with the increasing elevation of the sun there is an exchange of air with higher levels by convection, and the velocity at the ground increases rapidly. It was found that the velocity at 1,000 m. at 7h. obtained by pilot balloon, gave an indication of the ground velocity to be expected later in the day, and experiments are being carried out with a view to making practical forecasts on this basis.

BOOKS RECEIVED

Monthly Rainfall of India for 1930. Published by the various Provincial Governments and issued by the Meteorological Dept., Calcutta, 1932.

Anales del Observatorio Nacional de San Bartolomé en los Andes Colombianos. Observaciones meteorologicas de 1931. Bogotá 1933.

OBITUARY

Charles Henry Kellett, B.Sc.—The news of the death, from pneumonia, on September 8th, 1934, of C. H. Kellett, came as a great shock to his colleagues in the Meteorological Office. He had been on leave for about a fortnight, and none of his friends knew of the illness which proved fatal.

Kellett was born in Yorkshire on November 16th, 1887. He went to Baines's Grammar School, Poulton-le Fylde, and received his later general scientific training at the Manchester School of Technology and London University. For a few years before the War he was a science and mathematics master at the Warehousemen and Clerks Schools, Cheadle Hulme, Cheshire. During the War he served in the Special Brigade, Royal Engineers, on the Western front, and later, a few months before the Armistice, proceeded to No. 5 Officers' Cadet Battalion at Cambridge. On being appointed to the professional staff of the Meteorological Office in April, 1919, he was resident observer at Kew Observatory until the close of 1923, when he was transferred to Eskdalemuir Observatory. His tour of duty there, broken only by a few weeks spent at Lerwick Observatory, continued until nearly the end of 1928, after which time he served in the Forecast and Aviation Services Divisions at Headquarters and at Croydon.

Kellett was a very loyal colleague with whom it was a pleasure to work. His likeable and genial personality, his faculty of co-operation and of rising above the common difficulties and irritations of life endeared him to all sections of the staff and to a much wider circle. His general sociability, his interest in music and games counted for much in the small community at Eskdalemuir and among his friends in that district. He was a prominent member of the old boys' association of his school and was recently the president of the London branch.

We grieve the untimely passing of a friend, and extend to Mrs. Kellett and her two infant daughters our deepest sympathy in their great loss.

We regret to learn of the death on August 11th, 1934, of Nicolas G. Martinez, Director of the Meteorological and Astronomical Observatory at Quito, Ecuador.

NEWS IN BRIEF

We learn that Prof. F. Akerblom retired from the directorship of the Meteorological Observatory at Upsala on September 3rd, 1934, and that Herr Hilding Köhler, of the University of Upsala is, in the interim, acting as Director.

We learn that Heer P. M. van Riel, Director of the Oceanographic and Marine Meteorological Department of the Royal Dutch Meteorological Institute at De Bilt, has been appointed Director of the Meteorological Office at Amsterdam in place of the late Heer P. H. Gallé.*

Erratum

September, 1934, p. 192. The whirlwind at Horndon-on-the-Hill occurred on Sunday, August 12th, 1934, not on Sunday, August 17th, as stated.

The Weather of September, 1934

Pressure was above normal over Spitsbergen, most of Europe, the Mediterranean, Madeira, the Azores, western North Atlantic, the Atlantic coasts of the United States, Newfoundland, Canada and Alaska, the greatest excesses being 10·5 mb. at Waigatz and 6·3 mb. at Kodiak. Pressure was below normal over most of the United

*See *Meteorological Magazine* **69,** 1934, p. 124.

States, the eastern North Atlantic, Jan Mayen, Iceland, the British Isles and western France, the greatest deficits being 8·4 mb. at Reykjavik and 2·8 mb. at 30° N., 100° W. Temperature was considerably above normal in northern and central Europe but below normal in Portugal, while rainfall was in excess generally and nearly twice the normal in the neighbourhood of Värmland, Sweden.

