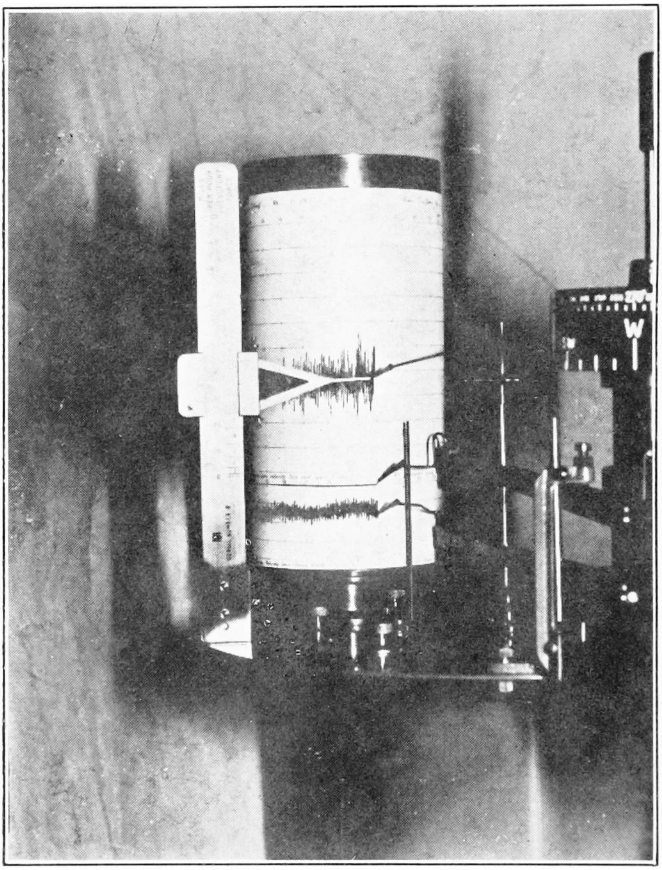
facing p. 53



DINES ANEMOGRAPH WITH ACCESSORIES (see p. 69)

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Summer Thunderstorms

By C. K. M. DOUGLAS, B.A.

1. *General Thermal Structure.*—It is convenient for practical purposes to distinguish the layers below and above the condensation level. In the lower region the lapse-rate of temperature, the horizontal temperature gradient, orographic features on the ground, converging winds, and probably the dynamical effects of wind shearing (*i.e.*, variation with height), are all important factors. In some cases when the relative humidity is high, only a small vertical displacement is required to form clouds. Above the cloud base the saturated adiabatic lapse-rate proves to be a sound criterion of stability. Only a small excess over this value is required, but as a rule the clouds must be able to grow to a height exceeding 10,000 feet from base to summit before thunderstorms develop, and although on some occasions the height is less, it is usually much greater. The large number of tephigrams now available show that nearly all the energy is released above the condensation level, so that the rising air must gain vertical velocity far up into the clouds, except in so far as it is retarded by friction with the surrounding air, or with solid or liquid particles. A quantitative use of the energy measured by tephigrams proves difficult, partly owing to the lack of an absolute criterion of the intensity of a storm. The severity noted at a particular place must depend partly on whether the storm happens to be overhead or a few miles away.

(1367) 107/27 1,050 4/33 M. & S. Gp.303

So far there seems to be a complete lack of upper air observations within the storms. Observations made just outside thunderstorms, plotted on tephigrams or Hertz diagrams, show that air rising adiabatically would often be 5°F. or more warmer than its environment (in extreme cases over 10°F.), through a considerable range of height, probably sometimes up to the tropopause. If we consider a column of air in hydrostatic equilibrium extending from the ground to 8 kilometres, and there is no pressure change at the top, then a rise of 1°F. of the mean temperature of the column involves a fall of pressure of over 2 mb. at the ground. Actually there is usually a rise of pressure under a thunderstorm, once the precipitation has started. Occasionally the barograph drops sharply just outside the rain area, but rarely falls more than 1 mb. below its undisturbed level. Little is known about the vertical acceleration, but its effect must be small. If there is a vertical acceleration of 2 cm. per sec. per sec. up to 5 kilometres (giving a vertical velocity of 14 metres per second at that height), and if its cumulative effect is all transmitted downwards, and friction is neglected, there would be a rise of surface pressure of 1 mb. to be superposed on the statical effect. This figure may be exceeded for short periods over small areas, especially in view of the importance of friction, but when averaged over a period of hours, and over the whole area of the storm, the effect in question must be less. Thus the available evidence seems to show that the storm is little warmer than its environment. Factors tending to reduce the temperature in the storm are mixing with the environment, and the effect of precipitation, especially hail, soft hail and snow melting into rain. Near the ground the cooling is increased by evaporation, and the importance of the resulting pool of cold air is generally recognised.

It should be kept in mind that thunderstorms normally take hours to develop, and that a severe storm generally covers a considerable area. The scale of the phenomena is important; small scale convection cannot in itself cause a thunderstorm.

2. *Diurnal Variation.*—In hot weather in south-east England there are more thunderstorms in the evening and night than there are before 18h. G.M.T. I have examined the data in the *Daily Weather Report* for the period 1916-32 in the forecast districts, south-east England, east England and east Midlands, and noted cases of thunder with a day temperature reaching 75°F. or more, either at the same place or within 60 miles, and find that there were 62 cases during the period 7h. to 18h., and 85 cases during the period 18h. to 7h. following the warm days. Many of the late evening and night storms were previously-formed diurnal convectional storms, but many others were of a different type, though no doubt due partly to the surface heating and convection during the day, especially to heating on the

continent when there was an upper current exceeding 20 m.p.h. from a southerly point. (Each day or night was only counted once.)

Thunderstorms on hot afternoons are never numerous, and in late summer they are extremely rare. Out of 173 days when the temperature reached 80°F. somewhere in the London area during the period 1916-32, thunder occurred in the area between 7h. and 18h. only on nine days, or 5 per cent, and the percentage is even smaller if one considers one place only. (A report of thunder at any London station in the *Daily Weather Report*, including Croydon, determined a day of thunder; temperatures of 80°F. or more at any station except Greenwich or Camden Square were included.) In the middle of London the only severe storm of diurnal convection type on a day when temperature reached 80° was on June 16th, 1917. The severe storm of July 10th, 1923, just skirted the south-west suburbs; the storms of June 18th, 1917, and of July 22nd, 1925, were of an entirely different type, and the other storms on the list were not severe. Storms in the afternoon generally require cumulus formation to commence before noon, but in hot weather the temperature is high at the height of a few thousand feet, and the relative humidity near the ground is usually low, so that cumulus formation is usually delayed and may never commence at all. Quite a number of afternoon storms develop in definitely cool weather in polar air, associated with a large deficiency of upper air temperature. More often the surface temperature is near the normal, and the lapse-rate is slightly above normal through a large range of height. The necessary conditions as regards humidity and lapse-rate are usually associated with a depression, a trough, or a col of a shape which gives convergence (*see* Section 4 below). A favourite region is the centre of an old Atlantic depression which has drifted over land, even if it has largely filled up, and perhaps degenerated into a rounded trough of low pressure. The air has generally followed an irregular track, with mainly cyclonic curvature, between latitudes 47° and 60°. It is often called "maritime sub-polar air" but labels of this type are not very helpful. A suitable length of land track is required for storms of diurnal convection type, varying according to the strength of the upper wind, and at coast stations it is important that the upper wind should have a component off land. For the development of local thunderstorms there should not be too much vector change of wind with height, at least above the cloud base, as otherwise the top of the rising column is sheared away and the clouds break up.

Night storms are of two main types, which we may term low-based and high-based. The former are mainly winter, maritime or coastal, and polar air phenomena, and they are rare in early summer. The latter are essentially associated with warm weather, because an adequate moisture supply at 4,000 feet or above requires a high temperature at those levels, and the surface layers are quickly warmed up unless there is a thick low cloud sheet from the North Sea. The height of the base of the storm ranges up to probably 10,000 feet in extreme cases (in lower latitudes this figure is exceeded). High level storms may occur during the day, but they are probably more frequent at night.

At stations where there is a complete record of thunder throughout the 24 hours for several years, it would be worth while to examine the diurnal variation in relation to temperature and other factors.

