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The Storm of November 11th—12th, 1929

By H. W. L. ABSALOM, B.Sc., D.I.C.

Over the British Isles generally the weather of Armistice Day, 1929, was the wildest experienced on that anniversary since its inception. Strong winds and gales accompanied by considerable falls of rain occurred in most districts. The very special associations of the day itself and the loss of life, loss of and damage to property on both land and sea resulting from the storm ensure the occasion a place in public memory. Meditations on "A Night of Storm" form the subject of a characteristically elegant and erudite leading article in *The Times* of November 13th.

During Sunday, November 10th, relatively cold air spread eastwards over the country, and at 6 p.m. G.M.T. barometric pressure had still an upward tendency even in extreme western districts. Although the rather scanty weather information received from the Atlantic at 1 p.m. and 6 p.m. indicated that a fresh depression would affect us before long, there was no very definite evidence of the great activity which was revealed subsequently. At 1 a.m. on November 11th a strong southwesterly wind and a brisk fall in pressure were reported from the southwest of Ireland, and the synoptic chart suggested that a depression was centred probably not less than 400 miles southwest of the Hebrides. The main centre, travelling at 50 or 60 miles per hour on a northeasterly course reached the Hebrides at

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about 1 p.m. and the Shetlands by 6 p.m., while between 7 a.m. and 6 p.m. the barometric pressure at the centre decreased by probably more than 15 millibars. During the forenoon pressure fell at the rate of from 10 to 15 millibars in three hours in northern England and in Scotland. In the course of the day a secondary depression arrived from the west giving rise to a considerable trough-like extension of the main depression. The passage of this trough across the country during the night hours was associated with a noteworthy example of a line squall.

Strong winds or gales from a southwesterly direction occurred in most districts, except perhaps in the northern half of Scotland. The gale was of relatively short duration in the southwest of Ireland and ceased before 10 a.m. With the advance of the depression the wind increased generally and had reached gale force at places on the east coast of England by the early afternoon. The gale lasted for 13, 14 and 16 hours respectively at Lympne, Falmouth and Scilly. Gusts well above 50 miles per hour were registered at several places. The highest gusts which have come to notice are those of 82 and 83 m.p.h. at Scilly and Cardington (see Fig. 1), respectively. Other stations at which a momentary speed of 70 m.p.h. or more occurred are Falmouth and Holyhead. At Falmouth the average speed was between 50 and 60 m.p.h. from 10 a.m. to 1 p.m.

The day was sunless apart from small amounts of sunshine in the morning in the southeastern districts of England. Rain commenced late on the 10th in the southwest of Ireland, extending to Wales and the western parts of England and Scotland, reached London by 11 a.m. and continued to spread eastwards. During the storm rain fell in all parts of the country, though locally in eastern districts of Scotland and in northeastern England the amounts were comparatively small. In southern and western districts falls of between one and two inches were of fairly general occurrence. Heavier falls occurred locally, *e.g.*, in south Wales, resulting in disastrous floods. An outstanding fall of 8·3 inches in twenty-four hours is reported from Mardy Reservoir, Glamorgan. Mr. R. G. C. Sandeman, Dan-y-Park, Crickhowell, south Wales, writes that between 9 a.m. and 10 p.m. the reading of the barometer decreased from 29·8 to 28·975 inches. He says: " It rained in torrents at that time (10 p.m.); I have only once seen such a downpour. The River Usk rose during the night to a height which I think is a record for about 30 years. The valley was like a sea, the peak of the flood being reached about 7 a.m. on the 12th. The raingauge showed 2·02 inches."

The depression had a considerable warm sector, the warm air at ground level reaching western Ireland an hour or two after 7 a.m. and the western districts of England, Wales and Scotland early in the afternoon, by which time somewhat cooler air had spread over northern and western parts of Ireland.

The approximate positions of the boundaries, at ground level, between the chief air masses at 6 p.m. are shown by broken lines in Fig. 2, A denoting the warm and B the cold front. As a result of the sweep of the warm air across the country temperature reached a high level for the season, maximum readings between 55° and 60°F. being numerous, while 60°F. was exceeded locally in north Wales and northwest England. In most parts of England and Wales the highest temperature was registered during the night hours of the 11th-12th shortly or immediately before the arrival of the cold air in the rear of the trough line.