The weather of September over the British Isles was generally unsettled but sunnier than usual. Rainfall was in excess in Scotland, Ireland and parts of south-west England and the Midlands, but still deficient in the south and east. From the 1st to the 4th depressions passed across the country and the weather was generally unsettled and thundery with heavy rain locally but bright intervals, 1·38 in. of rain fell at Compton (Sussex) and Holne (Devon) on the 2nd. Gales occurred in the north and west on the 3rd and thunderstorms in many places on the 1st, 3rd and 4th. Fog was experienced locally in the early morning. On the 5th there was a change to fine sunny weather as the anticyclone extending over most of Europe had moved also across the British Isles. Over 10 hrs. bright sunshine were experienced over most of the country with 11·8 hrs. at Nairn and Troon and 11·6 hrs at Hastings and Dunbar. On the 6th however another depression was advancing from the Atlantic and the weather again became unsettled until the 10th. Thunderstorms occurred in eastern England and north Scotland on the 8th—at Kirkwall, Orkney, 0·75 in. of rain fell during a thunderstorm in ¾ hr. Except locally in Scotland (Dumfries had 1·29 in. on the 8th) the rainfall during this period was slight or moderate and the bright intervals long though mist or fog occurred at times. The 7th was the warmest day when 83° F. was recorded at Maldon, 82° F. at Tunbridge Wells and 81° F. at Norwich. As the depression moved away northwards on the 11th, strong winds and gales were experienced in the extreme north-west but the anticyclone over northern and central Europe was advancing over the British Isles at the same time and the weather became fair or fine and warm generally over the whole country from the 11th–15th except for local fog or mist which persisted through part of the day occasionally in the Midlands, north-east England and east Scotland. Temperature was generally above normal, reaching 82° F. at Cambridge on the 13th and Greenwich on the 15th and exceeding 80° F. in several parts of the south and Midlands on the 13th and 14th; minimum temperatures also rose over 60° F. in parts of the south. On the night of the 14th the approach of a depression caused rain in Ireland and this spread slowly across Scotland and England the following day. From then until the 30th depressions continued to move north-eastwards across the country giving unsettled weather with heavy rain at times but long bright sunny intervals especially in the south-east. The heaviest rainfall was generally on the 15th, 16th and 30th, 1·79 in. fell at Trowbridge (Wilts) on the 15th, 1·85 in. at Florencecourt (Co. Fermanagh) on the 16th and 3·49 in. at Borrowdale

(Cumberland) followed by floods and 4·16 in. at Snowdon (Carnarvon) on the 30th. Sunshine records were variable but exceeded 10 hrs. on a few days, Lerwick had 11·3 hrs. on the 18th, Lowestoft 10·7 hrs. on the 25th and 28th, and Ilfracombe and Rhyl 10·5 hrs on the 25th and 18th respectively. Thunderstorms were experienced locally on the 15th–17th and again on the 29th and gales occurred at exposed places in the west and north. Temperature was generally about normal during this period, but the 28th was an outstandingly warm day, 81° F. was reached at Cambridge and Greenwich, followed by a warm night. The distribution of bright sunshine for the month was as follows :—

	Total (hrs.)	Diff. from normal (hrs.)		Total (hrs.)	Diff. from normal (hrs.)
Stornoway ...	115	+ 1	Liverpool ...	142	+11
Aberdeen ...	143	+19	Ross-on-Wye ...	141	+ 5
Dublin	150	−17	Falmouth ...	152	− 8
Birr Castle ...	132	+13	Gorleston ...	204	+46
Valentia... ...	123	− 1	Kew	186	+41

Miscellaneous notes on weather abroad culled from various sources.

A severe storm accompanied by hail swept over south-west France on the 1st, killing several persons and causing much damage to property and crops; the wind at Perpignan is stated to have reached 112 m.p.h. This was followed by a sudden drop in temperature generally in France and snow fell in the Pyrenees. A violent storm passed across central Switzerland on the 9th, causing dislocation of traffic by the blocking of roads and railways, and inundating many houses. Cloudbursts on the 17th caused much damage in the Saxon mountain district of Luchau and Glashütte—in some places the hailstones were lying 3 ft. deep. Hot weather was experienced in Finland just after the middle of the month.