3. *Upper Wind Structure.*—Many thunderstorms are associated with warm south-east winds from the continent, and since the west component of wind velocity increases with height on the average, there is often a south-west current higher up. Sometimes the development of thunderstorms is helped by a slight fall of upper air temperature, especially above 10,000 feet. The combination of these two facts has sometimes given rise to the misleading notion that thermal instability is developed between a warm south-east current and an over-running colder south-west current, even at considerable heights. Such a process is *a priori* improbable, because when the geostrophic wind veers with increasing height, the effect of the horizontal motion is to increase the temperature. This was first pointed out by Exner, and I mentioned it in 1922,* adding that a veer above 10,000 feet was unfavourable for thunder. The results given below show that this is true even above 5,000 feet.

Since single summers are apt to be misleading, I have examined the whole period from 1923 to 1932, from May to September, in the south-eastern area (south-east and east England and east Midlands). Pilot balloon observations were used up to 5,000 feet, and when available to 15,000 feet, but these were rare, and the high level current usually had to be determined from nephoscope observations. Alto-cumulus observations were preferred when available (since the middle levels are the important ones for thunderstorms), but in many cases cirrus observations were used. The great majority of high level south-easterly currents extended right up to the cirrus. Due south winds, or cases of a roughly equal number of observations with east and west components, were ignored. The occurrence of thunder anywhere in the area, within 12 hours after the wind observation, was determined from the *Daily Weather Report*, with the condition that the thunder should be within 100 miles of the place of measurement of the upper wind. Only two observations per day were used, normally morning and evening.

The results showed that out of 156 cases of winds at 1,000 feet in the south-east quadrant, there were 121 cases with

* *London, Q.J.R. Meteor. Soc.*, 48, 1922, *p.* 355. The subject is discussed quantitively in *Mem. R. Meteor. Soc.* 1, 1926. *No.* 7. A fair measure of agreement was found between fact and theory.

a wind in the south-west quadrant at the higher levels, and thunder occurred within 12 hours in 34 cases, or 28 per cent. There were 35 cases when the south-east current extended right up to the higher levels (middle or upper troposphere, usually both), and thunder occurred within 12 hours in 23 cases, or 66 per cent. It is satisfactory to find theory confirmed in this manner.

The layers from 1,000 to 5,000 feet, and thence up to the higher levels, were then examined separately. Out of 170 cases of south-east wind at 1,000 feet, there were 57 with south-west winds at 5,000 feet, and thunder followed in 18 cases, or 32 per cent. There were 113 cases of south-east wind up to 5,000 feet, and thunder followed in 41 of these, or 36 per cent. The difference is small and probably has no significance. In some cases with thunder in the last group, there was a considerable veer up to 5,000 feet, though the wind remained east of south. Sometimes it certainly appears as if the advection of warm air in the lower levels, associated with a wind veering upwards, increases the lapse-rate at the top of the layer affected, and helps the development of thunderstorms. At Berck (north-east France) in 1918, aeroplane observations were made on three occasions very close to thunderstorms of this type on summer evenings, with clouds at 5,000 or 6,000 feet moving from south-south-west, and south-easterly winds lower down. The lapse-rate from 1,000 feet up to the cloud level was above the normal, and it is fairly certain that advection had increased it, even though equally high values were sometimes observed in fine hot weather or in polar air. The lapse-rate in the south-south-west upper current was also above normal. The lapse-rate below the clouds was nearly up to the dry adiabatic, but nowhere quite reached that figure. The thunderstorms occurred along cold fronts, and no isolated storms were visible, so that the breakdown of stability was due to the trigger action of the front, and did not take place spontaneously. Subsequent experience has shown that storms of this type are almost always associated with fronts, whereas super-adiabatic lapse-rates have not yet been observed.

Turning now to the upper layers, we find that out of 107 cases of south-east wind at 5,000 feet, there was an upper south-west current in 66 cases, and thunder followed within 12 hours in 19 cases, or 29 per cent; while the south-east current extended to medium or high levels in 41 cases, with thunder after 30 of these, or 73 per cent. (The examples in this group are not quite identical with those discussed earlier, as there were some cases when the wind was north-easterly at 1,000 feet, but south-easterly higher up.) The results at these levels are decisive.

Fairly frequently there is a slight or moderate fall of temperature at high levels before the thunderstorms, generally accompanied by a fall of the barometer and a transition from an anticyclone to a shallow depression. The upper wind direction is not in itself important, so long as it does not veer with height. As a rule the direction does not change much with height, -though there is often an increase of velocity. In the case of a slow fall of temperature it is not necessary that the wind should back with height, even when the fall is due to advection, which is by no means the only factor. If there is anything in the nature of a travelling rotary system, there is a small wind component across the isobars bringing over the colder air.*

It is almost certain that the fall of temperature at high levels is not directly connected with land and sea distribution. A change from a warm anticyclone to a relatively cold depression may take place at any season. It may also be noted that similar synoptic situations give thunderstorms in the eastern United States, and also sometimes near our western coasts, even when no continental air can have reached that region. The storms are less frequent in the west than in the south-east, but it must be remembered that a suitable lapse-rate in the middle layers of the troposphere is only one of the factors required for thunderstorms.

Sometimes there are widespread outbreaks of thunderstorms moving from south or south-west over the British Isles, while near the ground there is an easterly current which is warm in the south of England but cool further north, chiefly owing to the North Sea. A feature common to the whole area is marked wind shearing below the level of the cumulo-nimbus clouds, which may produce dynamical effects helping to start off thunderstorms. Above the cloud base, shearing is rarely large, but there is no reason to believe that moderate shearing destroys widespread, as distinct from purely local, thunderstorms. Any marked wind discontinuity generally indicates a thermally stable layer, and any thunderstorms which develop must be entirely above or below it. A discontinuity at about 8,000 to 10,000 feet is on the average the most effective for stopping thunderstorms.

4. *The Moisture Supply.*—Most of our severe storms occur when the dew-point is higher than the sea temperature near our coasts, so that no evaporation can take place there. The sea south of latitude 49° is no doubt usually the ultimate source of the moisture, but frequently the air has been over the land for a considerable period. Evaporation from the land adds moisture, especially if the ground is wet, but convective mixing carries up moisture out of the surface layer, more particularly if the humidity is low in the upper air. When air passes from sea to land, the absolute humidity may increase, decrease, or remain constant, according to the relative magnitude of these factors. If there is no precipitation, the total moisture in a column of air

* *London. Mem. R. Meteor. Soc.* 1, 1926, No. 7. p. 101, and *London Q.J.R. Meteor. Soc.*, 55, 1929, p. 145.

will normally increase over land, as evaporation can never be zero in Europe in summer, and this moisture may later become available for thunderstorms, especially if convection is at first limited to the lowest 6,000 feet.

Increases of moisture which are attributed to the replacement of continental by maritime air may be really due to the replacement of an anticyclone by a depression, which usually comes in from west. If there is a depression over eastern France and an anticyclone off the Bay of Biscay, the chances of thunder spreading to England are enormously greater with a south-easterly than with a south-westerly upper current. The immense influence of the pressure distribution on the humidity is of course due to convergence or divergence, which is a dominant factor, even if we ignore development and consider only the effect of surface friction. Dr. F. J. W. Whipple* has shown that the total flow at right angles to an isobar is $\frac{G \sin \alpha \cos \alpha}{B}$ where G is the gradient wind, and α the angle between the isobars and the surface wind, and $B^2K = \omega \sin \lambda$, where K is the coefficient of eddy diffusivity. If we take $K = 10^5$ cm^2 per sec., then a volume of 1,300 cubic metres of air flows over each metre of isobar per second. This is a high value of K, but it is reasonable on a summer day. With a surface temperature inversion, K is usually below 10^4, so that the flow across the isobars is less, in spite of a larger value of α. The order of magnitude of the flow can be verified from pilot balloons, but the variation is large, and in thundery weather small irregularities make accurate computation impossible. If we take a circle of radius of 500 Km., and a flow of 1,300 cubic metres per metre per second, with a water content of 12 gms. per cubic metre (corresponding to a relative humidity of 50 per cent. at a temperature of 77°F.), then the inflow in 12 hours would carry in moisture equivalent to a layer of water 3 mm. deep over the area. This moisture could add 25 per cent to the relative humidity of a layer a kilometre thick at a mean temperature of 50°F. At night, or over the sea in summer, the inflow would be less, owing to the smaller value of K. The increase of moisture per unit area would be larger with a smaller circle, and less with a weaker gradient. In the case of many depressions and most anticyclones, the same air mass remains for a few days in the same system, so that the effect of convergence or divergence is cumulative, and must be much greater than land and sea effects.

