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## The Cup Anemometer

By T. W. VERNON JONES, B.Sc.

As an instrument for measurements of wind velocity, the cup anemometer has occupied an important position in meteorological work since the middle of last century. During recent years it has been largely superseded by the pressure tube anemometer, which not only gives more accurate results but also shows the structure of the wind, as well as its mean velocity over a given period. For some purposes, however, the cup anemometer is still of great value, more particularly in cases where the run of the wind over a considerable period is required; and moreover on the grounds of its much greater portability and cheapness, it is probable that the small cup anemometer will continue to be used for meteorological observations for many years to come.

The records from a cup anemometer are generally obtained in one of three ways; a trace is made upon a moving chart, a revolution counter of the ordinary type is attached to the instrument, or the anemometer may be designed to complete an electrical circuit after a known number of revolutions have been made. Whatever method is adopted, the interpretation of the results and the determination of the wind speed depends upon an accurate knowledge of the " Robinson factor " of the instrument, that is, the ratio of the wind velocity to the velocity of the centres of the cups.

Since the time of Dr. Robinson's original experiments with cup anemometers, many observations have been made to determine factors for obtaining the true wind velocity from the rate

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of revolution of the cups. These factors have been obtained in several ways: in the earlier experiments the instrument under test was attached to an arm and whirled in a circle at a known speed. Dr. Robinson himself used this method, but came to the conclusion that the results obtained were doubtful, owing to the difficulty of allowing for the air which was dragged along by the arm of the whirling machine and by the anemometer itself. More recently, comparisons of a cup anemometer set up side by side with a pressure tube anemometer have been made, or experiments have been carried out in a wind-tunnel. The great advantage of calibrating a cup anemometer by comparison with a pressure tube anemometer is that the gustiness of the wind can be taken into consideration. On the other hand measurements in a modern wind-tunnel can be made with very great precision and delicacy, although normally it is a steady and non-gusty wind which is used. The difficulty in calibrating a cup anemometer is to allow for its inertia, as, when subjected to intermittent impulses, the cups spin continuously. It is at low speeds particularly that the inertia effect has to be considered, and unfortunately at low speeds comparisons with a pressure tube anemometer are apt to be unreliable owing to the comparative insensitiveness of this latter type of instrument in light winds.

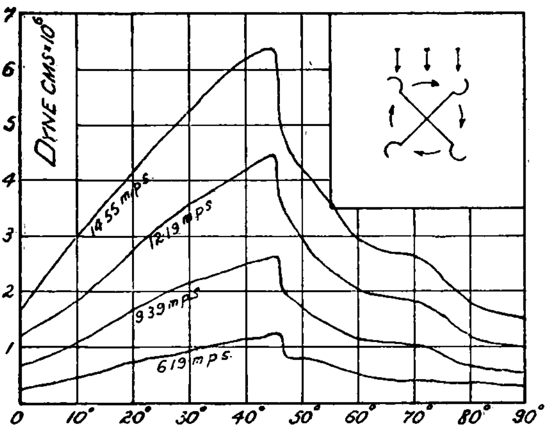
Dr. Robinson's original experiments* with a small cup anemometer, led him to adopt the factor 3 for all his instruments; he came to the conclusion later, however, that the factor varied according to the type of instrument in use, and it was shown still later that the factor varied also with the wind velocity. Cup anemometers of many sizes are now in use for different purposes, and the factors of these instruments of standard size have been determined with considerable accuracy for all wind speeds.

It has been recently pointed out, however, by J. Patterson† that no systematic series of experiments has ever been made to determine the best form of cup anemometer; that is to say, to find out whether large cups are better than small, long arms better than short, or whether four cups in an anemometer system are better than any other number. Patterson's observations were made in the wind-tunnel at the University of Toronto and consisted of a large number of measurements of torque and of factor at different wind speeds for various sizes and types of cup anemometers. The static torque was obtained by observing the actual turning moment which had to be applied to the cups to keep them stationary at a given wind speed.

* *Dublin, Proc. R. Irish Acad.* 22 (1850), p 159.

† The Cup Anemometer, by J. Patterson, M.A., F.R.S.C. *Ottawa, Trans. R. Soc. Canada. Third Series*, XX. Sec. III, 1926.

It had been generally assumed that the static torque was greatest when a four cup anemometer was placed so that two of the arms of the anemometer were parallel to the wind direction and the other two at right angles to it. Patterson's experiments show, however, that this is not the case ; the minimum static torque occurs when the anemometer is so placed, and the maximum when the anemometer is turned through 45° from this position. Curves showing the variation of static torque on a four cup anemometer of standard Canadian pattern for a rotation of the head through 90° are given in the accompanying figure. The angular position of the anemometer head is plotted horizontally and the static torque vertically. The zero position is when one arm is parallel to the wind direction and facing the wind, and the angular position increases from 0° to 90° as the anemometer head is turned clockwise through a right angle. The wind speed in metres per second is shown on each curve.




TORGUE ON 4 CUPS FOR DIFFERENT WIND VELOCITIES

These curves are characteristic of the static torque acting on a four cup anemometer ; but it was found that in the case of anemometers with short arms and comparatively large cups a much more constant value for the static torque through a revolution was obtained ; that is, the curves, though of the same form, were much flatter. It was found, also, that the more constant the static torque, the more constant was the factor of the anemometer for different wind velocities. This smaller variability of torque and factor is to be attributed to the fact that when short arms are used the cups are close together, and exert a shielding effect upon one another. This was conclusively proved by Patterson, by measurements made of the static torque on a single cup throughout a complete revolution, firstly by itself, and secondly when shielded by the other three cups. For short arms, the difference between the shielded and unshielded results was very considerable, but it became less with longer arms. For arms double the diameter of the cups and longer, the shielding effect was found to be negligible. A constant factor for all wind speeds is a highly desirable feature in a cup anemometer, and in the paper under notice, it is shown that, by using extremely short arms, the factor can to all intents and purposes be made constant for all velocities. The disadvantage of short arms is that the torque obtained is comparatively small, and, to offset this, Patterson tried the effect of semi-cylindrical cups on the short arms. He found that a much greater torque could be obtained thus, but that the cups revolved with nearly half the velocity of the wind, and at high speeds the centrifugal force was very great, involving undue wear on the bearings of the instrument.

It was shown also by a large number of measurements, that a somewhat more constant torque and factor were obtained by using a three cup anemometer system than with four cups, and these experiments have led to the adoption of a three cup anemometer as a standard instrument in the Canadian Meteorological Service. This new standard has cups 5 inches in diameter and arms 6·3 inches long. It is interesting to compare the size of this instrument with the two small standard four cup anemometers used in the British Meteorological Office. The electric cup anemometer has cups 3·05 inches in diameter and arms 4 inches long, and the self indicating instrument 3 inch cups and $7\frac{3}{8}$ inch arms. It had been a general assumption that the four cup anemometer was better, in that it gave a more constant torque through a revolution. This was due to lack of observations, and based on the belief that the maximum torque occurred in the zero position instead of the 45° position.

A general equation which would enable the factor of any anemometer system to be calculated from its dimensions had not been developed before the publication of this paper, although satisfactory equations for particular anemometer systems and the form of a general equation had been given. From considerations of the static and dynamic torque obtained in this experimental work, and allowing for the fact that when an anemometer is in rotation the wind stream lines are turned somewhat due to the eddies produced by the shape of the cup, Patterson has developed an equation for calculating the factor of any cup anemometer. The equation has been developed, neglecting the effects of friction and interference between the cups. This means, of course, that it can be applied only to anemometer systems with comparatively long arms, and, for such systems, the values of the factor calculated from Patterson's equation are found to agree quite well with values determined experimentally.

Perhaps the most important fact brought out in this paper is that the three cup anemometer does possess definite advantages over the traditional four cup system, and it is a fact which should be noted by all those interested in anemometry.

# OFFICIAL NOTICES

## A Course of Training for Observers

The fifth course of training for meteorological observers will be held at Kew Observatory, commencing at 10 a.m. on Monday, September 19th, and terminating on the morning of Friday, September 23rd. Kew Observatory, situated in the Old Deer Park, Richmond, is about ¾ mile from Richmond station, which is easily reached from any part of London by train or omnibus.

The syllabus will comprise the following subjects :—

Meteorological instruments and methods of observation.

The recording of observations and their transmission to the Meteorological Office.

The Weather Map : charting of observations distributed by wireless-telegraphy.

British climatology.

The aim of the course is threefold :—

(A) to provide a sound foundation in meteorological observation for those who have had little or no previous experience of the work ; (B) to deal with the difficulties encountered by the more advanced observer ; (C) to develop consistency of method. In particular, such difficulties as may arise in instrumental manipulation and in the detailed compilation of the pocket and permanent registers will be considered as fully as possible.

The course is addressed primarily to observers at stations which report regularly to the Meteorological Office. Others will, however, be admitted, at the discretion of the Director, as far as the accommodation permits. Applications for tickets of admission should be made to the Director, Meteorological Office, Air Ministry, Kingsway, London, W.C. 2. There will be no fee for the course, but travelling and other incidental expenses incurred by observers attending the course will in no case be paid by the Meteorological Office.