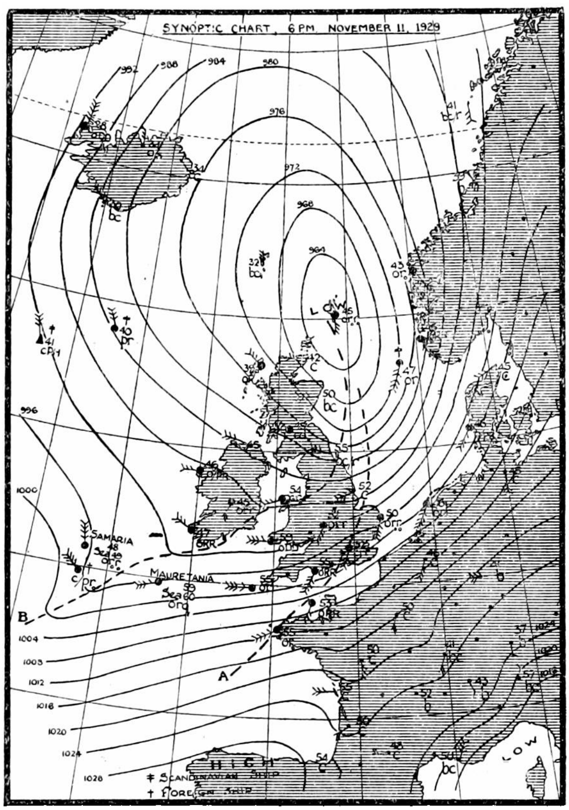


FIG. 2.

During the night hours the trough of low pressure became sharper than is indicated in Fig. 2 and at places in the Midlands and in the southern districts of England the transition from the warm to the invading cold air was marked by a sudden and considerable veer in wind direction, a rapid fall in temperature and an abrupt rise in barometric pressure. The times of passing of the cold front as shown by those autographic records which have been examined were : Cranwell, 10.30 p.m. ; Scilly, 10.50 p.m. ; Falmouth, 11.27 p.m. ; Cardington, 1.10 a.m. ; Calshot, 1.47 a.m. ; Croydon, 2.25 a.m. ; Felixstowe, 2.57 a.m. ; Lympne, 3.40 a.m. The front thus passed in a general southeasterly direction across the country, the rate of travel being greater in southwestern than in eastern districts. By 7 a.m. on the 12th this front extended from west of Denmark through northern Holland to Belgium and northwestern France.

The autographic records obtained at Cardington, where the sequence of changes during the storm were typical in main features of those at many places in England, are reproduced in Fig. 1, the wind record being that of the anemometer at 150 feet above the ground. As the cold front passed this station the wind veered from southwest to northnorthwest in the course of a very few minutes and the average speed decreased from about 45 to about 25 m.p.h; temperature fell 11°F. in about fifteen minutes and a further 6°F. by 3 a.m.; pressure rose 1·8 millibars in about two minutes and an additional millibar in the ensuing eight minutes; the rate of precipitation, part of which was in the form of hail, was accelerated. Reference has been made in the daily press to the effects of this line squall on the airship R.101, which was riding at the mooring tower at Cardington.

Serious loss was sustained during the gale by the Scottish fishing fleet whilst off East Anglia. Lives and drifters were lost after the onset of the southsouthwesterly gale on the afternoon of the 11th, and events consequent upon the sudden veer of wind during the night hours resulted in the loss of nets valued at tens of thousands of pounds sterling.

It was stated in an evening journal that the Thames tide was unusually low during the latter part of November 11th. Similar occurrences in association with strong southwesterly winds over the North Sea are noted in a recent memoir by Dr. Doodson and Mr. J. S. Dines on floods and high tides in the Thames.* From information kindly supplied by the Port of London Authority it seems that at Tower Pier low water on the afternoon of the 11th was one foot below the predicted value and of much longer duration than usual, and that at the succeeding high water in the evening the level was as much as 6 feet 4 inches lower than that predicted.

Raingauges in Winter

By E. G. Bilham, B.Sc., D.I.C.