It is interesting to note that whether we consider lapse-rate or humidity, the most important factor proves to be the pressure distribution, which is the historic basis of forecasting. The isobaric systems and their movements and developments, as shown especially by the barometric tendencies, are still the central foundation of forecasting, and will probably always remain so,

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* *London, Q.J.R. Meteor. Soc.*, 46, 1920, *p.* 45, (equation 6.4).

however valuable supplementary information may be in certain cases.

Sometimes thunderstorms develop when the air is dry above 5,000 feet or so, except in the cumulus clouds. It should be kept in mind when interpreting observations on a tephigram or Hertz diagram that a particular humidity reading may depend on whether it was taken inside or outside a cloud. In the case of widespread storms the air is usually damp through a large range of height, but even then there may be damp and dry zones near together.

5. *Relation with Fronts.*—Though fronts are obviously of great importance in connexion with thunderstorms, the exact relation is very variable, and the problem is complicated by local squalls due to heavy rain or hail. Quite a number of cold fronts after hot weather, even in the afternoon, pass without thunder. A considerable number of storms are associated with warm or stationary fronts, though these may not be sharply defined. Whatever be the nature of the front, it frequently happens that the storms are carried on ahead by the upper wind, and in these cases the actual trough of low pressure, or the centre of the depression, may pass without thunder. Upper wind observations are certainly valuable for forecasting the time of arrival of such storms. A rather remarkable case occurred on May 20th-21st, 1932. There was a widespread outbreak of storms during the night of the 20th, and storms passed rapidly from south-southwest over parts of London at about 22h. G.M.T., when the surface wind was just beginning to back to east, well ahead of a diffuse warm front. The centre of the depression passed next day, and at about 11h. there was a temperature difference of 18°F. within 50 miles, but there was only a little local thunder during the morning, and the cold front then crossed south-east England without thunder. In London the weather remained fine at the first cold front, but rain commenced about six hours later and was heavy and continuous for twelve hours (21 mm. at Kew) with a WNW. wind in the lower layers.

6. *Classification of Thunderstorms.*—Thunderstorms depend on so many factors over so great a range of height that there is no satisfactory basis for a classification. An elaborate classification would be possible but futile. For practical purposes it is useful to distinguish between diurnal convectional storms and the various other types, but it must be remembered that instability is always developed near the ground by a few hours of summer sunshine, but that thunderstorms only form when conditions higher up are suitable. It is not by classification, but rather by the intensive study of individual cases, that progress may prove possible. The large mass of data being collected by Mr. S. Morris Bower should prove useful, especially in the area where the network of observations is close.

Summer Thunderstorms

The annual census of summer thunderstorms in the British Isles will be commenced on April 1st next. The assistance of readers in recording storms will be very much appreciated. The details required remain materially the same as last summer. A note of the date and time of the observation of thunder, lightning or hail, with the direction in which the lightning was seen, especially at night, will be very valuable. In the case of actual thunderstorms additional information of the following character will be welcome :—

1. Time of first observation of thunder or lightning, with direction and estimated distance.
2. Time of commencement of very heavy rain or hail, or approximate time of nearest approach of storm, with direction and estimated distance.
3. Approximate time of final observation of thunder or lightning with direction.
4. Severity of storm; changes in direction or strength of wind, changes in temperature, &c., during the storm.

The shortest note for any of the days is valuable; it is not anticipated that every observer will fully record each storm.

It is essential that the place from which the record is made should be specified by mentioning the approximate distance and direction from a railway station, or otherwise, and that the standard of time used should be stated.

In thanking all those who were good enough to send in data last year, I may mention that the report is in preparation and will be forwarded to observers in the course of summer.

S. Morris Bower.

Langley Terrace, Oakes, Huddersfield. March 11th, 1933.

Royal Meteorological Society

The monthly meeting of this Society was held on Wednesday evening, March 15th, at 49, Cromwell Road, Prof. S. Chapman, F.R.S., President, in the Chair. As is customary in March the meeting took the form of a lecture (The Symons Memorial Lecture), which was delivered on this occasion by Mr. P. M. S. Blackett, M.A., of the Cavendish Laboratory, Cambridge, his subject being

Cosmic Radiation.

The study of what is now known as cosmic or penetrating radiation began over 30 years ago with the experimental investigation of the conductivity of the air in closed vessels. By 1932 measurements of the ionisation had been carried out up to heights of 28 kilometres in the atmosphere and down to depths of 230 metres under water. The ionisation is found to be 100,000 times more intense at the highest point reached compared with that at the greatest depth. More than 400 papers have been written on the subject and still the nature of the primary radiation is not certain and its origin quite unknown.

The ionisation is constant in time to within 2 per cent at any one place, but is about 12 per cent less intense at the equator than in latitudes of 50° N. and S. From these latitudes to the poles it is nearly constant. It is probable, but not certain, that the primary radiation incident on the earth's atmosphere consists of an isotropic corpuscular radiation with a mean energy of more than 10^{10} volts.

The actual ionisation at sea level is due to fast particles, mainly electrons, protons and " positive electrons." The tracks of these particles can be photographed by the Cloud Method and such photographs have shown that very complex phenomena of great variety and interest occur in connexion with the absorption of the primary cosmic rays by matter. Many theories have been put forward to explain the origin of these rays but no one seems to fit the known facts.

OFFICIAL NOTICE

Course of Training for Observers

Provided enough applications are received, a course of training for meteorological observers at climatological stations will be held at the Meteorological Office, Exhibition Road, South Kensington, on Tuesday and Wednesday, May 9th and 10th, 1933. The Course will deal with ordinary climatological work, but not the special work carried out under the Crop Weather Scheme.

Subject to limitations of space the Course will be open to all climatological observers and deputy observers in connexion with the Meteorological Office. There will be no fee, but travelling and other incidental expenses incurred by observers attending the Course will in no case be paid by the Meteorological Office. Applications for admission to the Course should be made at once to The Director (M.O.7), Air Ministry, Kingsway, London, W.C.2, from whom further information about the Course may be obtained.

Correspondence

To the Editor, *The Meteorological Magazine.*

Spells of Sunshine

In comparing rainfall statistics we nearly always include figures relative to Rain Spells, Dry Spells, etc., and in analysing sunshine in this district for the past 30 or more years I have been trying to employ similar terms in relation to sunshine.

Sunshine figures are sometimes misleading. In December, 1932, the sunshine here amounted to 30·4 hours, while the normal is 22 hours, thus giving an excess of 38 per cent.; but in that month there was a period from the 9th to the end during which the only recordable sunshine was limited to eight days and only on two of these exceeded one hour.

I have not come across any attempts to classify sunshine records in a similar manner to the terms employed in rainfall and I had in my mind to use the following:—

Sunny Period ...	30 days on all of which there was recordable sunshine.
Bright Period ...	15 days each of which had one hour or more of sunshine.
Dull Period ...	15 days not having one hour or more of sunshine.
Sunless Period ...	10 days with no recordable sunshine.

If anyone has done anything along this line I will be pleased to hear what periods, etc., were employed

WILLIAM DUNBAR.

17, Kay Park, Kilmarnock. January 10th, 1933.

Large Hailstones

The following note in the second parish register book of St. Thomas, Southwark, may be of interest:—

"Thear was Haile stones ffell in Mr. Lock's yard the 18th day of May 1680 taken up and measured in circumference 5 ynches and 3 quarters, and by report bigger was taken up in severall places in Southwark.

Ger. Locke."

W. H. CHALLEN.

69, *Brambledown Road, Carshalton. February 7th,* 1933.

Frostless Periods at Abergele

The winter mildness of the North Wales coast is well known, but the following results of observations made here during the last 13 years may be of interest. My thermometers are certified and placed in a standard Stevenson screen:—

(1) Any month at any season of the year is liable to have no screen frost at all.