# Correspondence

To the Editor, *The Meteorological Magazine*

## A Lunar Rainbow at Aberdeen

At 21h. 43m. G.M.T. on May 15th a well-marked lunar rainbow was observed at Aberdeen. A brilliantly full moon, moderate rain showers and dark cumulo-nimbus clouds massing along the northern sky supplied the requisite conditions. The bow appeared as a rather dim, colourless arc probably slightly narrower than the average narrow solar rainbow. Persisting until 21h. 48m., when the moon was obscured by cloud, the bow re-appeared at 21h. 51m. and lasted until 21h. 54m.

Standing in a darker part of the town and looking northward, clear of the town "glare," I was in a very favourable position for noticing the phenomenon. The top of the bow appeared to be about 20° to 25° above the horizon with the moon, directly opposite, at an apparently slightly lower elevation. A later calculation shows the moon's elevation at this time to have been about 20°. P. T. JARROLD.

*The Observatory, King's College, Aberdeen. May 16th, 1927.*

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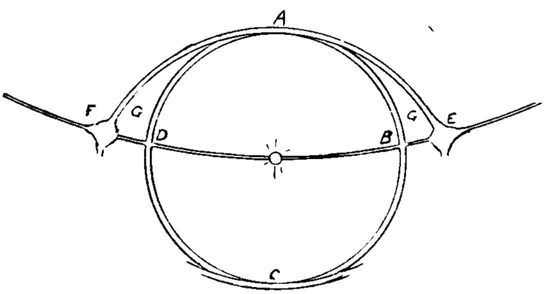
## Solar Halo Phenomena at Aberdeen on May 11th, 1927

On Wednesday, May 11th, at 10h. G.M.T. solar halo phenomena of an unusual nature were observed here. A normal halo of 22° was visible at 7h. G.M.T. with an upper arc of contact convex to the centre. Before 10h. G.M.T. the halo had become exceedingly brilliant, particularly the upper and lower portions, marked A and C on the sketch, where the halo was very vivid.

Touching the halo at A and C were well defined arcs of contact concave to the sun. The upper arc was prolonged downwards on either side to meet, at F and E, the parhelia which were situated about 7° from the edge of the halo, on a pale white parhelic circle which was faintly but plainly seen to extend horizontally right round the sky through the north. In the sketch a part of this circle is shown at F, D, B, E, the arc shape in the sketch being due to the effect of perspective. The intensity of the upper arc of contact mentioned above diminished greatly as the parhelia were approached, and it disappeared entirely below the parhelic circle. The areas between the contact arcs and halo proper were milky-white, considerably brighter than the sky either within or without the halo. Fairly strong prismatic colouring was exhibited in the mock-suns themselves.




The most outstanding feature however was the exceptional brilliance of colouring at A where the reddish-orange and greenish-yellow were clearly distinguishable together with a faint tinge of bluish green, after which it merged into the general milky tint of the cirro-nebula.

G. M. RATTRAY.

*The Observatory, King's College, Aberdeen. May 12th, 1927.*

[The observations are in agreement with theory except that the lower arc of contact is shewn by Pernter—Exner (Fig. 155) as curved with the concavity downwards at the point of contact.

The dimple is very small however and might well be missed in nature.

Latitude of Aberdeen = 57°. Declination on May 11th, 17° 45 N. Elevation of sun at 10h. G.M.T. approximately 45°. —F.J.W.W.]

## Aurora Australis

In the Melbourne "*Sun*," dated April 22nd, 1927, a correspondent refers to a "sky display" on April 14th, seen from the neighbourhood about 9.30 p.m. and again between 10 and 10.30 p.m. His description of a red glow above beams of white light in the east and south-east, looks like the Aurora Australis.

G. C. WOOLDRIDGE.

*Leicester Road, Ashby-de-la-Zouch. June 11th,* 1927.

## Early Summer Conditions in the Highlands.

What struck me most during my holiday in Scotland was the appalling damage wrought by the gale of January 28th, mentioned by Mr. Dines in the July number of the magazine. To speak of hundreds of trees down would be a misnomer, you see woods absolutely prone, and the occasional trees still upright are the exception; thousands of trees lying in inextricable confusion five months after the storm. This is specially noticeable up the Great Glen; Loch Lochy side seems to have suffered as badly as any place. I motored from Fort William to Inverness and back by bus and saw the destruction. At Fort William the pier was partly washed away and water got into the station. It was the worst storm ever known.

Loch Laggan suffered badly and hundreds of trees down at Ardverikie—Sir John Ramsden's place—but not so bad as Loch Lochy and the Great Glen.

I made many ascents; the weather was very clear and cold with occasional showers and one could see the Cairngorms pure white above 4,000 ft. till about June 12th. On June 14th there appeared bare patches in the white covering. On Ben Nevis on Whit Monday, June 6th, there were about 7 ft. snow, so that one could step on to the roof of the old Observatory without using hands; it was calm, sunny and cloudy and temperature 38°-40° at 2.15 (S.T.). No continuous snow below 4,000 ft. on south-west and west sides though drifts as low as 2,300 ft. On June 9th I was on Aonach Beag (4,060) and had the record temperature of 32° at 2.45 p.m. (S.T.); snow cap quite frozen and summit rocks had icicles hanging to them, cloudy, sunny and clear day, north airs.

June 14th I saw the sun set from Ben Lawers (3,984) at 10.15 p.m. (S.T.); very clear and light north airs and temperature 34°

at sunset ; the shadow of the Ben rose up the hills to the south-east and was finally projected into the sky, a wonderful sight. Marvellous view from Goat Fell in Arran to Ben Wyvis. There seemed more snow than usual for the time of year above 3,900 ft. and less than usual below that level. The depth at the summit of Ben Nevis and Cairngorms was remarkable for June. There were several inches of fresh snow on Ben Nevis on June 3rd which lay to 3,000 ft. and it was so cold that this was still lying on June 10th.

I have since heard that Ben Nevis had fresh snow down to below 2,200 ft. about June 25th, and it was well into July before the snow cap on the summit had dissolved into separate beds. A friend of mine who used to do duty at the summit Observatory tells me that he never remembers seeing so much snow on the hill top in July. R. P. DANSEY.

*Kentchurch Rectory, Hereford. August 6th, 1927.*

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## Waterspout on Loch Leven

An interesting account of a waterspout observed on Loch Leven, on Wednesday, June 8th, has been furnished me by Lieuts. Garnett and Trail, R.N., of Leuchars R.A.F. Training Base, who were out fishing on the Loch on that day. It is recounted here in their own words as nearly as possible.

The officers arrived at Loch Leven at 11.30 a.m., B.S.T., in very heavy rain accompanied by a slight breeze from the west. About noon the wind fell to a calm and with a clearing sky the air temperature rose rapidly. Judged by the movement of the remaining cloud the wind at 2,000-3,000 feet had no decided direction. Presently the sky clouded from the south-west while the wind on the surface was easterly though not exceeding 5 m.p.h. By about 2 p.m. the sky was overcast and at 2.30 rain fell heavily with no wind. A thunderstorm was in progress to the west, probably between Kinross and Stirling. At this stage the officers began to encounter difficulty in casting. At times the last five or six feet of cast would not remain on the water. After renewed attempts at throwing the line the gut with four flies attached persisted in rising from the water and more than once remained nearly vertical, staying in that position for about half a minute before sinking back. While this was taking place very heavy rain continued and there was no wind.

During the next hour the wind rose again to force 2 or 3 but seemed to blow from all directions in turn. It never remained steady for more than 10 minutes. At 4 p.m. it fell away to calm again but was soon followed by violent squalls with wind force 7 to 8 mainly from a southerly point. Simultaneously clouds became low and rain began to fall heavily. At this stage while watching the north side of the Loch at a distance of a quarter of a mile the surface showed signs of violent disturbance, and presently the water in that neighbourhood took on a rapid anti-clockwise movement and rose to a height of 15 to 20 feet. It then began to move about over the surface of the Loch covering an area of 2 or 3 acres in its peregrinations. The surface of the water in its vicinity was violently agitated over an area extending 10 to 15 feet around the base of the spout and frequently produced a dense spray. The spout itself varied in height from 7 or 8 feet to about 20 feet but kept the diameter of its base fairly steady within the limits of 15 and 20 feet. It tapered to about three-quarters of its base at the top, which was ragged and clouded in spray.

During these considerable vertical and horizontal movements of the waterspout, the clouds were 800-1,000 feet above the water surface. At the lower layer of the cloud above the waterspout an extension emerged for a distance of 50 to 100 feet, tapering off from the cloud downwards. At the place of emergence both the cloud base and the projection were well defined. While the Loch counterpart moved about, the lower end of this trunk-like protuberance swayed about, following its motion. The entire phenomenon lasted about a quarter of an hour, after which the wind fell to calm though the heavy rain continued for two hours. Just after 6 p.m. a wind, 8-10 m.p.h., sprang up from the north-northwest and continuous rain gave place to showers. Clear sky and calm prevailed later in the evening.