With the onset of winter every rainfall observer is liable to be confronted with difficulties which do not arise at other seasons. Snow and frost each bring their own problems, but it is with the latter that it is desired to deal more particularly in the present note. Methods of dealing with the occasions when the observer finds his gauge full of snow are described in official publications such as the *Observer's Handbook* and *Rules for Rainfall Observers*, and no doubt every experienced observer has adopted his own special methods of meeting such a contingency. It is hardly possible to say anything new on this aspect of the subject. There are, however, other winter problms on which some remarks may be profitable.

We may consider, first, the problem of combating the effects of frost on mountain raingauges, visited only once a month. Here we are not concerned with the problem of measuring a

* *Geophysical Memoirs*, No. 47.

month's precipitation, some or all of which may be in the form of snow, but of protecting the gauge itself from damage. The worst case will be that in which heavy rain during the early part of the month is followed by intense frost. The normal result in these circumstances is that the expansion of the water in freezing bursts the seams of the can. In March, 1928, Mr. F. Hudleston, of Hutton John, Penrith, suggested that this type of accident might be prevented by corrugating the sides of the can, with a view to giving it a certain amount of freedom to expand under the pressure. A can with corrugated sides was constructed and tested by filling it with water and subjecting it to freezing temperatures down to 18° F. The can survived five tests of this kind, but failed at the sixth attempt, when the sides bulged and the joints started. It occurred to the present writer that a can built on the lines of an elongated domestic bucket might prove better. One was made of heavy galvanised iron with riveted joints. It was 18 inches high and tapered from a diameter of 7·5 inches at the top to 5 inches at the bottom. The tests were applied as before and the results were similar; the seams burst and the rivets were forced apart. The can was repaired and strengthened by strapping a steel band round it half way up, but it again failed to survive the tests.

At this stage information was received with regard to a successful device used by Dr. F. J. W. Whipple, at Kew Observatory to protect glass water containers in Stevenson screens from fracture by frost. The device consists simply of a length of rubber tubing inserted in the container, in the water, the ends of the tubing being above the water level and open to the air. When the water freezes, the expansion simply causes the rubber tube to be pressed flat and the pressure on the container is thus relieved. It was decided to try this device in a raingauge can. A sufficient length of ½-inch rubber tubing to give an air space equal to ten per cent. of the capacity was inserted in the can of an ordinary 5-inch copper gauge with the two open ends projecting from the top. Freezing tests down to zero Fahrenheit were then applied. The result was completely successful, neither the can nor the rubber tubing showing any signs of injury.

We seem, therefore, to have arrived at a method by means of which damage to mountain or other gauges by frost can be completely prevented. When we seek to apply the method in practice, however, certain difficulties appear. In the Bradford gauge, the can has a closed top with small apertures for the admission of the funnel tube and dip rod, and for pouring out the water. The introduction of a considerable length of rubber tubing, free from kinks, is almost impracticable unless a considerable portion of the top is cut away. Again, the adherence of water to the tubing is likely to introduce appreciable errors of measurement and the dip rod cannot be used unless the tubing is taken out before measurement. The Seathwaite gauge, in which the can is open at the top, is easier to deal with, and it would be a simple matter to design a frame on which the tubing would be permanently wound, but there still would be the undesirable feature of the large mass of metal and rubber to which water drops would adhere.

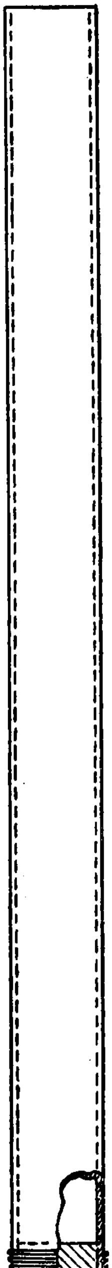


FIG. 1.

On consideration, it seems probable that the least objectionable form of "frost protector" would be that sketched in Fig. 1. It consists simply of a length of stout rubber hosing secured at the bottom to a lead plug heavy enough to keep it under water. The internal cross sectional area of the tube must be one-tenth the cross sectional area of the can. For a Bradford gauge the internal diameter works out at 1·4 inches, and the lead plug should weigh about $1\frac{1}{4}$ lbs. The joint between the plug and the tube must be absolutely watertight, and the tube itself must be stout enough not to collapse under the pressure of the water. The length should be about one inch more than the height of the can. The plate at the top of the can must be cut away to admit the tube, and as the tube will project through the hole so formed, no other support should be necessary. A device of this kind can readily be made locally and it would be interesting to learn the results obtained by observers who decide to try it.