(2) Throughout the period we have had only three Octobers and only six Aprils with any frost.

(3) We have never registered frost between April 17th and October 25th, both inclusive; *i.e.*, a period of 192 consecutive days without frost.

(4) The absolute minimum during the 13 years has been 15·3°F. on February 15th, 1929, and during the period there have been only 19 occasions when the temperature has fallen below 25°F. (8 of these being in February, 1929).

The remarkable mildness of Abergele may be due in some degree to the configuration of the country and to the adjacent wooded limestone hills.

I expect that Holyhead and possibly parts of the Pembrokeshirt coast can surpass Abergele as to mildness, but apart from those districts, it would be interesting to know whether any place north of Devonshire can do so.

SYDNEY WILSON.

Trem-y-Coed, Sea Road, Abergele. March 4th, 1933.

Great Diurnal Range of Temperature

During the recent spell of anticyclonic weather a diurnal range of temperature in excess of 40°F. was registered at this valley station on four successive days, March 26th-29th, and on March 28th there was a rise amounting to 47·7°F. within eight hours—the greatest yet noted here. In the standard Stevenson screen a minimum of 19·2°F. during the early morning was followed just before 13h. 30m. by a maximum of 66·9°F. The thermograph, which is exposed near-by in an old-pattern Stevenson screen of smaller size and more open construction, showed a still greater increase—from 19°F. at 5h. 30m. to 68°F. at about 13h. Hitherto the most extensive diurnal range given by the standard thermometers since the installation of the station four years ago was 46·7°F., on September 27th, 1929.

Relative humidity from the dry bulb and wet bulb readings was as low as 23 per cent. at 14h. on March 28th. The morning minimum by the radiation thermometer over short grass was 12·7°F.; the solar maximum (black bulb in vacuo) reached 131·7°F. by 13h., but fell more than 20°F. during the next hour with the arrival overhead of the northern fringe of a London smoke-haze.

At 11h., though the screen temperature stood at 62·1°F., storage cans of rain water, kept in the shade, still contained a considerable amount of ice. Incidentally, the garden was found littered with scores of dead earth-worms at 9h. These are believed to have been destroyed by the severe frost during the hours before sunrise, when they must have been prevented by the frozen state of the soil from re-burrowing after their nocturnal travels.

E. L. HAWKE.

Cœnwood, The Valley Road, Rickmansworth, Herts. April 3rd. 1933.

Beginning of Spring—and other Seasons

I do not think that anyone could spend much time in the endeavour to frame a logical scheme for delimiting the boundaries of the seasons without reaching the final conclusion that the quest is futile and the problem intractable for two reasons: firstly, because it is so much a matter of definition; and secondly, because the seasons are essentially overlapping periods, especially in a maritime climate like ours where every season is very long-drawn. In fact, so effectively does autumn join hands with spring through the depth of the open English winter, that almost every year reports from the shires appear in the Press of December primroses in token of the " extraordinary mildness of the season." In short, there is no precise date for the commencement of spring with any more significance than a human convention.

As regards the more general question, I do not think it is fully realised that if the average coldest part of the winter coincided with the darkest part, that is with the winter solstice, if the hottest period of summer were symmetrical with the lightest that is centred on the summer solstice, and if the value of its mean annual temperature were crossed precisely at the spring and autumn equinoxes, there would be no problem at all. It is the fact that the seasonal quarters as arranged by temperature lag a month behind the quarters as arranged by the duration of daylight and intensity of sunshine that makes the subject so debatable. Both temperature and light are important criteria in regard to living creatures. Thus February, though belonging to the winter quarter on the score of the cold, is in the spring quarter according to the light, whilst May, though too cool to be placed in the summer quarter, has precedence over August on the basis of long days and powerful sunshine.

The seasonal quarters adopted by meteorologists, viz., spring: March, April, May; summer: June, July and August; autumn: September, October and November; winter: December, January and February; rest upon a thermal basis, and though not perfect compromise better with other criteria than could any other arrangement of months.

L. C. W. BONACINA.

35, Parliament Hill, London, N.W.3. March 25th, 1933.

World's Altitude Record Flight

I was especially interested in the meteorological conditions during the World's Altitude Record Flight, as published in the *Meteorological Magazine* for February, p. 13. May I congratulate those concerned with the publication of the figures, on their promptness, as usually the chief snag lies in the fact that such, if published at all, are usually too late to revive interest.

I may mention that during the test of September 7th fine specimens of cirrus cloud were made by the exhaust gases, but referred to in local papers as " clouds of smoke," and the spectacle from a meteorological interest was very facinating.

The report given in the *Meteorological Magazine* later deals with the report of clouds up to 35,000 ft. on September 16th, and although the writer does not intend to convey that cirrus should have been reported from this area, I feel that it is only justice to state that his evident theory of haze is correct. At 7h. visibility at this station two miles from the aerodrome was only 550 yds., wind ENE., force 2 with 8-10ths of cumulus cloud from east to cb morn. bc, b, afternoon with haze or high fog, to c, b, m, at 18h. visibility 1,100 yds., wind NE., force 2 with 6-10ths of cumulus cloud, from the south and, as usual here, followed by dense fog on the morning of the 17th (7fe).

G. H. BROWN.

Parkstone Avenue, Horfield, Bristol. March 2nd, 1933.

The Duration of a Lightning Flash

In the December issue M. M'Cullum Fairgrieve reproduces a ciné film from which he deduces evidence of lightning flash duration of approximately 5/8 sec. In this connexion the following extracts from some notes made on a storm at Windsor, July 20th, 1929, and not hitherto published, may be of interest to your readers. These observations were made during the approach of a storm from the south-east and shortly before it passed overhead.

Most of the lightning appeared to be of the down-to-earth zigzag, unbranched type, most flashes consisting of several distinct discharges occurring in rapid sequence down the same channel or near it, the time interval between discharges being of the order of 1/10 sec. Two especially interesting cases were noted occurring probably within a mile of the point of observation, in which apparent incandescence of the air around the path of the flash took place. It appeared that the initial discharge consisted of a brilliant silver thread surrounded by an orange-red glow about 10 times the thickness of the central "thread." This red glow persisted for about ½ sec., during which time 6 or 7 "silver threads" passed through its centre, the glow disappearing almost immediately the last "thread" had passed.

Had a ciné film been taken of most of the flashes observed during this storm as recorded above, several successive exposures of the film would have shown tracks of the flash, very similar to those shown by Mr. Fairgrieve, since the rate of exposure of successive film areas would have been slower than the time interval between discharges. I would suggest therefore that what is regarded as evidence of a discharge of 5/8 sec. duration may be in reality a number of short duration discharges along the same path occurring at a greater frequency than 1/16 sec. This would also be more in agreement with results of radio observations on lightning flashes made at this station, which suggest a single visible " flash " to be composed of a number of short discharges lasting a few thousandths of a second occurring at intervals at 1/100th to 1/10th of a second.

To obtain ciné film confirmation or negation of this conception it would be necessary to record at a speed of 100 to 200 pictures per second, a rate not beyond the possibilities of ciné-photography at the present time.

F. E. LUTKIN.

Radio Research Station, Slough. January 11th. 1933.

The February Snowstorm

In your interesting article on the above, I see no mention of the Great Snowstorm of March 9th, 1891, which resembled the storm of the present year far more than that of January 18th, 1881.

I write from personal experience of both snowstorms, and in my opinion, so far as the south of England is concerned, the storm of last February is not to be compared for severity with either of the previous blizzards. For example, in January, 1881, London had such a heavy snowfall that snow was banked up against one's door so that it was impossible to get out without " digging one's way out "! In Sussex the drifts were from 8 to 10 feet deep, and I knew of a man who went out with a horse and cart from Worthing, whose vehicle got buried in a snowdrift, and he had to unharness the horse and return as best he could, the cart remaining in the drift for nearly a week. This February in the southern counties there was at most only about six inches of snow, which quickly melted as rain and sleet supervened.

The snowstorm of March 9th, 1891, chiefly affected the western counties, Devon and Cornwall being buried under snowdrifts for several days. London and the south generally had a lighter snowfall but very low temperatures.