J. M. STAGG.

*Leuchars. June 9th, 1927.*

[In a lecture on line squalls delivered before the Royal Aeronautical Society in March of this year, Mr. Giblett associated waterspouts with line squalls and stated that the seat of their occurrence appeared to be the region of strong air convergence immediately below the squall cloud which marks the forward edge of the advancing cold air. This would seem to be borne out in the present instance. The synoptic charts for June 8th indicate a cold front, although it is not very clearly defined, and the occurrence of the waterspout phenomenon would appear to coincide with the arrival of cold air from the north-northwest. This is supported by the fact that shortly after the waterspout movements were observed, the north-northwest wind sprang up and the sky cleared, the latter phenomenon probably coinciding with the arrival of the cold air at ground level.—F.E.]

## Erratum

July, 1927, page 135, line 16, *for* " British thermal units " *read* " Board of Trade units " and note one Board of Trade unit equals one kilowatt hour.

# NOTES AND QUERIES

## A Mammilated Cloud Sheet at Whitley Bay

The photograph of mammato cloud which forms the frontispiece of this volume of the magazine was taken by Mrs. E. Watts, of Whitley Bay, Northumberland, from the promenade there, at 11h. on July 5th. She writes that " It was a beautiful morning to commence with, then suddenly the clouds as shown began to roll up from the southwest rapidly. Everybody here described it as a padded quilt and expected anything. However it ended in a very heavy thunderstorm followed by floods."

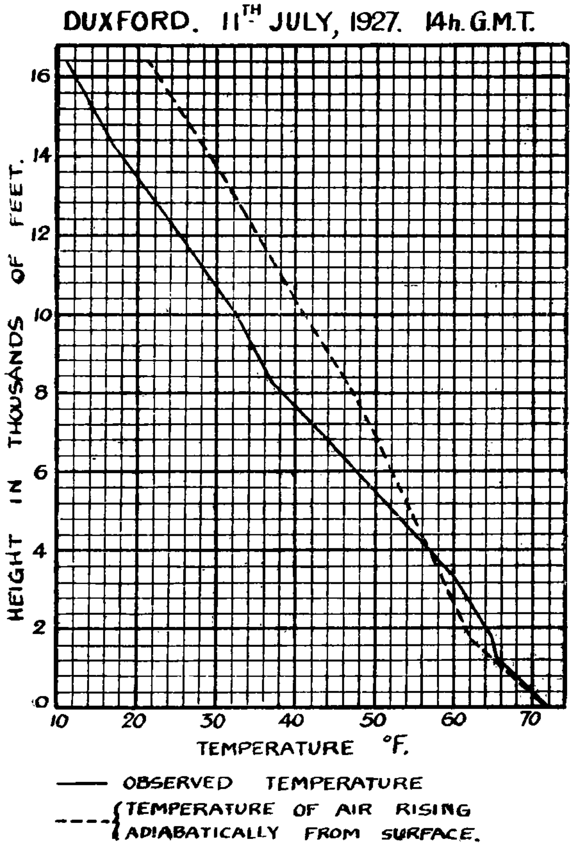
## Notes on Conditions prevailing during Thundery Weather about July 10th–13th, 1927

On Sunday, July 10th, the first day of the local thunderstorms, there was a rather deep depression over Germany and an anticyclone to westward of Ireland. Winds were northerly over the British Isles, but temperature nevertheless rose to about 80° F. over a large part of England, showing a considerable rise since the previous day, and exceeded 75° F. over parts of Scotland. The high temperatures are explained by the fact that the air originated in an easterly current which prevailed for some days over southern Scandinavia and the Baltic. Day temperatures in these districts ranged from 70° F. to 80° F., and (except on the west coast of Norway) the humidity was rather high, dewpoints being above 60° F. at several stations. The mean July temperature of the North Sea is about 57° F., so that a surface temperature inversion must inevitably have been formed as the warm air crossed the cool sea, but the passage was rapid and the inversion was evidently quickly removed by sunshine in the British Isles. The damp state of the ground after three weeks of unsettled weather no doubt further increased the water content of the air.

By the morning of the 11th a shallow depression had formed over the southern part of England, and persisted some days, with light indefinite winds. The storm over London on the afternoon of the 11th moved slowly in an upper current from south to north, but the origin of the air remained unchanged.

The diagram shows the upper air temperatures observed that afternoon at Duxford, near Cambridge, compared with the temperature which would have been assumed by air rising from the earth's surface under adiabatic conditions. The rising air would have become saturated at about 1,800 feet (an unusually low level for a warm day) and would thereafter have followed its " saturated adiabatic " curve. It may be noticed that from 8,000 feet up to at least 16,000 feet the rising air would have been about 10° F. warmer than its environment. Under these conditions powerful upward currents of great vertical extent were inevitable as soon as large cloud masses penetrated into this region, and it is unlikely that the rising currents came to rest before reaching the stratosphere. Temperatures between 8,000 and 16,000 feet were about normal for the season, the instability being due entirely to the warm damp air near the surface.

At Duxford the relative humidity dropped from 78 to 61 per cent. between about 1,000 and 2,000 feet, and the lapse-rate in that layer was small, both features being most unusual for a summer afternoon at an inland station. There was fog along the east coast in the morning, and this probably drifted inland from the Wash in the northerly current still prevailing. Duxford is only 50 miles from the Wash, and probably the comparatively recent dissolution of the fog explained the abnormal conditions. At stations further west afternoon temperatures before the thunderstorms ranged from 75° F. to 78° F., and the water content was about the same as at Duxford. It is therefore reasonable to assume that over most of the country there was no stable layer at about 2,000 feet (such as is shown in the diagram for Duxford), that the cloud base was not lower than 2,500 to 3,000 feet, and that the degree of instability up above was somewhat greater than is shown in the diagram.




Next day a sheet of low stratus cloud from the North Sea persisted over the eastern half of England, but further west, where there was some sunshine, thunderstorms again developed. Thunderstorms also occurred on the south-east coast during the night of July 12th—13th. At Duxford on the 13th there was a temperature inversion of 9° F. between 2,800 and 3,400 feet, above the stratus clouds, temperature having fallen 15° F. at about 2,000 feet since the 11th. The air was damp above the inversion, being actually saturated at 5,000 feet, with unstable conditions for saturated air above that level, which explains the occurrence of thunderstorms during the previous night.

The majority of the thunderstorms were of a perfectly straightforward diurnal convectional type. The unusual feature was the source of the warm damp air.

C.K.M.D.

## Rainfall associated with Thunderstorms of July, 1927

On more than half the days in July heavy falls of rain associated with thunderstorms were recorded somewhere in the British Isles. According to the available information those during the night of the 6th to 7th, the afternoon of the 11th and on the 21st were most widespread.

*Rainfall in Kent, July 6th–7th.* During the night of the 6th to 7th, more than 1 in. fell to the east of a line from the Wash to St. Leonards, as well as over part of the North Yorkshire Moors. More than 2 in. was recorded at Sheringham (near Cromer), between Colchester and Clacton and in the south-east of Kent. At Deal the fall just exceeded 3 in. Of the total fall at Dover (2·81 in.) as much as 2·3 in. occurred between 19h. 40m.* on the 6th and 0h. 40m. on the 7th at the fairly uniform rate of ·45 in. an hour. Persistent heavy rain was, therefore, the main feature of the storm. The storm was one of the worst experienced at Dover for many years. At times the streets were almost impassable and vivid lightning lit up the town. The rain commenced rather earlier to the south-west and later further north. At Norwich and Sheringham it rained from 2h. to 9h. on the 7th.

*Rainfall in London, July 11th.* The rainfall over London during the afternoon of the 11th presented features of unusual interest. More than 1 in. fell over large areas stretching from Kew Gardens to Alexandra Palace and from Carshalton to Battersea Park, as well as locally in Bermondsey and Forest Hill. The fall exceeded 2 in. over an area between Hammersmith Bridge, Wormwood Scrubbs and Kensington Gardens. The largest amounts recorded were :—

| | |
|---|---|
| Kensington (Holland House) .. | 3·42 in. |
| ,, (Cam House) .. .. | 2·93 ,, |
| Hammersmith Pumping Station .. | 2·65 ,, |
| Kensington (Campden Hill) .. | 2·45 ,, |

The rainfall gradient was very steep since in the Strand, on

* All times specified are G.M.T.

Putney Common and at Sudbury, 4 miles east, 4 miles south and 6 miles north-west of Holland House respectively the fall was less than half an inch. The rain commenced about 13h. 45m. in the South Kensington and Balham districts and as late as 14h. 30m. at Kings Cross and in the north-east of London. It ceased at about 16h. in the west and at 16h. 30m. in the north-east.