Egypt is stated to have experienced the highest Nile flood for over 40 years. Many towns and villages and some of the suburbs of Cairo were partly inundated and the Nile water level was prevented from rising even higher only by holding up a certain amount of water in the Aswan reservoir and by the Delta barrage. By the 11th the water level was falling rapidly on the Upper Nile.

Gales were experienced over the greater part of Manchuria about the 1st. The flood waters were rapidly draining away from most parts of Bihar by the 3rd. West of Rajshahi the embankments of the Ganges gave way and hundreds of villages were reported on the 3rd to have been flooded. The monsoon was generally weak in India during the first part of the month, becoming strong in Burma, and strengthening in north-east India by the middle of the month but continuing weak elsewhere until the end of the month. A severe typhoon was experienced in south-west Japan on the 21st (see p. 219).

Continual rain and snow seriously impeded the harvest in the prairie areas of Canada about the 20th, and again on the 24th. Damage had also been done to the grain by frosts earlier in the season. Temperature was above normal at first in the western United States and below normal generally elsewhere but later warmth spread in from the Atlantic seaboard and extended over the southern States while temperature in the north-western States became considerably below normal. Rainfall was mainly variable but considerably above normal in the eastern States in the middle of the month.

Daily Readings at Kew Observatory, September, 1934

* Date	Pressure, M.S.L. 13h.	Wind, Dir., Force 13h.	Temp. Min.	Temp. Max.	Rel. Hum. 13h.	Rain.	Sun.	REMARKS. (see p. 1).
	mb.		°F.	°F.	%	in.	hrs.	
1	1006·9	W.2	45	65	41	—	9·1	F early.
2	1008·7	SSW.3	44	66	49	0·02	8·4	r_0–r18h.45m.-19h.35m
3	1010·5	SW.4	57	70	57	0·56	7·0	r–$r_0$0h. 40m.-6h. 25m.
4	1018·4	SW.4	55	68	61	trace	2·8	pr_0 17h. 45m.
5	1025·6	W.2	49	68	48	—	10·6	
6	1021·4	E.3	48	69	48	—	6·3	F f early
7	1014·0	S.2	59	79	64	—	9·7	
8	1011·3	SW.4	62	73	55	0·08	5·0	r_0–r 19h.–23h.
9	1012·2	WSW.4	58	67	60	trace	7·9	pr_0 9h. 20m.
10	1021·6	SW.2	46	68	59	—	9·9	
11	1025·4	SW.2	47	70	52	—	8·9	f early.
12	1028·2	ESE.2	53	71	51	—	6·5	f early.
13	1023·8	ENE.3	58	79	61	—	6·4	f early.
14	1019·7	E.4	61	79	44	—	10·0	M z early.
15	1012·4	S.2	60	81	59	0·02	7·1	fz early ; T16h.; r19h.
16	1016·6	SW.4	59	71	52	—	8·9	[–20h.
17	1012·7	SSW.5	56	72	58	trace	6·6	pr_0 15h. and 16h.
18	1016·2	SSW.3	52	68	54	trace	2·0	pr_0 18h.
19	1010·9	SW.4	48	65	62	0·06	6·6	r–r_0 20h. 20m.–23h.
20	1008·5	W.3	56	62	74	0·01	0·2	pr 12h. 50m.–13h.
21	1014·2	WNW.3	54	62	52	—	1·7	Z 21h.
22	1009·1	SSW.4	45	63	91	0·14	0·0	r–r_0 12h.–20h.
23	1013·6	WNW.4	48	61	52	—	7·6	
24	1002·6	S.5	51	61	87	0·20	0·1	r_0–r 9h.–11h. ; R 15h.
25	1018·1	WSW.2	45	62	54	—	8·6	[15m.–40m.
26	1011·3	SW.5	50	65	74	0·01	0·7	$r_0$18h. ; $rr_0$20h. 25m.–
27	1023·3	SW.2	47	64	54	—	9·0	[45m
28	1016·6	SSE.3	57	77	58	—	8·2	
29	1013·7	S.4	64	72	71	0·16	1·9	r 16h. 30m.–17h. 45 m.
30	1021·3	S.5	49	65	61	—	8·2	
*	1015·6	—	53	69	59	1·26	6·2	* Means or totals.