Heavy snowfalls in the south and west of England are caused by a distribution of barometric pressure which is fortunately very uncommon, a rain-bearing depression from the Atlantic deflected from its usual course to the southward, drawing in cold Continental air, and thus producing snowfall instead of rain. Thus these " blizzards " are in this country generally associated with easterly or south-easterly gales, that of March 9th, 1891, being particularly severe.

DONALD W. HORNER.

62, *Canute Road, Clive Vale, Hastings, Sussex. March 27th,* 1933.

Snowstorms of February, 1933, and others

Attempts to make categorical comparisons of big snowstorms, or for that matter other classes of storms, seem unwise because of the many different aspects to be considered. In the 10-year supplement to my article in *British Rainfall*, 1927, I shall not put the case for the blizzard of February 23rd-26th, 1933, more strongly than to say that for area covered by deep snow it was one of the most severe in half a century. The snowstorm of January, 1881, which affected the southern half of Great Britain has been given relatively too much prominence in our meteorological annals mainly because it hit London; but there have been many equally severe snowstorms affecting areas just as great in the more northern parts of the country, all of which will be found recorded in my paper. It is doubtful whether the snowstorm of February, 1933, was more severe in Ireland than that of April, 1917. As regards considerable tracts of country in the south of England lying under deep snow there have been several months, particularly in the 1850's and 1870's, to surpass February, 1933, quite apart from the outstanding drifting blizzards of January, 1881, March, 1891 and December, 1927. In one respect the second week in February, 1900, is unique, since at least 1875, namely in the fact that the entire area of the British Isles lay under deep snow at the same time, due not so much to a particular blizzard, as to a succession of heavy snowfalls first in one district then in another.

All big blizzards, including February, 1933, have shown the interesting peculiarity of being preceded by heavy local snowfalls in areas which escaped the main storm.

L. C. W. BONACINA.

35, *Parliament Hill, London, N.W.3. March 25th*, 1933.

NOTES AND QUERIES

Ball Lightning at Stoke Poges ?

The *Slough, Eton and Windsor Observer* for March 10th contains an account of the destruction of a fir tree by lightning in the garden of Colonel and Mrs. Gordon Hall at Fairfield Lodge, Stoke Poges, on March 7th. An errand boy saw what he described as a ball of fire drop from the sky on to the tree, which immediately crumpled up. The tree was only a few feet from a corner of the house; fortunately it fell in the opposite direction, but pieces of wood weighing three or four hundredweight were thrown in all directions. One fell on the roof, making a large hole, and other pieces were found two or three hundred yards away. Mrs. Gordon Hall, who was shutting a window about six feet from the tree, was deafened and did not regain her hearing for two hours.

Lunar Corona seen from Stornoway

Mr. A. F. Owen of H.M. Coastguard Station, Stornoway, Isle of

Lewis, has sent the following description of a lunar corona he observed from there at 2h. 30m. on March 10th, 1933. The diameter of the corona was approximately 18°. The central part next the moon was coloured from white to reddish brown. This was surrounded by a circle of colour, light blue on the inner side and light green on the outer side. Surrounding this again came further circles of colour in the following order, light brown, dark brown, dark green, light green and light blue, dark brown, light brown with very light rim a "brownish-white" on the outside. The brown shade was distinctly noticeable three times, inner, midway and outer circles. At 4h. the corona became very indistinct, only two inner colours showing reddish brown and light blue and light green. At 4h. 10m. the moon was obscured by clouds. At 2h. 30m. the wind was S. force 6-7 and the sky 6/10ths covered, there being much cirrus, visibility 10 miles.

Accessories for use with the Dines anemograph

Soon after the adoption of the Dines anemograph by the Meteorological Office the plan was introduced of showing on the charts, in addition to the rulings for multiples of 10 miles per hour, scales by which the strength of the wind according to the Beaufort scale could be read. These scales were set out according to the velocity equivalents adopted in 1906. The observer having an anemograph provided with such a chart has been able to read off the Beaufort number without concerning himself with the wind velocity in miles per hour.

According to the new convention of the Meteorological Office, the equivalents of the Beaufort scale depend upon the exposure of the head of the anemograph, and as the printing of special charts for various exposures is not to be recommended some alternative method of reading the strength of the wind was required. The need has been met by the provision of a pointer which slides along an upright fixed to the top place of the recorder of the anemograph. As will be seen from the illustration (see frontispiece of this number of the magazine), the upright is graduated in miles per hour on one side and according to the local Beaufort scale on the other. The pointer can be swung out of the way when the chart is being changed or the pen adjusted.

The first pointer of this kind was made in the Kew Observatory workshop for the anemograph which is above the dome of the Observatory. The height of the vane above the ground is 75 ft. The "effective height" adopted for the anemograph is 50 ft. Similar pointers have now been made for use at the meteorological stations at Croydon and Holyhead and Birmingham.

Attention may be called to another accessory which is to be seen in the illustration and which also serves to facilitate direct readings of the Dines anemometer. This is a drum, with suitable graduations, fixed to the spindle of the direction recorder. A fixed vertical rod tapered at the top end acts as an index to show the direction of the wind. This accessory is now standardised by the makers of the anemograph, Messrs. R. W. Munro.

F. J. W. WHIPPLE.

Obituary

Captain William Gillon.—We regret to announce the death, at Edinburgh, on March 25th, 1933, of Captain W. Gillon, M.A., B.Sc., Senior Professional Assistant in the Meteorological Office, Air Ministry.

Captain Gillon was born at West Calder, Fifeshire, in September, 1889, and was educated at Edinburgh University, where he graduated with first-class honours in Mathematics and Natural Philosophy. Early in the war he was commissioned as Sub-Lieutenant in the Royal Naval Volunteer Reserve, and was afterwards transferred to the Meteorological Service of the Royal Air Force with the rank of Captain. He joined the staff of the Meteorological Office as Senior Professional Assistant in January, 1920, and, after serving in the Forecast Division at Headquarters, was posted to the Isle of Grain, where he was in charge of the meteorological station attached to the local Royal Air Force unit. Thereafter he remained in charge of meteorological stations at Royal Air Force units serving successively at Leuchars, Aldergrove and finally Catterick, where he was stationed when he died.

Although of a reserved nature, Captain Gillon was always popular with his staff and with the Royal Air Force personnel with whom he came in contact. While, during his service in the Meteorological Office, he did not make any outstanding contribution to scientific knowledge, his professional work was always of a high order and he gave proof from time to time of the ability to which his qualifications bore testimony. His chief relaxation was golf, to which sport he was much attached.

Dr. Robert Thorburn Ayton Innes.—We regret to learn of the death of Dr. R. T. A. Innes, formerly Union Astronomer in South Africa, on March 13th, 1933. Dr. Innes was born in Edinburgh on November 10th, 1861, and educated in Dublin, becoming a fellow of the Royal Astronomical Society in 1879. He soon became known as a double star observer of repute, and in 1896 he went as secretary to Sir David Gill at the Royal Observatory, Cape of Good Hope. In 1903 he was appointed to be the first Director of the newly established Transvaal Observatory at Johannesburg, where he was in charge of meteorological as well as astronomical observations. He was a fellow of the Royal Meteorological Society from 1903-12, and contributed papers to the *Quarterly Journal* on the Climate and Rainfall of

South Africa. Other meteorological papers by him are "The barometer in South Africa" and "Transvaal sea-level temperatures." The University of Leyden gave him the D.Sc. (*honoris causa*) for his astronomical work. He retired early in 1928.

News in Brief

The Brazilian Meteorological Service will in future be known as the Instituto Meteorologia, Hidrometria e Ecologia Agricola. Mr. R. P. Xavier, who succeeded Dr. Sampaio Ferraz as Director in February, 1931, has retired owing to ill-health, and Mr. C. de A. Martins Costa has become Director.

Prof. J. Proudman, Director of the Liverpool Observatory and Tidal Institute, and present holder of the Chair of Applied Mathematics in the University of Liverpool, has been elected to the Chair of Oceanography in the same University.