Estimates of the intensity of the rainfall are available from the charts of the autographic gauges maintained at certain stations in the area :—

| Station | Amount | Duration | Rate per hour |
|---|---|---|---|
| | in. | min. | in. |
| Kensington Palace .. .. | 1·00 | 12 | 5·00 |
| Balham High Road .. .. | 1·50 | 18 | 5·00 |
| Hammersmith Pumping Station | 2·00 | 36 | 3·33 |
| Campden Hill .. .. .. | 2·00 | 38 | 3·16 |

There is little doubt that in parts of Kensington the intensity of rainfall even surpassed that actually recorded by the autographic gauges.

The rainfall of July 11th over London was remarkably similar to that of June 16th, 1917, both in general distribution and in the duration of the storm. In 1917, however, there was no rain at all to the south-east of a line from Wimbledon to Liverpool Street, while the falls in the Kensington area were generally larger, as much as 4·65 in. being recorded in less than 2 hours and a half at Campden Hill. This constituted one of the most extreme instances of prolonged intense rainfall ever observed in the British Isles and incidentally gave the largest daily fall on record for London. The sewers and storm relief works could not cope with the intense rainfall of July 11th and much flooding occurred. It has been estimated that the amount of water falling in these two hours in Hammersmith, Fulham, Hampstead, Kensington and parts of Wandsworth, was equivalent to an open river, 100 yards wide and 4 feet deep flowing at a normal walking pace of 3 miles an hour. Fortunately when the storm began the tide in the River Thames had been falling for some hours, so that the discharge of the rain-water to the sea was not impeded.

Another unusual feature of the storm was the intense darkness. The temperature at Kensington during the storm dropped 10° F.

From Worthing the cumulus clouds to the north during the afternoon were very impressive, while the coast from Beachy Head to the Isle of Wight and the South Downs could be seen bathed in sunshine. In the late afternoon one massed cumulus cloud towering above all the others was noted.

*Rainfall, July 11th, outside London.* The rainfall also exceeded 1 in. on the rainfall day of the 11th over isolated areas in the south of England—in Exmoor, the Mendips, near Marlborough, Lechlade and Farnborough (Hampshire)—and in the Midlands near Wolverhampton and the southern Pennines, and near Strathaven (Lanarkshire). At Wolverhampton 3·70 in. was recorded as a result of two storms in the afternoon and evening. Very considerable damage by floods occurred in the Staffordshire and Oldham districts, although it is not possible at present to define the amount or intensity of the rainfall with any precision.

*Rainfall July 21st.* Heavy falls on the 21st accompanied by extensive floods, were reported from Ashton-under-Lyne, Stalybridge, Sunderland, Glasgow and Greenock. At Chew Valley and at Brushes Reservoir to the east of Ashton-under Lyne 2·2 in. and 1·8 in. respectively is reported to have fallen in an hour.

J.G.

## Weather Notes in the Fugger News-Letters

The great business house of Fugger in the sixteenth century spread its activities over all Europe, and to its headquarters in Augsburg came letters from correspondents in the chief cities, filled with the news, the hopes and the fears of the day. These "news-letters" were carefully filed, and ultimately found their way into the Vienna State Library, where they lay unnoticed until a few years ago, when a first selection was published in Vienna and subsequently translated into English. This series deals mainly with continental news; a second series concerned primarily with English activities has also been published by The Bodley Head.* The volumes cover the years 1568 to 1605, and I thought it worth while to search the extracts for any weather notes which might occur.

The contents of the books are of extraordinary historical interest, and from that point of view the books are well worth reading, but meteorologically the result of the search was disappointing; references to the weather are far less frequent than might have been expected from business correspondents in a seafaring and agricultural age. The times were very stirring, there was no lack of news, and perhaps either the original correspondents or the editor of the volume, or both, had so much material that the weather news went to the wall. In the whole of the first volume only two references to weather were noted:

1596, April 25th. "On the evening of St. Mark's Day there arose (in Rome) a terrible storm which lasted more than half-an-hour."

On July 18th, 1597, it rained blood near Vienna. [It is doubtful, however, whether the "rain" fell from heaven or from a cut in the tail of an ox].

*The Fugger News-Letters. Being a selection of unpublished letters from the Correspondents of the House of Fugger during the years 1568-1605, 2 Vols., London, John Lane, the Bodley Head, 1924, 1926.

The second volume, however, contains five important references to seasons:

In October 1579, in England, "fearful rough weather with rain, heavy snow and unusual cold, such as has not been experienced for sixty years."

In October 1590, the weather in Flanders was very wet and cold.

January 1597. In England, "the rain lasts day and night, and the country is waterlogged."

May 1598. In Holland "the bad weather has again done much damage."

August 1598. In England, "Weather for the crops remains splendid."

It appears that the autumn of 1588 may have been unusually stormy in the Atlantic. In addition to the well-known storm of May 30th which sprang up suddenly and lasted an hour, disabling many ships of the Armada, we hear that in September Drake was unable to stay at sea because of the gales, and in October Spanish ships were driven ashore in Ireland by a south-westerly gale. On April 16th, 1580, there was an earthquake in Flanders, France and England, "Some towers and houses collapsed." In the summer of 1582 there was rough weather off the coast of Brazil. In March, 1589, eight vessels were lost along the English (Channel) coast, in November, 1589, Spanish ships were damaged and sunk in a storm, and in November, 1596, a similar fate overtook a Spanish fleet going to Ireland.

A report of great interest is that for September, 1594, from Antwerp, reporting the discovery of the north-east passage to India, "behind Norway." "The sailing is very good there, but one must be careful to choose the months of June, July and August, as at all other times the channel will be found to be icebound."

C. E. P. B.

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## Fencing around Rain-Gauges

During 1925 and 1926 records are available from a fenced and unfenced rain gauge, both 8 in. in diameter with rims 1 ft. above the ground, at the Telegraphic Reporting Station, Portland Bill, Dorset. The ground on which the gauges stand is 32 feet above sea level with an upward slope from southeast to northwest, the approximate gradient being 1 in 15. The site is a very open one, devoid of trees and buildings other than the lighthouse. The winds felt here should be practically those of the open sea in the vicinity, and during strong winds it is possible that too little rain is recorded owing to the gauges being over-exposed. The standard gauge is erected 50 yards northeast of the lighthouse, the tower of which is 136 ft. high from base to vane. Owing to frequent interference by visitors the standard gauge was surrounded with a chestnut pale fence on February 1st, 1925, and remained fenced until March 13th, 1926, when it became necessary to remove the fence, and records were thereafter again obtained from the unfenced gauge.

The fence was 3 ft. 6 in. high with pales 5 in. apart, and enclosed a circle 30 ft. in diameter, the rain-gauge being in the centre of the circle. It was expected that a fence of the type used, by breaking the force of the wind over the gauge, would increase the catch, and the provision of a check gauge enabled this point to be examined. The unfenced check gauge was erected 50 yards north-northwest of the standard gauge, during December, 1924, and remained in this position until August 6th, 1926, when it was run over by a motor car and destroyed.

The following table compares the monthly results :—

| | Standard Gauge (both un | Check Gauge fenced) | | Standard Gauge (fenced) | Check Gauge (unfenc'd) |
|---|---|---|---|---|---|
| | mm. | mm. | | mm. | mm. |
| 1925. Jan. ... | 113·4 | 113·5 | 1925. Feb. ... | 102·9 | 105·9 |
| 1926. Apr. ... | 80·6 | 79·3 | ,, Mar. ... | 9·7 | 9·7 |
| ,, May ... | 31·9 | 30·9 | ,, Apr. ... | 56·9 | 57·4 |
| ,, June ... | 50·1 | 51·1 | ,, May ... | 75·4 | 75·4 |
| ,, July ... | 25·0 | 24·0 | ,, June ... | 12·9 | 12·9 |
| | | | ,, July ... | 73·3 | 74·0 |
| | | | ,, Aug. ... | 49·3 | 49·4 |
| | | | ,, Sep. ... | 79·8 | 79·7 |
| | | | ,, Oct. ... | 100·0 | 99·5 |
| | | | ,, Nov. ... | 65·4 | 63·2 |
| | | | ,, Dec. ... | 87·4 | 86·8 |
| | | | 1926. Jan. ... | 88·7 | 88·3 |
| | | | ,, Feb. ... | 44·1 | 44·4 |
| | | | ,, Mar. ... | 7·6 | 7·3 |
| Totals ... | 301·0 | 298·8 | | 853·4 | 853·9 |

During the five months when both gauges were unfenced the standard gauge, with a total measurement of 301 mm., shows an excess over the check gauge of 2·2 mm. only, and covering the period of fourteen months, when the standard gauge was fenced, there is a deficit of 0·5 mm. between this gauge and the check gauge. Bearing in mind the extremely exposed position of the site the agreement between the two gauges is remarkably close, the figures showing that if the chestnut pale fence has any effect at all on the gauge, such effect is a very small one, and is not in the direction of increasing the catch of the gauge.

The standard gauge, above referred to, is being maintained in its original position, but unfenced, for the present. A new check gauge was erected 30 yds. west of the lighthouse on the 9th September, 1926, and was surrounded with the chestnut pale fence, originally round the standard gauge, at the end of October, 1926. It is proposed, ultimately, to adopt this new site as the standard one at Portland Bill, and to discontinue the records from the old gauge.