The next problem for consideration is that of running a self-recording raingauge (or "rain recorder" as we now prefer to call it) in wintry weather. Here we are faced with two quite distinct questions: (*a*) the protection of the recorder from damage; (*b*) the conversion of solid precipitation into water in order that its rate of fall and duration may be recorded just as if it were rain. The latter includes the former, because if we are able to heat the gauge so effectively that snow is converted into water as fast as it falls, the main source of damage (the freezing of the contents of the gauge) is eliminated. It is, however, of great importance that excessive heating be avoided otherwise evaporation will occur. There can be no doubt that electrical heating is the form to use wherever possible. By so doing numerous difficulties which arise in connexion with lamps and night-lights are avoided. These difficulties include smoking of the flame, over- or under-heating and extinction of the flame by wind or by the accumulation of products of combustion. Assuming that electric current is available, the best procedure is to mount the recorder in a wooden case to which access may be gained by means of a weather-proof lid or door. This case should be so designed that (*a*) the funnel projects above it about a foot to avoid errors due to insplashing of rain; and (*b*) the base of the recorder is elevated just sufficiently above the floor of the case to permit of the insertion of an electric lamp plugged into a "batten" holder mounted on a small wooden block. The electric line should be brought up to a wall socket and switch screwed to the inside of the case, and the lamp mount should have a short length of waterproof twin cable terminating in a plug. An ordinary 40-watt or 60-watt lamp will be found capable of giving sufficient heat to keep the inside of the gauge well above freezing point. In severe weather snow may remain unmelted round the rim of the gauge. This cannot be cured without heating up the whole recorder to an undesirable extent, and must, therefore, be endured. The simple arrangement described above will prove effective provided the observer is able to attend and switch on the lamp when circumstances justify it. It would be possible, and not very difficult, to arrange for the lamp to be switched on automatically when the temperature fell to freezing point. To obtain the necessary "quick break" it would be necessary to employ a relay which might be operated by a bimetallic spiral.

If electric current is not available, the whole problem becomes vastly more difficult. Trials of various lamps have been made, but the results have not justified an official recommendation in favour of any particular type or make. It is felt that individual observers must have accumulated much useful data on this point, and it would be of great value to have particulars of any lamp which has been found really effective. Unfortunately, certain lamps which have been designed for the protection of motor-car radiators are too large for the present purpose, though otherwise suitable. In the meanwhile, commercial night-lights burning for 14 hours seem to be the least objectionable form of heater.

In the absence of some heating arrangement, it is very desirable that water should not be left in the float chamber of a rain recorder during frosty weather. Observers having such instruments are advised, therefore, to make a practice of starting each morning with the gauge empty and the recording pen at zero. With natural syphon recorders this can be done by pouring in just sufficient water to make the syphon operate before putting on the new chart.

The Relations between Annual Rainfall and the Average Amount of Cloud

Rainfall is associated with cloud, and without fear of contradiction one can make the general statement that the greater the cloudiness the heavier is likely to be the annual rainfall. Beyond that the relation between the average cloudiness of any particular locality and its average rainfall does not seem ever to have been investigated. Dr. G. C. Simpson accordingly suggested that a brief examination of the question on broad lines would serve a useful purpose.

The investigation must obviously be limited to land areas, and in order to ensure that the data selected as a basis should have a fairly uniform distribution, one station was selected for each ten-degree square from the network employed in the Réseau Mondial, the average cloudiness in tenths and hundredths being written down against the average rainfall in units of 50 millimetres. In addition, a few blank squares were filled by including stations not in the Réseau Mondial. For each ten-degree zone in which at least 15 stations were available the best-fitting equation was then calculated in the form

$$R = a + bC + cC^2$$

where R is the annual rainfall in millimetres and C the cloudiness in tenths of the sky. The values of c proved however to be small and very irregular—5 were positive, 1 zero and 4 negative—and the equations were re-calculated omitting the third term. The constants a, b, and the number of stations employed in each zone are shown in table 1.

TABLE 1.—VALUES OF THE CONSTANTS a AND b IN THE EQUATION $R = a + bC$.