The Weather of March, 1933

Pressure was above normal over Europe (except for the western British Isles), the Mediterranean, Spitsbergen, western Greenland, northern and western Canada, Alaska and the Mississippi Valley, the greatest excesses being 6·3 mb. at Prague and 9·1 mb. at Kodiak. Pressure was below normal over western Siberia, the North Atlantic, south-eastern Canada, north-eastern and most of western United States, the greatest deficits being 9·0mb. at 50°N., 30°W. and 5·3mb. at Ekaterinburg. Temperature was above normal over Europe with the exception of the Iberian Peninsula. In Sweden, it was normal in northern Norrland and 4°-5°F. above normal in other parts of the country. Rainfall was deficient at Spitsbergen and generally 15 per cent. below normal in Sweden.

Sunshine and warmth were the outstanding features of the weather of March over the British Isles. At Kew the total sunshine was 70 per cent. above the average, and has only once been exceeded (in 1907) since 1881; and at Birmingham (Edgbaston) the total was 64 per cent. above the average. High day maximum temperatures were followed by frequent ground frosts at night. During the opening days of the month the weather was unsettled with rain at times, slight in most places, but heavier in south-west Ireland and south-west England; 1·77 in. fell at Holne (Devon) on the 2nd. On the 4th, the complex low pressure area off our south-west coasts began to move northwards, giving easterly gales in north Scotland on the 4th, but the weather continued unsettled. Rainfall was moderate to heavy on the 5th and 8th locally, 1·64 in. fell at Trecastle (Brecon) on the 5th and 1·20 at Valentia on the 8th, and thunderstorms occurred on the 6th and 7th in the south and midlands, while snow was reported from the Shetlands and Highlands of Scotland on the

4th, 5th and 6th. On the 9th the British Isles came under the influence of the anticyclone over the continent, and a succession of fine, warm days and occasional night frosts followed until the 14th; 67°F. was reached at Collumpton and 65°F. at Bournemouth on the 13th, and 10·4 hrs. of bright sunshine were registered at Edinburgh, Collumpton and Armagh on the 11th and at Jersey on the 12th. On the 15th depressions from the Atlantic with vigorous secondaries caused a return to unsettled conditions for a time with gales in the English Channel on the 16th and 19th, and in north Ireland on the 16th. There was rain or heavy showers in all districts, and hail and thunderstorms in south Ireland and south and north-east England on the 17th-19th, but there were long sunny periods, and in the south temperature continued generally above normal. Snow and sleet were experienced in Scotland, north Ireland and parts of Wales on the 18th-20th. The deep depression over the Atlantic gave rain and occasional gales in the west and north on the 21st-23rd, but the anticyclone over Spain spread across the eastern British Isles on the 21st, and later over the west as well, and sunny, fine warm weather with night frosts inland prevailed generally until the 29th. Some remarkably good sunshine records were experienced, daily amounts being frequently between 10 and 12 hrs. Margate had over 11 hrs. each day between the 23rd and 29th inclusive. The day temperature of 70°F. at Aberdeen on the 28th was a record for March. A trough of low-pressure crossed the country on the 29th, and showers were prevalent on the 29th-30th, though long periods of bright sunshine were recorded in most places. In the rear of this trough temperature fell somewhat and hail was experienced locally and slight snow in Scotland. A thunderstorm occurred at Croydon on the 30th. The distribution of bright sunshine for the month was as follows:—

	Total (hrs.)	Diff. from normal (hrs.)		Total (hrs.)	Diff. from normal (hrs.)
Stornoway	88	—17	Liverpool	144	+36
Aberdeen	157	+40	Ross-on-Wye	178	+62
Dublin	128	+ 5	Falmouth	181	+43
Birr Castle	118	+ 8	Gorleston	178	+43
Valentia	115	— 8	Kew	178	+73

The special message from Brazil states that the rainfall in the northern and central regions was scarce and in the southern regions very scarce, with an average 2·64 in. below normal. Six anticyclones passed across the country without, however, any particular change in the weather. The crops were in generally good condition on account of the favourable weather. At Rio de Janeiro pressure was 0·8mb. above normal and temperature 0·9°F. below normal.

Miscellaneous notes on weather abroad culled from various sources.

The ice on the Danube below Galatz had broken up by the 3rd, and at Sulina the drift ice was running. A Hull trawler foundered off Hornö, near Vardö, in a heavy snowstorm at 1.30 a.m. on the 6th, five of the crew of 15 being lost. A heavy gale was experienced along the Anatolian coast of the Black Sea on the 8th. The river ice was moving at Riga on the 21st. A violent storm passed over Messina on the 22nd, but no casualties were reported. At Pori (Bjorneborg), Finland, navigation had opened by the 29th. (*The Times*, March 4th-30th.)

A dense sandstorm occurred over the Suez Canal on the 1st detaining all vessels. One person was killed and six injured by a tornado which struck Leopoldville (Belgian Congo) on the 6th (*The Times*, March 2nd-8th.)

Sandstorms were experienced by the Houston Mount Everest expedition between Baghdad and Bushire on the 4th, and one aeroplane of the expedition was lost in a sandstorm at Allahabad on the 12th. High winds at great heights prevented full trials of the expedition's aeroplanes during the closing days of the month. (*The Times*, March 6th-31st.)

Severe early frosts caused damage of over £50,000 to the tobacco crop in north-eastern Victoria. (*The Times*, March 23rd.)

A tornado approaching from Arkansas and Missouri swept across Tennessee on the night of the 14th-15th; 36 people were killed and about 200 injured. The damage was heaviest in Nashville, Harrogate and Jellico in Tennessee, and in Caruthersville in Missouri. The floods throughout the valley of the Ohio River were still rising on the 21st. Twenty-one people were killed and about 100 injured by tornadoes accompanied by thunderstorms which swept across east Texas, south-east Arkansas, and north-west Louisana on the 30th. A spell of warm weather passed slowly across the United States from west to east during the first three weeks of the month, temperature was as much as 16°F. above normal at Williston (North Dakota) and Havre (Montana) during the week ending the 7th, and 12°F. at Augusta (Galveston) during the week ending the 21st. Later temperature was for the most part below normal. Rainfall was irregular in distribution at first, becoming above normal in the eastern States during the week ending the 21st, then below normal generally later. (*The Times*, March 16th-April 1st; *Washington D.C., U.S. Dept. Agric., Weekly Weather and Crop Bulletin.*)

General Rainfall for March, 1933

England and Wales ...	119	per cent of the average 1881-1915.
Scotland	64	
Ireland	99	
British Isles	101	

Rainfall: March, 1933: England and Wales.