General Rainfall for September, 1934

England and Wales ...	109	per cent of the average 1881–1915.
Scotland	134	
Ireland	208	
British Isles	134	

Rainfall : September, 1934 : England and Wales

Co.	Station.	In.	Per cent of Av.
Lond .	Camden Square.........	2·78	153
Sur .	Reigate, Wray Pk. Rd..	1·79	86
Kent .	Tenterden, Ashenden...	1·47	69
,, .	Folkestone, Boro. San.	2·34	...
,, .	Eden'bdg., Falconhurst	1·81	80
,, .	Sevenoaks, Speldhurst.	1·28	...
Sus .	Compton, Compton Ho.	3·07	110
,, .	Patching Farm..........	1·75	73
,, .	Eastbourne, Wil. Sq....	1·63	65
,, .	Heathfield, Barklye....	2·21	90
Hants.	Ventnor, Roy.Nat.Hos.	2·87	116
,, .	Fordingbridge, Oaklnds	2·69	125
,, .	Ovington Rectory.......	2·41	105
,, .	Sherborne St. John......	1·62	79
Herts .	Welwyn Garden City ...	2·15	119
Bucks.	Slough, Upton...........	1·41	80
,, .	H. Wycombe, Flackwell	1·99	102
Oxf .	Oxford, Mag. College...	2·09	124
Nor .	Pitsford, Sedgebrook...	2·74	152
,, .	Oundle	1·51	...
Beds .	Woburn, Exptl. Farm...	2·05	114
Cam .	Cambridge, Bot. Gdns.	1·84	114
Essex.	Chelmsford, County Lab	·95	55
,, .	Lexden Hill House......	1·27	...
Suff .	Haughley House.........	1·77	...
,, .	Campsea Ashe...........	1·70	89
,, .	Lowestoft Sec. School...	1·69	86
,, .	Bury St. Ed., WestleyH.	1·54	77
Norf. .	Wells, Holkham Hall...	1·49	78
Wilts .	Calne, Castleway.........	2·77	134
,, .	Porton, W.D. Exp'l. Stn	1·65	94
Dor .	Evershot, Melbury Ho.	3·94	148
,, .	Weymouth, Westham.	2·59	125
,, .	Shaftesbury,Abbey Ho.	2·43	100
Devon.	Plymouth, The Hoe....	3·32	130
,, .	Holne, Church Pk. Cott.	6·03	168
,, .	Teignmouth, Den Gdns.	2·33	117
,, .	Cullompton	3·05	135
,, .	Sidmouth, U.D.C........	2·35	...
,, .	Barnstaple, N. Dev.Ath	3.33	123
,, .	Dartm'r,Cranmere Pool	6·30	...
,, .	Okehampton, Uplands.	4·71	145
Corn .	Redruth, Trewirgie......	3·91	125
,, .	Penzance, Morrab Gdn.	3·41	116
,, .	St. Austell, Trevarna...	4·23	133
Soms .	Chewton Mendip.........	4·62	150
,, .	Long Ashton............	2·55	107
,, .	Street, Millfield..........	2·46	109
Glos .	Blockley	2·08	...
,, .	Cirencester, Gwynfa....	3·19	145
Here .	Ross, Birchlea...........	1·91	100
Salop.	Church Stretton.........	2·58	127
,, .	Shifnal, Hatton Grange	1·75	91