SPENCER RUSSELL.

## Radiation from the Sky

RADIATION MEASURED AT BENSON, OXON, 1927.

*Unit: one gramme calorie per square centimetre per day.*

ATMOSPHERIC RADIATION only (dark heat rays)

Averages for Readings

| | | April | May | June |
|---|---|---|---|---|
| Cloudless days :— | | | | |
| Number of readings ... ... | $n$ | 2 | 13 | 5 |
| Radiation from sky in zenith ... | $\pi I$ | 493 | 521 | 531 |
| Total radiation from sky ... | J | 526 | 556 | 562 |
| Total radiation from horizontal black surface on earth ... | X | 714 | 752 | 789 |
| Net radiation from earth ... | X—J | 188 | 196 | 227 |

DIFFUSE SOLAR RADIATION (luminous rays).

Averages for Readings between 9 h. and 15 h. G.M.T.

| | | April | May | June |
|---|---|---|---|---|
| Cloudless days :— | | | | |
| Number of readings ... ... | $n_0$ | 0 | 1 | 2 |
| Radiation from sky in zenith ... | $\pi I_0$ | .. | 100 | 90 |
| Total radiation from sky ... | $J_0$ | .. | 115 | 92 |
| Cloudy days :— | | | | |
| Number of readings ... ... | $n_1$ | 0 | 1 | 1 |
| Radiation from sky in zenith ... | $\pi I_1$ | .. | 65 | 284 |
| Total radiation from sky ... | $J_1$ | .. | 47 | 216 |

Unit for I = gramme calorie per day per steradian per square centimetre.
Unit for J and X = gramme calorie per day per square centimetre.
For description of instrument and methods of observation, see *The Meteorological Magazine*, October, 1920, and May, 1921.

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## Reviews

*über Luftdruckwellen.* By Paul Mildner. Leipzig. Veröff. Geophysik Inst. Univ. Ser. II., Band 3, Heft 3, pp. 173-238, 1926.

The earliest daily weather charts covered a comparatively small area, in which as a rule only one anticyclone or depression was visible at one time, and early studies of synoptic meteorology generally regarded each anticyclone or depression as an entity to be studied without reference to its neighbours. The extension of the synoptic area led to the recognition of families or series of depressions, and the isobars which form the boundary between such a series and the anticyclonic belt on its equatorial side often showed a very neat wave form advancing from west to east round the globe. Such a series of waves passing over a fixed station leave their record in wave-like oscillations of the curve of pressure at the station. A regular oscillation which has persisted for some time in the past may be expected to persist for a time in the future. Hence F. Vercelli in 1923 initiated the analysis of barograms into their constituent periodicities, and employed the results to give experimental forecasts for a week in advance. The theory was further developed by L. Weickmann*, who sought for points at which the constituent curves either all reached maxima or minima together or all passed through points of inflexion together. In the first case the pressure curve to the right of the point will be a direct reflection of the curve to the left ; in the second case it will be an inverse reflection. Weickmann was able to pick out on curves of pressure a number of such points, which he termed " points of symmetry." As a rule they can only be recognised when both halves of the curve are available and the opportunity for a forecast has gone by, but the phenomena offer a promising field for study. The present paper is a continuation of Weickmann's researches.

There is considerable evidence for the existence of pressure waves of about 8 and 24 days, and the author accordingly selects them for study. Over the interval from December 10th, 1923, to February 19th, 1924, he calculates by harmonic analysis the amplitude and phase of these waves at a large number of stations in Europe, north Africa, and the North Atlantic. The results when plotted yield a great deal of information about the characteristics of such waves, and show that during the interval in question the variations of pressure over Europe and the Arctic were in fact dominated by the 24-day pressure wave, which reached an amplitude of 17 mb. over Spitsbergen and 14 mb. at Scilly. The author, however, closes on a note of warning ; such results are valid only for the interval actually covered by the analysis. Different intervals give different results, and until the causes of these differences are known, extrapolation is unsafe. He suggests, however, that the waves spread out from certain action centres, especially the Arctic Ocean and the Azores anticyclone, and that the variations from year to year are due to the conditions in these centres, which may be of cosmic origin.

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*El Gran Temporal de Nieve del* 28 *al* 31 *de Agosto de* 1923. By Guillermo Hoxmark. Buenos Aires, Anal. Soc. Cien. Argentina, Tome 101, pp. 5-10, 1926.

The area over which snow fell in the Argentine was about 193,000 square miles, mainly over the Central Pampas. The storm was

* Wellen im Luftmeer. By L. Weickmann, *Leipzig, Abh. Sächs. Akad. Wiss.*, Vol. 39, No. 2, 1924.

associated with the northward passage of an anticyclone from Patagonia while at the same time a depression moved southwestward across north-eastern Argentine. It was in the area of steep gradient and polar winds between these two systems that the snow fell. The snowstorm was disastrous, many thousands of horses, cattle and sheep being destroyed.

## Books Received

*Terrestrial Magnetism in the Twentieth Century.* By D. L. Hazard. Smithsonian Report for 1925, pp. 243-256. Washington D.C., 1926.

*Jaarboek, Koninklijk Nederlandsch Meteorologisch Instituut,* 1924. A. Meteorologie. B. Aard-magnetisme (No. 98). Utrecht, 1925.

*Ergebnisse Aerologischer Beobachtungen,* 1924. K. Ned. Meteor. Inst. (No. 106A). Utrecht, 1925.

*Onweders, Optische Verschijnselen, enz in Nederland.* Naar Vrijwillige Waarnemingen in 1923. Deel XLIII. K. Ned. Meteor. Inst. No. 81. Amsterdam, 1925.

*Royal Alfred Observatory, Mauritius,* Annual Report, 1925, and Results of Magnetical and Meteorological Observations for September to December, 1925.

*Nautisk-Meteorologisk Aarbog,* 1926. Copenhagen, 1927.

*Falmouth Observatory,* Meteorological Notes and Tables for the Year 1926. By J. B. Phillips. Falmouth, 1927.

*Monthly Rainfall of India for* 1925. Calcutta, 1927.

## Obituary

*Mrs. G. M. Whipple.*—We regret to learn of the death of Mrs. Whipple which occurred at Highgate on August 6th in her 82nd year. Mrs. Whipple was the daughter of Mr. Robert Beckley who was on the staff of Kew Observatory for many years. She married in 1871 Mr. G. M. Whipple then first assistant and later (from 1876 to his death in 1893) Superintendent of the Observatory. One of her three surviving sons succeeded Dr. Chree as Superintendent of the same Observatory in 1925.

## News in Brief

The degree of Ph.D. (Science) has been conferred by the University of London on R. E. Watson, B.Sc., for a magnetic research which was carried out in a coal mine near Birmingham in 1923.

*Staff News.* Civil Service Lawn Tennis Championships, Women's Doubles, winners Miss Lovell and Miss Quennell. Women's Singles, Class B, runner-up Miss Quennell.

# The Weather of July, 1927

Unsettled thundery weather with many fair periods prevailed generally throughout the month. With the exception of the 10th, which was sunny and warm, rain occurred on most days between the 1st and 11th, the heaviest falls being on the night of the 6th-7th when a severe thunderstorm was experienced over the eastern and south-eastern districts of England* and on the 11th when a thunderstorm of unusual intensity occurred in London and southeast England†. Heavy rain, including 1·65 inch at Portland Bill, also fell on the 1st when a depression remained centred near the Straits of Dover throughout the day. Another depression deepening considerably as it approached our western coasts brought gales to Cornwall and Scilly Isles on the morning of the 4th. By Sunday the 10th the low pressure system which had dominated the weather during the earlier part of the month began to move away eastwards and a ridge of high pressure over the Atlantic extended northeast over Ireland and Scotland giving fair weather in the north and west of these countries for some days. At the same time shallow areas of low pressure were situated over England and further thunderstorms developed locally in southern England and Wales. After the 14th the unsettled sunless conditions were confined to the southeast of England and on the 18th and 19th the anticyclone moved across Great Britain giving fine warm weather over nearly the whole country during those two days. A fresh depression however was approaching our southwest coasts, and an unsettled type of weather was renewed and maintained from the 20th to the end of the month, though on several days good sunshine records were obtained locally, *e.g.*, 14·3 hours at Margate on the 25th. The highest temperature reported during the month was 82° F. at Worksop on the 10th, but at most stations in the south the mean monthly temperature was below normal. At Ross-on-Wye it was dullest July since records began there in 1914, but in northwest Scotland there was an excess of sunshine.

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Pressure was below normal generally except over Scandinavia, Newfoundland, Nova Scotia, Bermuda, and the south of the Iberian Peninsula, the greatest deficit being 4·9 mb. at Valentia and the greatest excess 6·3 mb. at Vardö. Temperature was generally above normal and rainfall below normal in Scandinavia (except for parts of Sweden, where the rainfall was in excess) and the northern part of the British Isles, and temperature below and rainfall above normal in southwestern and central Europe. At Spitsbergen both elements were below normal.