Co.	Station	In.	Per-cent. of Av.	Co.	Station	In.	Per-cent. of Av.
Lond	Camden Square	2·27	124	*Leis.*	Thornton Reservoir	2·99	162
Kent	Tenterden, Ashenden	2·30	107	,,	Belvoir Castle	2·85	157
,,	Folkestone, Boro. San.	1·77	...	*Rut*	Ridlington	2·71	156
,,	St. Peter's, Hildersham	...	...	*Lincs*	Boston, Skirbeck	2·28	146
,,	Eden'bdg., Falconhurst	3·73	150	,,	Cranwell Aerodrome	2·61	186
,,	Sevenoaks, Speldhurst	2·96	...	,,	Skegness, Marine Gdns	2·02	122
Sus	Compton, Compton Ho.	4·03	145	,,	Louth, Westgate	2·63	124
,,	Patching Farm	2·49	116	,,	Brigg, Wrawby St.	2·15	...
,,	Eastbourne, Wil. Sq.	1·98	88	*Notts*	Worksop, Hodsock	2·61	154
,,	Heathfield, Barklye	3·57	143	*Derby*	Derby, L. M. & S. Rly.	2·27	132
Hants	Ventnor, Roy. Nat. Hos.	2·78	136	,,	Buxton, Terr. Slopes	3·46	84
,,	Fordingbridge, Oaklnds	4·17	179	*Ches*	Runcorn, Weston Pt.	1·99	99
,,	Ovington Rectory	4·68	180	*Lancs*	Manchester, Whit Pk.	2·79	123
,,	Sherborne St. John	3·04	136	,,	Stonyhurst College	2·68	73
Herts	Welwyn Garden City	2·80	...	,,	Southport, Hesketh Pk	2·20	99
Bucks	Slough, Upton	2·54	144	,,	Lancaster, Greg Obsy.	2·23	70
,,	H. Wycombe, Flackwell	3·10	...	*Yorks*	Wath-upon-Dearne	2·76	159
Oxf	Oxford, Mag. College	2·20	144	,,	Wakefield, Clarence Pk.	2·12	118
Nor	Pitsford, Sedgebrook	2·34	133	,,	Oughtershaw Hall	4·24	...
,,	Oundle	2·35	...	,,	Wetherby, Ribston H.	1·87	96
Beds	Woburn, Crawley Mill	2·42	141	,,	Hull, Pearson Park	1·99	109
Cam	Cambridge, Bot. Gdns.	1·74	118	,,	Holme-on-Spalding	2·49	...
Essex	Chelmsford, CountyLab	1·64	95	,,	West Witton, Ivy Ho.	2·33	75
,,	Lexden Hill House	1·62	...	,,	Felixkirk, Mt. St. John	1·89	96
Suff	Haughley House	1·60	...	,,	York, Museum Gdns.	2·06	123
,,	Campsea Ashe	1·63	97	,,	Pickering, Hungate	2·51	126
,,	Lowestoft Sec. School	...	...	,,	Scarborough	1·84	102
,,	Bury St. Ed., Westley H.	2·27	120	,,	Middlesbrough	1·41	90
Norf	Wells, Holkham Hall	1·92	118	,,	Balderdale, Hury Res.	2·57	83
Wilts	Devizes, Highclere	2·73	130	*Durh*	Ushaw College	1·27	58
,,	Calne, Castleway	3·14	147	*Nor*	Newcastle, Town Moor	1·08	51
Dor	Evershot, Melbury Ho.	5·25	176	,,	Bellingham, Highgreen	1·09	37
,,	Weymouth, Westham	3·13	152	,,	Lilburn Tower Gdns.	·86	32
,,	Shaftesbury, Abbey Ho.	2·71	115	*Cumb*	Carlisle, Scaleby Hall	2·79	114
Devon	Plymouth, The Hoe	3·76	129	,,	Borrowdale, Seathwaite	...	...
,,	Holne, Church Pk. Cott.	9·59	178	,,	Borrowdale, Moraine	7·28	...
,,	Teignmouth, Den Gdns.	4·05	156	,,	Keswick, High Hill	3·88	86
,,	Cullompton	3·59	131	*West*	Appleby, Castle Bank	1·79	67
,,	Sidmouth, Sidmount	3·18	130	*Mon*	Abergavenny, Larch	3·47	114
,,	Barnstaple, N. Dev. Ath	2·98	114	*Glam*	Ystalyfera, Wern Ho.	6·03	112
,,	Dartm'r, Cranmere Pool	8·60	...	,,	Cardiff, Ely P. Stn.	3·35	104
,,	Okehampton, Uplands	5·64	136	,,	Treherbert, Tynywaun	8·05	...
Corn	Redruth, Trewirgie	4·81	134	*Carm*	Carmarthen Friary	3·46	91
,,	Penzance, Morrab Gdn.	4·37	137	*Pemb*	Haverfordwest, School	3·34	98
,,	St. Austell, Trevarna	4·33	126	*Card*	Aberystwyth	2·61	...
Soms	Chewton Mendip	4·38	123	*Rad*	BirmW.W.Tyrmynydd	4·67	87
,,	Long Ashton	3·71	145	*Mont*	Lake Vyrnwy	3·71	87
,,	Street, Millfield	2·34	114	*Flint*	Sealand Aerodrome	1·95	109
Glos	Blockley	2·47	...	*Mer*	Dolgelley, Bontddu	3·36	68
,,	Cirencester, Gwynfa	3·52	152	*Carn*	Llandudno	1·56	72
Here	Ross, Birchlea	2·60	128	,,	Snowdon, L. Llydaw 9	9·82	...
,,	Ledbury, Underdown	2·23	117	*Ang*	Holyhead, Salt Island	2·18	83
Salop	Church Stretton	3·09	131	,,	Lligwy	3·46	...
,,	Shifnal, Hatton Grange	2·24	122	*Isle of Man*			
Staffs	MarketDrayt'n.Old Sp.	2·68	126		Douglas, Boro' Cem.	3·34	112
Worc	Ombersley, Holt Lock	1·91	112	*Guernsey*			
War	Birminghm, Edgbaston	2·92	153		St. PeterP't. Grange Rd	2·46	99

At Borrowdale, Seathwaite for February and March 24·25 inches.

Rainfall: March, 1933: Scotland and Ireland.

Co.	Station	In.	Per-cent. of Av.	Co.	Station	In.	Per-cent of Av.
Wigt .	Pt. William, Monreith	1·92	67	*Suth* .	Melvich	1·60	56
,, .	New Luce School	3·13	88	,, .	Loch More, Achfary	2·86	44
Kirk .	Dalry, Glendarroch	3·78	84	*Caith* .	Wick	1·87	82
,, .	Carsphairn, Shiel	5·45	90	*Ork* .	Deerness	2·58	92
Dumf.	Dumfries, Crichton, R.I	1·98	70	*Shet* .	Lerwick	2·59	82
,, .	Eskdalemuir Obs.	3·68	75	*Cork* .	Caheragh Rectory	5·05	...
Roxb .	Branxholm	1·72	59	,, .	Dunmanway Rectory	4·69	96
Selk .	Ettrick Manse	4·06	80	,, .	Cork, University Coll.	2·78	93
Peeb .	West Linton	1·25	...	,, .	Ballinacurra	2·57	90
Berw .	Marchmont House	1·01	38	*Kerry* .	Valentia Obsy	6·57	145
E.Lot .	North Berwick Res.	0·89	47	,, .	Gearahameen	9·70	...
Midl .	Edinburgh, Roy. Obs.	0·88	45	,, .	Killarney Asylum	...	...
Lan .	Auchtyfardle	2·71	...	,, .	Darrynane Abbey	5·06	124
Ayr .	Kilmarnock, Kay Pk.	2·48	...	*Wat* .	Waterford, Gortmore	3·62	133
,, .	Girvan, Pinmore	2·85	75	*Tip* .	Nenagh, Cas. Lough	3·68	119
Renf .	Glasgow, Queen's Pk.	2·42	93	,, .	Roscrea, Timoney Park	2·30	...
,, .	Greenock, Prospect H.	3·95	80	,, .	Cashel, Ballinamona	1·94	71
Bute .	Rothesay, Ardencraig.	3·10	...	*Lim* .	Foynes, Coolnanes	2·75	93
,, .	Dougarie Lodge	2·41	...	,, .	Castleconnel Rec.	2·57	...
Arg .	Ardgour House	5·20	...	*Clare* .	Inagh, Mount Callan	4·15	...
,, .	Glen Etive	...	...	,, .	Broadford, Hurdlest'n.	3·76	...
,, .	Oban	3·09	73	*Wexf* .	Gorey, Courtown Ho.	3·02	131
,, .	Poltalloch	3·37	88	*Kilk* .	Kilkenny Castle	2·54	111
,, .	Inveraray Castle	5·26	83	*Wick* .	Rathnew, Clonmannon	2·59	...
,, .	Islay, Eallabus	2·98	78	*Carl* .	Hacketstown Rectory	2·84	101
,, .	Mull, Benmore	...	...	*Leix* .	Blandsfort House	3·03	116
,, .	Tiree	2·62	78	,, .	Mountmellick	3·80	...
Kinr .	Loch Leven Sluice	1·78	60	*Offaly*.	Birr Castle	3·32	138
Perth .	Loch Dhu	4·85	74	*Kild'r*.	Monasterevin	...	...
,, .	Balquhidder, Stronvar	3·66	...	*Dublin*	Dublin, FitzWm. Sq.	1·71	88
,, .	Crieff, Strathearn Hyd.	1·78	56	,, .	Balbriggan, Ardgillan.	2·04	101
,, .	Blair Castle Gardens	1·41	54	*Meath*.	Beauparc, St. Cloud	2·12	...
Angus.	Kettins School	1·50	62	,, .	Kells, Headfort	2·10	76
,, .	Pearsie House	2·48	...	*W.M*.	Moate, Coolatore	2·93	...
,, .	Montrose, Sunnyside	1·59	76	,, .	Mullingar, Belvedere	2·65	98
Aber .	Braemar, Bank	1·57	53	*Long* .	Castle Forbes Gdns.	3·46	117
,, .	Logie Coldstone Sch.	1·54	59	*Gal* .	Ballynahinch Castle	6·43	125
,, .	Aberdeen, King's Coll.	2·00	83	,, .	Galway, Grammar Sch.	2·45	...
,, .	Fyvie Castle	2·52	93	*Mayo* .	Mallaranny	4·44	...
Moray	Gordon Castle	0·68	29	,, .	Westport House	3·34	86
,, .	Grantown-on-Spey	...	...	,, .	Delphi Lodge	8·37	101
Nairn.	Nairn	0·61	33	*Sligo* .	Markree Obsy	3·98	117
Inv's .	Ben Alder Lodge	1·75	...	*Cavan*.	Belturbet, Cloverhill	2·05	74
,, .	Kingussie, The Birches	1·08	...	*Ferm* .	Enniskillen, Portora	2·09	...
,, .	Loch Quoich, Loan	4·85	...	*Arm* .	Armagh Obsy	2·01	85
,, .	Glenquoich	...	...	*Down* .	Fofanny Reservoir	4·90	...
,, .	Inverness, Culduthel R.	0·42	...	,, .	Seaforde	2·90	99
,, .	Arisaig, Faire-na-Sguir	2·14	...	,, .	Donaghadee, C. Stn.	2·79	127
,, .	Fort William, Glasdrum	4·76	...	,, .	Banbridge, Milltown	1·76	80
,, .	Skye, Dunvegan	2·79	...	*Antr* .	Belfast, Cavehill Rd.	2·60	...
,, .	Barra, Skallary	3·06	...	,, .	Aldergrove Aerodrome	1·78	71
R & C .	Alness, Ardross Castle	1·52	47	,, .	Ballymena, Harryville	2·64	84
,, .	Ullapool	1·36	33	*Lon* .	Londonderry, Creggan	2·47	77
,, .	Achnashellach	3·22	45	*Tyr* .	Omagh, Edenfel	2·88	92
,, .	Stornoway	2·18	53	*Don* .	Malin Head	2·31	...
Suth .	Lairg	1·31	42	,, .	Milford, The Manse	3·29	97
,, .	Tongue	1·83	54	,, .	Killybegs, Rockmount.	2·41	47