Zone of Latitude. N.	No. of Stations.	a	b	Zone of Latitude. S.	No. of Stations	a	b
70-60	22	+ 37	70	70-60	—	—	—
60-50	25	—381	173	60-50	—	—	—
50-40	21	—609	240	50-40	—	—	—
40-30	22	—416	265	40-30	—	—	—
30-20	18	—400	290	30-20	17	—289	267
20-10	18	—595	370	20-10	20	+353	205
10- 0	19	+617	257	10- 0	17	+557	175

The values of a are rather irregular; positive values occur between 10° N. and 20° S. latitude, and again from 60 to 70° N., while in the intermediate zones the values are negative. Over the whole area from 70° N. to 30° S. the average value is -113. A positive value of a implies that a fairly heavy rainfall occurs even when the average cloudiness is small, while a negative value implies that the cloudiness may be considerable without giving any appreciable rainfall.

The constant b is on the whole more regular, and varies comparatively little with latitude; the values, as would be expected, are all positive, and an increase of one-tenth of the sky covered is roughly equivalent to an increase of about 240 millimetres of rainfall. The fact that the coefficients of C^2 in the full equations proved to be small shows that this increase is fairly constant whatever the cloudiness. It is, however, obvious that the equations cannot apply in extremely wet areas. The values of the constants a and b are plotted in Figs. 1 and 2. Finally, the

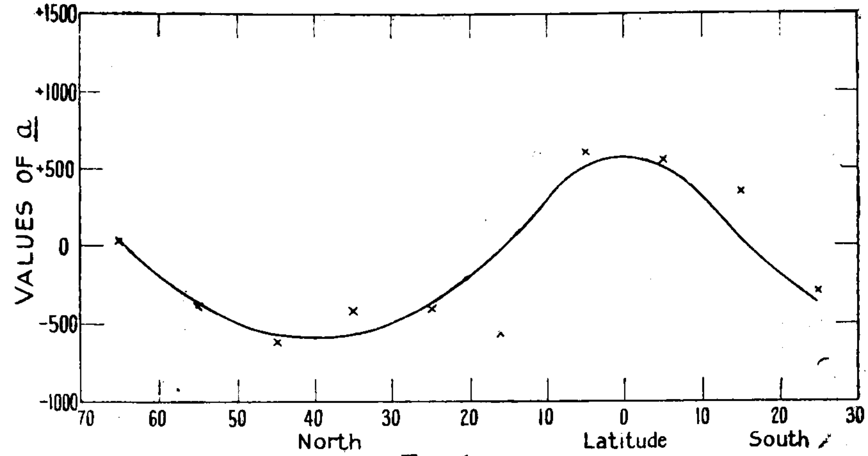


FIG. 1.

smooth curves represent an attempt to smooth the data by general equations connecting the constants with the latitude.

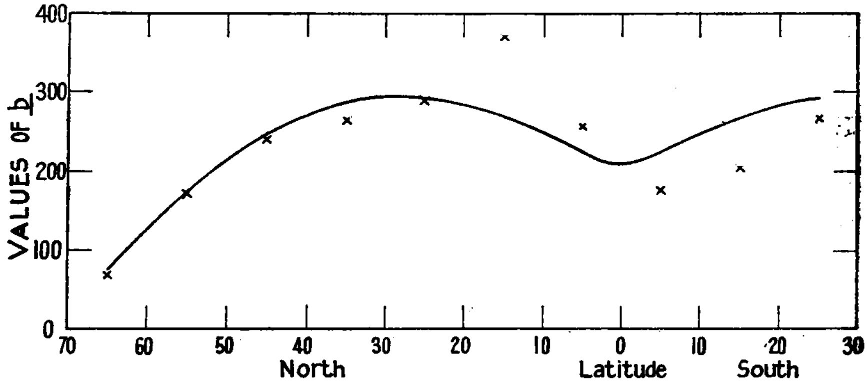


FIG. 2

Since the constant a obviously reaches a minimum about latitude 45°, these general equations must include a term 2ϕ, where ϕ is the latitude. The equations deduced were:—

$$a = 770 + 835 \sin \phi - 1930 \sin 2\phi$$
$$b = 203 - 445 \sin \phi + 360 \sin 2\phi$$

The following figures give the rainfall in each latitude, employing values of the constants a and b calculated from these equations, corresponding with a cloudiness of five tenths:—

Latitude	65	55	45	35	25	15	5
Rainfall ... ... (in millimetres)	420	520	670	870	1100	1360	1630

The values of the mean rainfall over the land, calculated from the mean cloudiness and the smoothed constants *a* and *b* are shown in table 2. For comparison is given the average rainfall

TABLE 2.—RAINFALL OVER THE LAND, CALCULATED FROM CLOUDINESS, AND ESTIMATED BY KERNER.