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* See p. 160. † See p. 158.

Severe thunderstorms and heavy rain followed by floods were the main features of the weather over Europe. Storms and floods occurred round Paris on the 6th and over France generally on the 11th. On the 8th an exceptionally severe thunderstorm broke over the highlands of Saxony. Three villages were nearly destroyed and about 150 people killed. Other severe storms and floods were reported from south Russia, Caucasus and Turkestan on the 3rd, from Upper Austria and Brussels on the 12th, from Westphalia on the 15th–17th, from Switzerland on the 15th–17th, and again on the 23rd, from Isère and Germany on the 22nd–24th and from Lombardy and Venetia on the 23rd. Early in the month hot sunny weather occurred in south France and Italy, and a heat wave swept over Yugoslavia, 104° F. being reported from Skoplye on the 2nd.

The heat wave which occurred in Cairo about the 6th was said to be the most unpleasant experienced for 20 years owing to the combination of high temperatures with high humidities.

The monsoon at Bombay has been very "vigorous," 42 in. of rain being recorded at Colaba Point up to the 8th. As a result extensive floods occurred in Gujarat and Kathiawar throughout the rest of the month. On the 28th an abnormal rainfall of 6 in. was experienced at Balasore (Calcutta) and neighbouring districts have been flooded. A typhoon wrought havoc among the districts of the Canton delta (Hongkong) on the 25th and 10,000 people have been drowned near Changshowfu Amoy, as a result of the mountain flood in the Fukien Province.

It was reported on the 8th that the drought in west Queensland was still continuing but plentiful rains fell in the agricultural districts of South Australia about the 22nd.

Storms doing much damage to the crops were experienced in Alberta, Saskatchewan and Manitoba on the 9th–12th, and hailstorms later in the month. A heat wave occurred in the eastern States of America on the 13th–14th.

The special message from Brazil states that the rainfall in the northern districts was 63 mm. above the normal and in the central and southern districts 12 mm. and 39 mm. below normal respectively. Four anticyclones passed across the country and frosts and high winds were experienced at the beginning and end of the month in southern Brazil. The cotton, cane, coffee and cocoa harvests were good generally. Pressure at Rio de Janeiro was 3·7 mb. above normal and temperature 1·3° F. below normal.

## Rainfall, July, 1927—General Distribution

| | | |
|---|---|---|
| England and Wales .. | 133 | per cent. of the average 1881-1915. |
| Scotland .. .. .. .. .. | 99 | |
| Ireland .. .. .. .. .. | 113 | |
| British Isles .. .. .. .. | 120 | |

## Rainfall: July, 1927: England and Wales

| CO. | STATION. | In. | Per-cent. of Av. | CO. | STATION. | In. | Per-cent of Av. |
|---|---|---|---|---|---|---|---|
| *Lond.* | Camden Square | 3·24 | 136 | *Leics* | Thornton Reservoir | 2·70 | 109 |
| *Sur.* | Reigate, The Knowle | 2·69 | 128 | ,, | Belvoir Castle | 2·39 | 98 |
| *Kent.* | Tenterden, Ashenden | 4·66 | 223 | *Rut.* | Ridlington | 2·36 | ... |
| ,, | Folkestone, Boro. San. | 4·70 | ... | *Linc.* | Boston, Skirbeck | 2·01 | 91 |
| ,, | Margate, Cliftonville | 4·90 | 248 | ,, | Lincoln, Sessions House | 2·13 | 96 |
| ,, | Sevenoaks, Speldhurst. | 2·78 | ... | ,, | Skegness, Marine Gdns. | ... | ... |
| *Sus.* | Patching Farm | 3·16 | 132 | ,, | Louth, Westgate | 2·16 | 86 |
| ,, | Brighton, Old Steyne | 1·41 | 65 | ,, | Brigg | 2·84 | 122 |
| ,, | Tottingworth Park | 3·65 | 146 | *Notts.* | Worksop, Hodsock | 2·41 | 106 |
| *Hants* | Ventnor, Roy.Nat.Hos. | 3·61 | 179 | *Derby* | Mickleover, Clyde Ho. | 2·72 | 111 |
| ,, | Fordingbridge, Oaklnds | 3·42 | 171 | ,, | Buxton, Devon. Hos. | 3·54 | 90 |
| ,, | Ovington Rectory | 4·19 | 162 | *Ches.* | Runcorn, Weston Pt. | 2·27 | 83 |
| ,, | Sherborne St. John | 5·01 | 224 | ,, | Nantwich, Dorfold Hall | 2·23 | ... |
| *Berks* | Wellington College | 3·76 | 182 | *Lancs* | Manchester, Whit. Pk. | 1·87 | 57 |
| ,, | Newbury, Greenham | 3·31 | 149 | ,, | Stonyhurst College | 4·93 | 127 |
| *Herts.* | Benington House | 2·16 | 89 | ,, | Southport, Hesketh Pk | 2·88 | 101 |
| *Bucks* | High Wycombe | 3·71 | 188 | ,, | Lancaster, Strathspey. | 3·96 | ... |
| *Oxf.* | Oxford, Mag. College | 2·85 | 126 | *Yorks* | Wath-upon-Dearne | 2·36 | 94 |
| *Nor.* | Pitsford, Sedgebrook | 2·86 | 121 | ,, | Bradford, Lister Pk. | 3·94 | 143 |
| ,, | Oundle | 2·39 | ... | ,, | Oughtershaw Hall | 6·15 | ... |
| *Beds.* | Woburn, Crawley Mill. | 1·79 | 80 | ,, | Wetherby, Ribston H. | 4·77 | 191 |
| *Cam.* | Cambridge, Bot. Gdns. | 1·68 | 78 | ,, | Hull, Pearson Park | 3·08 | 132 |
| *Essex* | Chelmsford, CountyLab | 2·18 | 102 | ,, | Holme-on-Spalding | 2·95 | ... |
| ,, | Lexden, Hill House | 3·52 | ... | ,, | West Witton, Ivy Ho. | 4 61 | ... |
| *Suff.* | Hawkedon Rectory | 3·90 | 160 | ,, | Felixkirk, Mt. St. John | 4·58 | 168 |
| ,, | Haughley House | 2·92 | ... | ,, | Pickering, Hungate | 2·27 | ... |
| *Norf.* | Beccles, Geldeston | 1·83 | 79 | ,, | Scarborough | 2·36 | 97 |
| ,, | Norwich, Eaton | 2·47 | 95 | ,, | Middlesbrough | 4·32 | 169 |
| ,, | Blakeney | 2·59 | 115 | ,, | Baldersdale, Hury Res. | 4·79 | ... |
| ,, | Little Dunham | 3·68 | 134 | *Durh.* | Ushaw College | 3·55 | 127 |
| *Wilts.* | Devizes, Highclere | 5·19 | 224 | *Nor.* | Newcastle, Town Moor. | 3·69 | 139 |
| ,, | Bishops Cannings | 4·25 | 171 | ,, | Bellingham, Highgreen | 3·80 | ... |
| *Dor.* | Evershot, Melbury Ho. | 3·98 | 157 | ,, | Lilburn Tower Gdns. | 3·87 | ... |
| ,, | Creech Grange | 2·25 | ... | *Cumb* | Geltsdale | 4·14 | ... |
| ,, | Shaftesbury, Abbey Ho. | 2·00 | 78 | ,, | Carlisle, Scaleby Hall | 4·37 | 134 |
| *Devon* | Plymouth, The Hoe | 3·57 | 129 | ,, | Seathwaite M. | ... | ... |
| ,, | Polapit Tamar | 3·86 | 143 | ,, | Keswick | 6·17 | ... |
| ,, | Ashburton, Druid Ho. | 5·19 | 170 | *Glam.* | Cardiff, Ely P. Stn. | 4·38 | 141 |
| ,, | Cullompton | 3·27 | 122 | ,, | Treherbert, Tynywaun | 9·81 | ... |
| ,, | Sidmouth, Sidmount | 3·57 | 142 | *Carm* | Carmarthen Friary | 5·52 | 157 |
| ,, | Filleigh, Castle Hill | 5·04 | ... | ,, | Llanwrda, Dolaucothy. | 7·56 | 174 |
| ,, | Barnstaple, N.Dev.Ath. | 3·92 | 148 | *Pemb* | Haverfordwest, School | 3·80 | 119 |
| *Corn.* | Redruth, Trewirgie | 4·31 | 141 | *Card.* | Gogerddan | 5·52 | 143 |
| ,, | Penzance, Morrab Gdn. | 2·40 | 88 | ,, | Cardigan, County Sch. | 3·55 | ... |
| ,, | St. Austell, Trevarna | 3·57 | 107 | *Brec.* | Crickhowell, Talymaes | 5·60 | ... |
| *Soms* | Chewton Mendip | 5·39 | 155 | *Rad.* | Birm. W. W. Tyrmynydd | 6·26 | 152 |
| ,, | Street, Hind Hayes | 4·23 | ... | *Mont.* | Lake Vyrnwy | 4·83 | 141 |
| *Glos.* | Clifton College | 5·13 | 181 | *Denb.* | Llangynhafal | 2·25 | ... |
| ,, | Cirencester, Gwynfa | 3·49 | 135 | *Mer.* | Dolgelly, Bryntirion | 6·16 | 145 |
| *Here.* | Ross, Birchlea | 3·37 | 149 | *Carn.* | Llandudno | 1·68 | 70 |
| ,, | Ledbury, Underdown. | 3·40 | 150 | ,, | Snowdon, L. Llydaw 9 | 12·73 | ... |
| *Salop* | Church Stretton | 2·09 | 85 | *Ang.* | Holyhead, Salt Island. | 1·64 | 63 |
| ,, | Shifnal, Hatton Grange | 2·73 | 121 | ,, | Lligwy | 1·20 | ... |
| *Worc.* | Ombersley, Holt Lock. | 4·00 | 187 | *Isle of Man* | | | |
| ,, | Blockley, Upton Wold. | 3·33 | 137 | | Douglas, Boro' Cem. | 2·84 | 93 |
| *War.* | Farnborough | 3·63 | 142 | *Guernsey* | | | |
| ,, | Birminghm, Edgbaston | 3·12 | 134 | | St. Peter P't. Grange Rd | 3·05 | 151 |