Staffs.	Market Drayt'n, Old Sp.	1·81	89
Worc .	Ombersley, Holt Lock.	1·62	92
War .	Alcester, Ragley Hall...	1·82	102
,, .	Birminghm, Edgbaston	2·07	116
Leics .	Thornton Reservoir ...	1·62	89
,, .	Belvoir Castle...........	1·28	68
Rut .	Ridlington	1·76	92
Lincs .	Boston, Skirbeck.........	1·24	70
,, .	Cranwell Aerodrome...	1·06	60
,, .	Skegness, Marine Gdns.	1·17	65
,, .	Louth, Westgate.........	1·52	75
,, .	Brigg, Wrawby St.......	1·89	...
Notts .	Worksop, Hodsock......	1·37	90
Derby.	Derby, L. M. & S. Rly.	2·00	121
,, .	Buxton, Terr. Slopes...	4·15	128
Ches .	Runcorn, Weston Pt....	2·25	84
Lancs.	Manchester, Whit. Pk.	2·50	105
,, .	Stonyhurst College......	4·21	110
,, .	Southport, Bedford Pk.	3·22	117
,, .	Lancaster, Greg Obsy.	5·24	155
Yorks.	Wath-upon-Dearne......	1·68	106
,, .	Wakefield,Clarence Pk.	1·82	114
,, .	Oughtershaw Hall.......	5·20	...
,, .	Wetherby, Ribston H..	2·53	141
,, .	Hull, Pearson Park......	1·67	97
,, .	Holme-on-Spalding......	2·17	125
,, .	West Witton, Ivy Ho.	2·27	106
,, .	Felixkirk, Mt. St. John.	1·91	105
,, .	York, Museum Gdns....	1·43	88
,, .	Pickering, Hungate......	1·26	66
,, .	Scarborough..............	1·64	92
,, .	Middlesbrough...........	1·72	104
,, .	Baldersdale, Hury Res.	2·43	97
Durh .	Ushaw College...........	1·76	88
Nor .	Newcastle, Town Moor.	1·13	55
,, .	Bellingham, Highgreen	2·31	96
,, .	Lilburn Tower Gdns....	1·49	63
Cumb.	Carlisle, Scaleby Hall...	4·06	150
,, .	Borrowdale, Seathwaite	16·25	173
,, .	Borrowdale, Moraine...	13·35	178
,, .	Keswick, High Hill......	7·03	166
West .	Appleby, Castle Bank...	3·30	130
Mon .	Abergavenny, Larchf'd	2·02	86
Glam .	Ystalyfera, Wern Ho....	7·63	175
,, .	Cardiff, Ely P. Stn......	3·70	119
,, .	Treherbert, Tynywaun.	8·40	...
Carm .	Carmarthen, Priory St..	5·61	162
Pemb .	Haverfordwest, School.	...	...
Card .	Aberystwyth	3·98	...
Rad .	BirmW.W.Tyrmynydd	4·61	119
Mont .	Lake Vyrnwy	5·17	146
Flint .	Sealand Aerodrome......	1·35	66
Mer .	Dolgelley, Bontddu......	4·90	115
Carn .	Llandudno	1·76	83
,, .	Snowdon, L. Llydaw 9..	21·10	...
Ang .	Holyhead, Salt Island...	3·67	137
,, .	Lligwy	5·36	...
Isle of Man	Douglas, Boro' Cem....	4·61	140
Guernsey	St. PeterP't.Grange Rd.	3·24	125