Zone of Latitude. N.	Rainfall. Calculated.	Rainfall. Estimated.	Zone of Latitude. S.	Rainfall. Calculated.	Rainfall. Estimated.
70-60	509	380	70-60	—	—
60-50	691	560	60-50	—	—
50-40	670	600	50-40	868	870
40-30	582	600	40-30	812	675
30-20	630	630	30-20	746	690
20-10	1092	1010	20-10	1253	1190
10- 0	1674	1680	10- 0	1808	1790

over the land, obtained from a paper by F. Kerner.* It will be noticed that the calculated rainfall is on the whole in excess of the estimated amounts, but the differences nowhere reach 150mm.

C. E. P. BROOKS.

OFFICIAL PUBLICATIONS

PROFESSIONAL NOTES—

No. 52. *Bumpiness on the Cairo-Basra Air Route.* By J. Durward, M.A. (M.O. 2731).

Everybody who has been on the sea is familiar with the sensation caused by the motion of the boat as it rises and falls on the waves. Travellers by air become accustomed to a rather different sensation which, to the air pilot, is known as a " bump." This sensation is due to the involuntary rise or fall of the aeroplane as it flies through the air, caused by up and downward currents in the atmosphere. Unlike the motion of a boat, however, bumps are irregular, and for this reason many people, on whom sea travel has an adverse effect, find no discomfort in flying, even on a relative bumpy day.

Some interesting facts regarding bumpiness on the Cairo-Basra section of the England-India air route are brought out in this paper by J. Durward of the Meteorological Office, Heliopolis. The data are based on the reports of pilots of Imperial Airways Ltd., who fly regularly along this route. An analysis of these reports has enabled the author to compare the various subsections of the route between Cairo and Basra as regards bumpiness, and also to discuss the relation which bumpiness bears to the time of day at which flying takes place, and to special meteorological conditions. The route between Baghdad and Basra lies over the Mesopotamian desert and as this route is subject to dust and sand storms, one would expect flying to be

*Revision der zonaren Niederschlagsverteilung. *Wien, Mitt. K.K. Geogr. Ges.*, 1907, pp. 139-64.

very bumpy. The report, however, is reassuring from this point of view. In fact, the author finds that the worst part of the route from the point of view of bumpiness is the belt of country known as Trans-Jordan, where the surface is very irregular and, owing to its nature, readily becomes heated by the sun's rays during the day. Even along this portion of the route there may be complete absence of bumps in certain meteorological conditions. Speaking generally the air is more bumpy near the ground, and frequently the pilot is able to avoid the bumps altogether by climbing to a sufficient height. On occasions, however, the air is found to be bumpy, even at a height of 12,000ft. Interest is added to the paper by references to particular experiences of individual pilots.

Discussions at the Meteorological Office

The subjects for discussion for the next meeting will be:—

January 13th.—*The distribution of excessive precipitation in the United States.* By A. J. Henry (Washington, D.C., Monthly Weath. Rev., 56, 1928, pp. 355-363); and *The weather map story of the flooding rainstorm of New England and adjoining regions, November 3rd-4th,* 1927. By J. H. Weber and C. F. Brooks (New London, Conn., J. New England Water Works Ass., 42, 1928, pp. 91-103). *Opener*—Prof. Dinsmore Alter.

Royal Meteorological Society

The monthly meeting of this Society was held on Wednesday, November 20th, at 49, Cromwell Road, South Kensington, Sir Richard Gregory, D.Sc., President, in the Chair.