## Rainfall: July, 1927: Scotland and Ireland

| CO. | STATION | In. | Per-cent. of Av. | CO. | STATION. | In. | Per-cent of Av. |
|---|---|---|---|---|---|---|---|
| *Wigt.* | Stoneykirk, Ardwell Ho | 3·46 | 119 | *Suth.* | Loch More, Achfary... | 2·25 | 42 |
| ,, . | Pt. William, Monreith. | 2·28 | ... | *Caith* | Wick ............... | 1·28 | 49 |
| *Kirk.* | Carsphairn, Shiel. .... | 6·27 | ... | *Ork* . | Pomona, Deerness .... | 1·72 | 67 |
| ,, . | Dumfries, Cargen..... | 6·28 | 194 | *Shet* . | Lerwick ........... | 1·96 | 86 |
| *Roxb* | Branxholme ......... | 2·60 | 86 | *Cork.* | Caheragh Rectory .... | 4·17 | ... |
| *Selk* . | Ettrick Manse........ | 4·52 | ... | ,, .. | Dunmanway Rectory. | 4·84 | 123 |
| *Berk.* | Marchmont House .... | 3·40 | 112 | ,, .. | Ballinacurra ......... | 4·00 | 143 |
| *Hadd* | North Berwick Res.... | 2·34 | 91 | ,, .. | Glanmire, Lota Lo. ... | 4·73 | 163 |
| *Midl* | Edinburgh, Roy. Obs.. | 2·22 | 84 | *Kerry* | Valentia Obsy. ....... | 3·95 | 104 |
| *Lan* . | Biggar ............. | ... | ... | ,, . | Gearahameen ........ | 9·50 | ... |
| ,, . | Leadhills............ | 3·85 | ... | ,, . | Killarney Asylum..... | ... | ... |
| *Ayr* . | Kilmarnock, Agric. C.. | 4·51 | 145 | ,, . | Darrynane Abbey .... | 3·69 | 97 |
| ,, . | Girvan, Pinmore...... | 3·69 | 101 | *Wat* . | Waterford, Brook Lo.. | 4·99 | 154 |
| *Renf.* | Glasgow, Queen's Pk.. | 3·83 | 131 | *Tip* . | Nenagh, Cas. Lough... | 2·81 | 90 |
| ,, . | Greenock, Prospect H.. | 4·75 | 96 | ,, . | Roscrea, Timoney Park | 3·96 | ... |
| *Bute.* | Rothesay, Ardencraig. | 4·43 | 112 | ,, . | Cashel, Ballinamona .. | 4·87 | 168 |
| ,, . | Dougarie Lodge ...... | 3·92 | ... | *Lim* . | Foynes, Coolnanes .... | 2·13 | 69 |
| *Arg* . | Ardgour House ...... | 4·04 | ... | ,, . | Castleconnell Rec. .... | 3·03 | ... |
| ,, . | Manse of Glenorchy.. | 4·61 | ... | *Clare* | Inagh, Mount Callan .. | 3·53 | ... |
| ,, . | Oban .............. | 3·83 | ... | ,, . | Broadford, Hurdlest'n. | 2·70 | ... |
| ,, . | Poltalloch .......... | 3·19 | 77 | *Wexf* | Newtownbarry ...... | 4·61 | ... |
| ,, . | Inveraray Castle...... | 4·46 | 90 | ,, . | Gorey, Courtown Ho... | 2·68 | 91 |
| ,, . | Islay, Eallabus....... | 4·35 | 128 | *Kilk.* | Kilkenny Castle ...... | 4·28 | 152 |
| ,, . | Mull, Benmore ....... | 8·80 | ... | *Wic* . | Rathnew, Clonmannon | 2·81 | ... |
| *Kinr.* | Loch Leven Sluice .... | 3·42 | 119 | *Carl.* | Hacketstown Rectory. | 5·18 | 150 |
| *Perth* | Loch Dhu .......... | 6·00 | 124 | *QCo..* | Blandsfort House..... | 4·50 | 144 |
| ,, .. | Balquhidder, Stronvar. | 5·50 | ... | ,, | Mountmellick ........ | 3·35 | ... |
| ,, .. | Crieff, Strathearn Hyd. | 4·65 | 157 | *KCo.* | Birr Castle........... | 2·96 | 100 |
| ,, .. | Blair Castle Gardens .. | 5·77 | 225 | *Dubl.* | Dublin, FitzWm. Sq... | 2·83 | 111 |
| *Forf.* | Kettins School....... | 2·76 | 117 | ,, . | Balbriggan, Ardgillan. | 3·48 | 128 |
| ,, . | Dundee, E. Necropolis. | 2·17 | 79 | *Me'th* | Beauparc, St. Cloud .. | 4·17 | ... |
| ,, . | Pearsie House........ | 2·40 | ... | ,, . | Kells, Headfort...... | 3·44 | 108 |
| ,, . | Montrose, Sunnyside.. | 1·75 | 67 | *W.M* | Moate, Coolatore..... | 3·08 | ... |
| *Aber.* | Braemar, Bank ...... | 2·66 | 114 | ,, . | Mullingar, Belvedere. | 3·34 | 105 |
| ,, . | Logie Coldstone Sch. .. | 2·62 | 89 | *Long* | Castle Forbes Gdns.... | 2·42 | 78 |
| ,, . | Aberdeen, King's Coll.. | 1·88 | 67 | *Gal* . | Ballynahinch Castle .. | 3·89 | 94 |
| ,, . | Fyvie Castle ......... | 1·43 | ... | ,, . | Galway, Grammar Sch. | 2·54 | ... |
| *Mor* . | Gordon Castle........ | 1·16 | 36 | *Mayo* | Mallaranny.......... | 5·07 | ... |
| ,, | Grantown-on-Spey.... | 3·17 | 103 | ,, . | Westport House...... | 3·86 | 124 |
| *Na* . | Nairn, Delnies........ | 1·76 | 66 | ,, . | Delphi Lodge ....... | 6·76 | ... |
| *Inv..* | Ben Alder Lodge ..... | 4·33 | ... | *Sligo* | Markree Obsy. ....... | 3·16 | 91 |
| ,, . | Kingussie, The Birches | 2·23 | ... | *Cav'n* | Belturbet, Cloverhill.. | 2·59 | 83 |
| ,, . | Loch Quoich, Loan.... | 5·00 | ... | *Ferm* | Enniskillen, Portora .. | ... | ... |
| ,, . | Glenquoich .......... | 3·53 | 55 | *Arm.* | Armagh Obsy. ....... | 2·57 | 89 |
| ,, . | Inverness, Culduthel R. | 2·91 | ... | *Down* | Fofanny Reservoir ... | 7·57 | ... |
| ,, . | Arisaig, Faire-na-Squir | 2·95 | ... | ,, . | Seaforde ........... | 3·33 | 104 |
| ,, . | Fort William......... | 4·07 | 84 | ,, . | Donaghadee, C. Stn... | 3·74 | 134 |
| ,, . | Skye, Dunvegan...... | 4·77 | ... | ,, . | Banbridge, Milltown. | 4·14 | 127 |
| ,, . | Barra, Castlebay ..... | ... | ... | *Antr.* | Belfast, Cavehill Rd.. | 3·07 | ... |
| *R&C* | Alness, Ardross Cas. .. | 3·56 | 117 | ,, . | Glenarm Castle....... | 3·22 | ... |
| ,, . | Ullapool............ | 2·82 | ... | ,, . | Ballymena, Harryville | 3·55 | 104 |
| ,, . | Torridon, Bendamph.. | 4·23 | 78 | *Lon* . | Londonderry, Creggan | 2·77 | 76 |
| ,, . | Achnashellach ....... | 4·77 | ... | *Tyr* . | Donaghmore ........ | 3·11 | ... |
| ,, . | Stornoway .......... | 3·92 | 129 | ,, . | Omagh, Edenfel ...... | 3·13 | 92 |
| *Suth.* | Lairg ............... | 3·42 | ... | *Don* . | Malin Head ......... | 3·89 | 137 |
| ,, . | Tongue Manse........ | 1·77 | 58 | ,, . | Dunfanaghy ........ | 3·53 | 102 |
| ,, . | Melvich School....... | 1·70 | 61 | ,, . | Killybegs, Rockmount. | 4·38 | 100 |