Climatological Table for the British Empire, October, 1932

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.	1006·5	— 7·5	64	33	55·4	43·0	49·2	— 0·7	45·0	90	6·1	5·00	+ 2·30	24	3·1	29
Gibraltar	1017·7	+ 0·5	80	52	74·3	56·6	65·5	— 0·6	56·5	82	3·5	2·43	— 0·88	9	..	..
Malta	1014·3	— 1·7	90	57	78·6	69·0	73·8	+ 2·9	68·6	77	5·9	5·67	+ 2·80	9	7·4	65
St. Helena	1015·6	+ 0·1	61	51	58·4	52·6	55·5	— 2·8	53·4	96	9·9	0·84	..	12	..	..
Freetown, Sierra Leone	1013·5	+ 1·9	88	70	85·5	73·2	79·3	— 0·8	76·0	83	6·8	8·23	— 4·39	23	..	..
Lagos, Nigeria	1012·3	+ 1·3	87	70	83·9	74·0	78·9	— 0·8	74·8	85	8·8	5·16	— 2·61	12	6·2	52
Kaduna, Nigeria	1012·6	— 0·7	92	66	87·0	68·3	77·7	+ 1·4	71·9	85	6·8	7·85	+ 5·10	14	7·3	61
Zomba, Nyasaland	1010·7	— 0·2	90	52	85·3	62·4	73·9	— 0·2	..	48	2·3	0·20	— 1·32	1	..	..
Salisbury, Rhodesia	1012·1	+ 0·3	91	50	83·8	57·9	70·9	+ 0·2	57·1	38	1·8	0·03	— 1·10	1	9·4	75
Cape Town	1018·4	+ 1·0	92	45	72·5	53·1	62·8	+ 1·6	55·1	67	4·6	0·83	— 0·82	7	..	..
Johannesburg	1013·9	+ 1·4	86	41	76·7	53·2	64·9	+ 2·1	53·3	46	3·6	1·34	— 1·22	9	8·8	69
Mauritius	..	..	82	60	79·0	64·6	71·8	— 0·9	66·9	63	6·3	..	..	..	8·0	64
Calcutta, Alipore Obsy.	1009·1	— 0·3	94	68	90·0	76·4	83·2	+ 3·9	77·2	88	3·2	3·79	— 1·11	7*	..	..
Bombay	1008·3	— 1·5	95	73	90·3	78·1	84·2	+ 1·8	77·4	83	5·7	9·01	+ 7·34	9*	..	..
Madras	1008·2	— 0·7	93	71	87·0	76·2	81·6	— 0·7	77·6	85	6·9	21·63	+ 10·48	10*	..	..
Colombo, Ceylon	1009·8	— 0·2	86	73	84·3	75·3	79·8	— 0·7	77·0	83	8·1	30·74	+ 17·38	31	6·3	53
Singapore	1009·1	— 0·6	91	72	87·3	74·9	81·1	0·0	77·4	78	7·6	3·57	— 4·50	21	5·5	45
Hongkong	1014·1	+ 0·4	86	66	80·7	72·8	76·7	— 0·2	69·0	65	6·3	0·09	— 4·85	3	5·0	43
Sandakan	..	..	90	72	88·8	75·2	82·0	+ 0·6	77·7	82	6·7	7·12	— 3·21	17	..	..
Sydney, N.S.W.	1013·3	— 1·5	88	48	69·6	54·6	62·1	— 1·5	57·3	63	6·0	0·87	— 1·98	16	7·1	55
Melbourne	1014·0	— 0·8	85	38	64·8	45·6	55·2	— 2·5	51·6	65	7·3	5·15	+ 2·52	19	5·3	40
Adelaide	1016·2	+ 0·2	83	41	67·3	49·2	58·3	— 3·7	52·0	55	7·6	2·32	+ 0·59	15	5·0	39
Perth, W. Australia	1015·5	— 1·3	88	43	70·1	52·8	61·5	+ 0·7	54·4	57	3·9	3·43	+ 1·21	11	8·8	69
Coolgardie	1014·6	— 0·5	90	42	72·7	48·8	60·7	— 3·0	52·9	54	4·0	2·15	+ 1·49	12	..	..
Brisbane	1014·8	— 1·4	86	52	77·7	59·5	68·6	— 1·2	61·9	59	6·3	2·98	+ 0·40	11	7·6	60
Hobart, Tasmania	1010·3	0·0	73	37	60·2	44·9	52·5	— 1·6	47·8	63	7·0	4·15	+ 1·89	18	5·2	39
Wellington, N.Z.	1016·6	+ 3·5	67	41	59·9	48·2	54·1	— 0·3	52·2	77	7·6	3·87	— 0·21	14	5·6	42
Suva, Fiji	1013·7	+ 0·5	92	68	83·2	72·8	78·0	+ 2·2	73·0	77	7·4	8·35	+ 0·06	17	5·0	40
Apia, Samoa	1011·1	— 0·4	88	70	85·7	74·5	80·1	+ 1·7	76·4	73	5·0	6·77	+ 0·39	14	8·0	65
Kingston, Jamaica	1010·9	— 0·6	92	69	87·6	73·1	80·3	— 0·2	72·6	88	5·2	4·82	— 2·64	14	7·2	61
Grenada, W.I.	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..
Toronto	1014·9	— 2·6	73	33	58·6	44·1	51·3	+ 2·7	46·0	84	6·4	1·79	— 0·78	9	4·4	40
Winnipeg	1016·6	+ 1·7	67	12	44·1	29·7	36·9	— 3·8	..	..	7·8	1·96	+ 0·59	9	3·1	29
St. John, N.B.	1016·6	+ 0·8	70	30	56·4	43·6	50·0	+ 4·7	46·8	87	6·4	4·29	— 0·25	14	4·4	40
Victoria, B.C.	1018·8	+ 1·7	76	40	57·2	47·1	52·1	+ 1·8	49·8	87	7·2	2·34	— 0·23	15	4·0	37

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