M. G. Bennett, M.Sc.—The physical conditions controlling visibility through the atmosphere.

In this paper, a theory is developed to show how the visibility of an object is affected by the optical properties of the matter suspended in the air between the observer and the object; and this theory received experimental verification from a series of special observations carried out at Leafield and Cranwell. The theory, briefly, may be described thus. The visibility of any (large) object is a function of its brightness, and its contrast with the background. When dispersed matter is introduced between the observer and object, the apparent values of these variables are modified, and thus the visibility is altered. The modification is the result of three different processes, the relative importance of which depends on the circumstances. These processes are: (1) Screening or absorption, (2) Glare or superposition of scattered light, (3) Diffusion or reduction of definition.

The experimental work was a matter of determining the data involved in this theory, so that certain conclusions could be drawn, which could be tested in practice. As an example of such conclusions, the following may be quoted. It was deduced that the obscuring power of a cloud of opaque (carbon) particles was mainly due to screening, whilst that due to water drops was due to diffusion. This should result in a certain difference between the falling off of visibility of an object as an observer recedes from it in a dry dusty atmosphere, as compared with a humid clean atmosphere. This difference was satisfactorily verified by the observations at Leafield.

L. F. Richardson, D.Sc., F.R.S.—The reflectivity of woodland, fields and suburbs between London and St. Albans.

The paper gives a record of measurements made from aeroplanes, using a white-wedge photometer, showing the reflectivity of different types of surface—woodland, bare earth, standing wheat and a water surface, for red, green and blue.

Thora C. Marwick.—The electric charge on rain.

The paper describes the method used to measure the electric charge on rain and gives the results obtained over a period of several months. These are briefly as follows:—Thunderstorm rain showed a high positive charge per cubic centimetre. Of the total quantity observed 94·6 per cent was positively charged. Non-thunderstorm rain showed a lower charge per cubic centimetre and a lower percentage of positively charged rain, 79·5 per cent. Hail and rain mixed showed a large excess of negatively charged drops, 39·4 per cent of the total quantity being positive. The charge per cubic centimetre was approximately the same as for non-thunderstorm rain.

Correspondence

To the Editor, *The Meteorological Magazine*

A Peculiarity in the Variation of Distribution of the Annual Rainfall

With reference to the letter on the above subject on p. 234 of the November magazine, Mr. Alter might with advantage give a short explanation to make it clear that the result is not merely another way of expressing that the spring months are usually dry and the autumn months wet. As it stands at present the article leaves that impression in the reader's mind.

E. GOLD.

It should be stated explicitly that the correlations were based on the variations of the means of twenty year stretches for each of the months, from the means of the same months for other twenty year stretches. The fact that March might have 8 per cent. of the annual rainfall and September 10 per cent. would have no bearing, but if when March decreased to 7 per cent., September increased its percentage during the same twenty years there would be established a negative correlation. If such a negative relationship held consistently, the one month increasing its percentage during any given twenty years and the other decreasing, the negative correlation coefficient would be high. This was found to be true in general.

DINSMORE ALTER.

Summer Thunderstorms

With reference to the correspondence under the above title in the October and November magazines, surely the question is sufficiently answered by the strong tendency there undoubtedly is for thunderstorms in hot weather to develop at night. It is in cool weather that thunderstorms only very rarely occur in the night; and it is the habit of mixing up all types of storm together that has caused so much stress to be laid upon the statistical afternoon maximum. Statistics are very necessary, but they undoubtedly cover a multitude of sins!

L. C. W. BONACINA.

27, Tanza Road, Hampstead. November 21st, 1929.

Smoking Sea

On November 1st, 2nd and 4th the sea on the south side of Mount Batten presented the appearance of smoking or steaming, and the steam produced accumulated to a mist or fog over the sea. The time of observation was 7h.

The formation of this mist or fog appears to bear a similarity to that off the Newfoundland Banks for the sea temperature was between 50°F. and 55°F. and the air temperature between 34°F. and 36°F. The wind was from a northerly point, was cold, blowing as it did from the cooled land, and was passing over a stretch of warm water; thus fulfilling all the conditions for Newfoundland fogs formation. The mist or fog did not persist however, and it cleared by 10h. or soon afterwards when the air temperature had increased considerably.

T. H. APPLEGATE.

R.A.F. Station, Mount Batten, Plymouth, Devon. November 9th, 1929.

Colouring of Evening Sky

To-day I observed a phenomenon which I have never before seen, viz., about 4 o'clock and just before the light faded the whole sky was suffused with a red colour, notwithstanding that it was quite heavily overclouded. No clear sky showing. The brickwork shone with an added glow of red as one sometimes sees in a brilliant sunset.