# Climatological Table for the British Empire, February, 1927

| STATIONS | PRESSURE Mean of Day M.S.L. | PRESSURE Diff. from Normal | TEMPERATURE Absolute Max. | TEMPERATURE Absolute Min. | Mean Values Max. | Mean Values Min. | Mean Values ½ max. and min. | Mean Values Diff. from Normal | 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. | 1018·3 | + 2·3 | 54 | 25 | 45·0 | 35·1 | 40·1 | 0·0 | 37·0 | 91 | 8·1 | 3·40 | + 1·86 | 14 | 1·2 | 12 |
| Gibraltar | 1021·0 | + 1·0 | 70 | 45 | 60·7 | 48·2 | 54·5 | − 1·4 | 49·3 | 85 | 5·7 | 5·84 | + 1·62 | 18 | ... | ... |
| Malta | 1019·6 | + 2·9 | 68 | 45 | 58·3 | 49·4 | 53·9 | − 1·4 | 49·7 | 82 | 5·6 | 1·74 | − 0·46 | 9 | 7·1 | 65 |
| St. Helena | 1011·6 | + 2·0 | 73 | 58 | 68·1 | 60·3 | 64·2 | + 2·2 | 61·8 | 93 | 3·0 | 1·57 | − 2·23 | ... | ... | ... |
| Sierra Leone | 1011·3 | + 0·5 | 95 | 71 | 89·3 | 74·4 | 81·9 | − 0·4 | 74·9 | 74 | 2·9 | 0·00 | − 0·30 | 0 | ... | ... |
| Lagos, Nigeria | 1007·9 | − 2·2 | 93 | 71 | 88·1 | 74·8 | 81·5 | − 0·7 | 77·5 | 85 | 8·2 | 2·35 | + 0·28 | 3 | ... | ... |
| Kaduna, Nigeria | 1015·3 | + 3·3 | 97 | 57 | 91·5 | 62·3 | 76·9 | 0·0 | 63·2 | 47 | ... | 0·00 | − 0·04 | 0 | ... | ... |
| Zomba, Nyasaland | 1008·0 | + 0·1 | 88 | ... | 80·7 | ... | ... | ... | ... | 82 | 8·5 | 10·83 | + 0·22 | 20 | ... | ... |
| Salisbury, Rhodesia | 1008·1 | − 0·8 | 84 | 53 | 78·5 | 59·1 | 68·8 | 0·0 | 62·8 | 74 | 6·7 | 5·29 | − 2·11 | 10 | 7·2 | 57 |
| Cape Town | 1013·2 | − 0·2 | 101 | 55 | 80·8 | 63·0 | 71·9 | + 1·6 | 63·2 | 73 | 2·6 | 1·30 | + 0·72 | 6 | ... | ... |
| Johannesburg | 1011·4 | − 0·1 | 87 | 51 | 77·4 | 54·9 | 66·1 | + 0·7 | 58·5 | 74 | 3·5 | 1·39 | − 3·83 | 12 | 7·8 | 60 |
| Mauritius | ... | ... | ... | ... | ... | ... | ... | ... | ... | ... | ... | ... | ... | ... | ... | ... |
| Bloemfontein | ... | ... | 96 | 49 | 84·4 | 59·4 | 71·9 | 0·0 | 59·9 | 60 | 3·5 | 0·70 | − 2·75 | 8 | ... | ... |
| Calcutta, Alipore Obsy. | 1013·0 | − 0·3 | 88 | 54 | 82·4 | 61·6 | 72·0 | + 1·0 | 61·3 | 79 | 2·6 | 1·19 | + 0·09 | 2* | ... | ... |
| Bombay | 1012·3 | − 0·4 | 85 | 63 | 82·8 | 68·4 | 75·6 | 0·0 | 64·7 | 70 | 1·4 | 0·04 | + 0·01 | 0* | ... | ... |
| Madras | 1012·7 | − 0·2 | 98 | 65 | 88·5 | 69·7 | 79·1 | + 1·4 | 73·2 | 83 | 4·0 | 0·00 | − 0·32 | 0* | ... | ... |
| Colombo, Ceylon | 1011·0 | − 0·1 | 90 | 70 | 87·6 | 72·9 | 80·3 | + 0·6 | 76·2 | 74 | 6·0 | 3·67 | + 1·60 | 11 | 7·9 | 66 |
| Hongkong | 1017·8 | − 0·9 | 74 | 46 | 62·2 | 55·2 | 58·7 | − 0·4 | 55·0 | 80 | 9·0 | 4·35 | + 2·75 | 11 | 1·5 | 14 |
| Sandakan | ... | ... | 89 | 74 | 87·4 | 75·7 | 81·5 | + 1·4 | 76·9 | 82 | — | 8·80 | − 0·82 | 11 | ... | ... |
| Sydney | 1013·4 | − 0·7 | 98 | 56 | 77·5 | 63·6 | 70·5 | − 0·8 | 64·4 | 64 | 6·1 | 0·82 | − 3·42 | 9 | 6·9 | 51 |
| Melbourne | 1012·2 | − 2·3 | 101 | 49 | 78·6 | 57·1 | 67·9 | + 0·5 | 57·9 | 52 | 4·8 | 0·75 | − 0·97 | 5 | 8·2 | 60 |
| Adelaide | 1014·2 | − 0·1 | 107 | 51 | 81·5 | 58·8 | 70·1 | − 4·0 | 58·0 | 41 | 5·5 | 0·91 | + 0·25 | 3 | 8·8 | 66 |
| Perth, W. Australia | 1014·0 | + 1·0 | 100 | 49 | 83·0 | 61·1 | 72·1 | − 2·0 | 61·5 | 51 | 3·9 | 0·15 | − 0·30 | 2 | 9·8 | 74 |
| Coolgardie | ... | ... | ... | ... | ... | ... | ... | ... | ... | ... | ... | ... | ... | ... | ... | ... |
| Brisbane | 1012·7 | + 0·2 | 93 | 64 | 83·8 | 68·5 | 76·1 | − 0·4 | 70·7 | 71 | 5·4 | 5·37 | − 0·82 | 11 | 7·7 | 59 |
| Hobart, Tasmania | ... | ... | ... | ... | ... | ... | ... | ... | ... | ... | ... | ... | ... | ... | ... | ... |
| Wellington, N.Z. | 1012·3 | − 3·5 | 84 | 47 | 73·4 | 57·3 | 65·3 | + 2·8 | ... | 68 | 5·2 | 1·82 | − 1·32 | 7 | 8·2 | 60 |
| Suva, Fiji | 1006·7 | − 1·0 | 91 | 71 | 87·1 | 74·6 | 80·9 | + 0·4 | 76·6 | 81 | 6·8 | 14·10 | + 3·97 | 24 | 5·7 | 45 |
| Apia, Samoa | 1010·0 | + 1·6 | 88 | 72 | 82·9 | 74·8 | 78·9 | − 0·1 | 77·1 | 81 | 7·8 | 17·95 | + 2·24 | 25 | 4·3 | 35 |
| Kingston, Jamaica | 1016·5 | + 1·2 | 88 | 63 | 84·6 | 66·9 | 75·7 | − 0·8 | 65·0 | 86 | 2·6 | 1·02 | + 0·42 | 5 | 9·4 | 82 |
| Grenada, W.I. | 1011·5 | − 1·8 | 87 | 70 | 83·3 | 72·0 | 77·7 | + 0·6 | 72·3 | 75 | 3·9 | 5·07 | + 2·29 | 21 | ... | ... |
| Toronto | 1016·2 | − 1·8 | 47 | 8 | 32·9 | 21·1 | 27·0 | + 5·3 | 22·9 | 77 | 6·8 | 2·04 | − 0·54 | 13 | 2·6 | 25 |
| Winnipeg | 1019·3 | − 2·5 | 41 | −24 | 14·6 | − 1·5 | 6·5 | + 7·1 | ... | ... | 5·8 | 0·39 | − 0·45 | 10 | 3·6 | 36 |
| St. John, N.B. | 1015·9 | + 1·8 | 38 | − 3 | 24·9 | 11·0 | 17·9 | − 2·0 | 13·9 | 74 | 6·8 | 2·98 | − 0·92 | 14 | 3·2 | 31 |
| Victoria, B.C. | 1011·7 | − 4·2 | 52 | 31 | 47·8 | 38·0 | 42·9 | + 2·6 | 39·5 | 85 | 6·8 | 2·51 | − 1·02 | 12 | 4·5 | 45 |

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