Rainfall: September, 1934: Scotland and Ireland

Co.	Station.	In.	Per cent of Av.	Co.	Station.	In.	Per cent of Av.
Wig .	Pt. William, Monreith.	5·02	172	*Suth* .	Melvich	1·73	62
,, .	New Luce School	5·36	149	,, .	Loch More, Achfary	5·64	98
Kirk .	Dalry, Glendarroch	6·45	175	*Caith* .	Wick	2·30	92
,, .	Carsphairn, Shiel	10·35	195	*Ork* .	Deerness	3·49	120
Dumf.	Dumfries, Crichton, R.I.	6·30	247	*Shet* .	Lerwick	3·17	105
,, .	Eskdalemuir Obs.	7·14	193	*Cork* .	Caheragh Rectory	8·90	...
Roxb .	Branxholm	3·27	146	,, .	Dunmanway Rectory	9·10	222
Selk .	Ettrick Manse	7.23	200	,, .	Cork, University Coll.	5·98	223
Peeb .	West Linton	2·75	...	,, .	Ballinacurra	6·82	270
Berw .	Marchmont House	2·62	109	,, .	Mallow, Longueville	6·06	252
E.Lot .	North Berwick Res.	1·67	80	*Kerry*.	Valentia Obsy.	8·06	194
Midl .	Edinburgh, Roy. Obs.	1·69	82	,, .	Gearhameen	11·90	195
Lan .	Auchtyfardle	3·67	...	,, .	Darrynane Abbey	5·82	163
Ayr .	Kilmarnock, Kay Pk.	4·94	...	*Wat* .	Waterford, Gortmore	6·09	223
,, .	Girvan, Pinmore	6·44	168	*Tip* .	Nenagh, Cas. Lough	5·82	207
Renf .	Glasgow, Queen's Pk.	4·57	165	,, .	Roscrea, Timoney Park	6·05	...
,, .	Greenock, Prospect H.	6·55	138	,, .	Cashel, Ballinamona	5·70	232
Bute .	Rothesay, Ardencraig	6·69	...	*Lim* .	Foynes, Coolnanes	4·41	158
,, .	Dougarie Lodge	5·88	...	,, .	Castleconnel Rec.	5·02	...
Arg .	Ardgour House	12·17	...	*Clare* .	Inagh, Mount Callan	7·75	...
,, .	Glen Etive	13·71	178	,, .	Broadford, Hurdlest'n.	5·91	...
,, .	Oban	6·90	...	*Wexf* .	Gorey, Courtown Ho.	5·08	205
,, .	Poltalloch	8·84	193	*Wick* .	Rathnew, Clonmannon.	5·42	...
,, .	Inveraray Castle	10·89	169	*Carl* .	Hacketstown Rectory	5·91	211
,, .	Islay, Eallabus	6·15	147	*Leix* .	Blandsfort House	6·01	221
,, .	Mull, Benmore	13·70	117	,, .	Mountmellick	...	...
,, .	Tiree	8·01	216	*Offaly*.	Birr Castle	5·02	219
Kinr .	Loch Leven Sluice	3·01	117	*Dublin*	Dublin, FitzWm. Sq.	2·81	146
Perth .	Loch Dhu	10·50	183	,, .	Balbriggan, Ardgillan	3·60	176
,, .	Balquhidder, Stronvar.	9·71	...	*Meath*.	Beauparc, St. Cloud	4·75	...
,, .	Crieff, Strathearn Hyd.	5·33	186	,, .	Kells, Headfort	4·65	175
,, .	Blair Castle Gardens	5·08	214	*W.M* .	Moate, Coolatore	5·13	...
Angus.	Kettins School	3·51	159	,, .	Mullingar, Belvedere	6·06	227
,, .	Pearsie House	5·08	...	*Long* .	Castle Forbes Gdns.	5·92	205
,, .	Montrose, Sunnyside	3·03	152	*Gal* .	Galway, Grammar Sch.	5·07	...
Aber .	Braemar, Bank	2·94	117	,, .	Ballynahinch Castle	10·19	214
,, .	Logie Coldstone Sch.	1·63	70	,, .	Ahascragh, Clonbrock.	5·86	189
,, .	Aberdeen, King's Coll.	2·90	131	*Mayo*.	Blacksod Point	...	...
,, .	Fyvie Castle	2·31	88	,, .	Mallaranny	8.09	...
Moray	Gordon Castle	1·43	57	,, .	Westport House	8·42	237
,, .	Grantown-on-Spey	...	...	,, .	Delphi Lodge	14·32	190
Nairn.	Nairn	1·16	53	*Sligo* .	Markree Obsy.	6·58	194
Inv's .	Ben Alder Lodge	5·90	...	*Cavan*.	Crossdoney, Kevit Cas.	6·48	...
,, .	Kingussie, The Birches	3·11	...	*Ferm* .	Enniskillen, Portora	6·07	...
,, .	Inverness, Culduthel R.	1·41	...	*Arm* .	Armagh Obsy.	4·62	188
,, .	Loch Quoich, Loan	...	...	*Down*.	Fofanny Reservoir	10·39	...
,, .	Glenquoich	13·88	160	,, .	Seaforde	6·93	252
,, .	Arisaig, Faire-na-Sguir.	9·55	...	,, .	Donaghadee, C. Stn.	5·55	232
,, .	Fort William, Glasdrum	9·54	...	,, .	Banbridge, Milltown	4·45	181
,, .	Skye, Dunvegan	9·79	...	*Antr* .	Belfast, Cavehill Rd.	5·03	...
,, .	Barra, Skallary	7·21	...	,, .	Aldergrove Aerodrome.	5·65	228
R&C .	Alness, Ardross Castle.	2·31	79	,, .	Ballymena, Harryville.	6·17	198
,, .	Ullapool	3·61	96	*Lon* .	Garvagh, Moneydig	6·13	...
,, .	Achnashellach	7·05	97	,, .	Londonderry, Creggan.	5·76	175
,, .	Stornoway	5·51	139	*Tyr* .	Omagh, Edenfel	6·75	221
Suth .	Lairg	1·71	60	*Don* .	Malin Head	6·43	...
,, .	Tongue	2·26	72	,, .	Killybegs, Rockmount.	...	...

Climatological Table for the British Empire, April, 1934

STATIONS.	PRESSURE. Mean of Day M.S.L.	PRESSURE. Diff. from Normal.	TEMPERATURE. Absolute. Max.	TEMPERATURE. Absolute. Min.	TEMPERATURE. Mean Values. Max.	TEMPERATURE. Mean Values. Min.	TEMPERATURE. Mean Values. ½ Max. and Min.	TEMPERATURE. Mean Values. Diff. from Normal.	TEMPERATURE. Mean. Wet Bulb.	Relative Humidity.	Mean Cloud Am'nt	PRECIPITATION. Am'nt.	PRECIPITATION. Diff. from Normal.	PRECIPITATION. Days.	BRIGHT SUNSHINE. Hours per day.	BRIGHT SUNSHINE. Percentage of possible.
	mb.	mb.	°F.	°F.	°F.	°F.	°F.	°F.	°F.	%	0–10	in.	in.			
London, Kew Obsy	1007·8	− 6·6	75	28	55·8	41·4	48·6	+ 1·3	42·4	85	8·0	1·46	+ 0·01	15	4·39	32
Gibraltar	1014·3	− 2·1	73	46	66·9	51·4	59·1	− 1·8	51·3	83	5·2	5·31	+ 2·62	14	...	...
Malta	1013·4	0·0	77	50	68·0	56·6	62·3	+ 1·4	56·8	75	4·4	0·27	− 0·59	4	9·06	69
St. Helena	1011·8	− 0·2	70	60	67·6	62·2	64·9	− 0·4	63·1	95	9·5	7·53	...	19	...	...
Freetown, Sierra Leone	1012·1	+ 1·3	91	64	87·4	68·5	77·9	− 4·5	76·7	83	7·4	2·09	− 1·97	6	...	...
Lagos, Nigeria	1010·1	+ 0·7	90	71	87·4	76·5	81·9	− 0·9	77·1	83	7·7	5·73	− 0·35	9	6·1	50
Kaduna, Nigeria	1006·0	...	105	67	93·9	71·8	82·9	+ 1·4	72·7	73	7·0	2·78	− 0·30	8	7·5	61
Zomba, Nyasaland	1012·5	0·0	83	56	79·6	62·8	71·2	+ 1·9	66·3	76	6·7	2·98	− 0·68	11	...	...
Salisbury, Rhodesia	1014·6	− 0·1	83	43	78·5	55·2	66·9	+ 1·2	59·8	65	3·0	1·76	+ 0·77	6	8·2	70
Cape Town	1016·9	+ 0·5	96	46	77·3	57·4	67·3	+ 4·1	58·7	84	4·5	0·16	− 1·71	5	...	...
Johannesburg	1016·5	+ 0·9	78	44	72·4	53·1	62·7	+ 2·7	53·4	60	4·2	0·64	− 1·10	5	8·1	70
Mauritius	1015·5	+ 1·5	85	64	83·3	69·8	76·5	+ 0·7	72·1	73	5·7	9·70	+ 5·23	21	8·2	71
Calcutta, Alipore Obsy.	1005·3	− 1·0	105	70	96·4	77·7	87·1	+ 1·5	78·0	82	4·3	1·95	− 0·23	4*	...	...
Bombay	1008·1	− 0·7	93	75	90·1	77·4	83·7	+ 0·6	76·6	77	2·6	0·00	− 0·05	0*	...	...
Madras	1007·4	− 1·0	102	71	92·1	77·6	84·9	− 0·4	78·7	77	5·6	0·74	+ 0·11	2*	...	...
Colombo, Ceylon	1009·4	+ 0·7	88	72	86·1	75·5	80·8	− 1·9	77·6	80	6·2	17·04	+ 7·31	17	7·3	59
Singapore	1008·7	− 0·2	90	70	86·6	73·6	80·1	− 1·5	77·0	80	7·6	3·62	− 4·01	16	6·4	53
Hongkong	1013·3	+ 0·7	85	55	72·8	64·9	68·9	− 1·9	65·6	81	9·6	2·45	− 3·20	15	1·8	14
Sandakan	1009·5	...	90	73	87·9	75·0	81·5	− 0·7	77·4	85	7·7	10·21	+ 5·72	19	...	...
Sydney, N.S.W.	1016·8	− 1·6	85	47	71·1	57·5	64·3	− 0·4	59·2	77	...	7·94	+ 2·42	18	6·8	60
Melbourne	1019·2	− 0·3	86	39	66·2	50·3	58·3	− 1·2	54·4	77	7·2	5·68	+ 3·51	20	3·6	32
Adelaide	1021·0	+ 1·1	91	42	70·8	53·3	62·1	− 1·8	55·2	60	6·1	1·51	− 0·22	13	5·4	49
Perth, W. Australia	1020·0	+ 1·6	80	53	73·9	57·2	65·5	− 1·3	57·3	63	4·6	1·28	− 0·37	7	7·3	65
Coolgardie	1019·6	+ 1·0	82	43	69·8	53·2	61·5	− 3·5	57·3	77	4·8	3·20	+ 2·24	9	...	...
Brisbane	1016·2	− 1·4	86	50	77·9	61·6	69·7	− 0·6	64·1	75	6·1	6·33	+ 2·56	16	6·1	54
Hobart, Tasmania	1019·0	+ 4·2	78	39	58·7	47·6	53·1	− 2·1	49·2	71	7·7	2·64	+ 0·79	22	3·0	28
Wellington, N.Z.	1021·1	+ 3·0	67	41	61·8	51·0	56·4	− 0·7	53·9	81	6·9	3·50	− 0·38	9	5·0	45
Suva, Fiji	1012·3	+ 1·7	89	71	84·5	73·8	79·1	+ 0·5	75·0	79	6·3	10·77	− 1·44	23	5·2	44
Apia, Samoa	1010·0	+ 0·1	89	70	85·5	74·0	79·7	+ 0·8	75·9	79	6·5	7·42	− 2·73	17	...	...
Kingston, Jamaica	1013·9	− 0·2	88	67	85·2	69·0	77·1	− 1·3	69·3	79	2·8	0·37	− 0·87	7	5·6	45
Grenada, W.I.	1010·7	− 1·8	90	72	86	72	79	+ 0·1	74	74	5	4·16	+ 2·00	13	...	...
Toronto	1014·0	− 2·1	71	27	50·0	34·1	42·1	0·0	36·2	70	6·9	2·42	+ 0·13	12	5·0	37
Winnipeg	1014·3	− 2·4	85	17	46·2	29·7	37·9	+ 0·2	30·5	79	6·6	0·64	− 0·76	4	5·7	42
St. John, N.B.	1015·9	+ 2·5	59	22	48·8	32·7	40·7	+ 1·7	36·5	77	5·8	5·42	+ 1·91	14	6·3	47
Victoria, B.C.	1017·6	+ 0·1	75	36	60·4	46·3	53·3	+ 5·4	49·1	77	4·9	1·06	− 0·46	11	8·2	60

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

(22767) Wt.25/32 1000 10/34 Hw. G.377/6