The most noticeable fact was that the sky showing this red light penetrating or suffusing the blue-grey expanse of cloud was not much, if any, more brilliant (or dull) in one direction than in another, whether east, west, north or south or on the horizon or overhead.

H. W. SOUTHCOMBE.

5, Crescent Road, Kingston-on-Thames. December 2nd, 1928.

The Atmosphere as a Colloid

In a review under this heading on the September number of the *Meteorological Magazine*, Dr. F. J. W. Whipple states that one of the outstanding puzzles is to discover how and why cloud particles combine to form raindrops, and among other things, if the age of the cloud is a factor.

I have long made a study of the rain-bearing clouds of cyclonic disturbances; some of my observations were published some years ago,* but since they bear directly on this subject, I may perhaps be permitted to recapitulate them briefly.

Rain appears to condense in the tenuous indefinite cloud which forms between the fracto-stratus and alto-stratus of cyclones. (By the word " cyclone " I mean to cover all varieties of cyclonic disturbance producing steady rain.) Difficult to detect, because if not masked by the former, it is seen against a featureless grey background of the latter, it may occasionally be observed when a break near the horizon allows it to be seen in elevation. It then appears as a vague indefinite mass, often merged into fracto-stratus at its base, while alto-stratus or alto-cumulus may lie clean edged and definite far above.

The rain of cyclones is undoubtedly caused by dynamical cooling *en masse*, and the indefiniteness of this cloud is readily attributable to a process which cannot bring about the sudden discontinuities of water content to which turbulence clouds owe their hard outlines. It has another feature however which is not so easily explained; that is extreme transparency.

The cyclonic clouds frequently break before the rain has finished entirely. When they do so, the upper clouds generally appear hazy, while the blue of the sky is grey and dirty looking instead of clean. This is a sure sign that more rain is to come, and many observations during the breaking up of rain clouds have shown that this grey appearance is due to the intervention of this transparent nimbus. Moreover, I have frequently known rain to fall when this grey appearance of the blue sky overhead has been the only sign of cloud, though other clouds may have formed soon after.

Curiously enough, the day after reading Dr. Whipple's notes I witnessed this phenomenon in a striking form. On September 21st at 8h. 30m. G.M.T. a rainbow appeared. It was broad and diffuse, and its colours were pale and watery. The sky at

London, Q.J.R. Meteor. Soc. XLVII., 1921, p. 271.

the time was 9/10 covered with thin indefinite cirro-cumulus, while a few wisps of fracto-stratus were beginning to form in the rising westerly breeze. Apart from these there was no sign of cloud lower than the cirro-cumulus, but the sky had the greyish appearance already referred to. A few drops of rain were reaching the earth at the time, and by 10h. drizzle was falling which increased to steady rain by 10h. 45m., the sky in the meantime becoming clouded over with fracto-stratus. The rainbow was formed against a background of cirrus and therefore was not due to rain falling from definite low clouds to the windward, and since light rain was falling at the time of observation the sun must have been shining through the layer in which the rain was formed.

The transparency of this rain-producing cloud is remarkable when compared with the opacity of the slightest turbulence cloud, whose heaviest masses can at the most precipitate fine drizzle. There can be but one explanation. The water particles in this nimbus must be very much larger and more widely separated than those in the turbulence cloud. That this should be so is only in part explained by the larger amount of water available. How is it that this can condense into rain without the prior formation of a dense cloud of small droplets? And how is it that the dense clouds formed by turbulence will remain for days on end without their droplets running together and falling?

It is here that the study of colloids may give a clue. Colloids are suspensions of finely divided particles in a fluid medium, the particles and the medium being mutually insoluble. Their stability (*i.e.*, the reluctance of the particles to coalesce and settle) is due to forces which are only effective on very finely divided matter. In smoke, a typical colloid, the smaller particles are kept in suspension and hindered from coagulating to a great extent by Brownian movement which keeps them in ceaseless agitation. Another potent factor is the electric charge they bear, whose neutralization will cause the smoke to flocculate and settle.

Water clouds are not colloids, but if their droplets are below a certain size, they may be susceptible to similar forces. Their particles may be as small as 0.4 microns, while Brownian movement becomes evident on particles from 3-5 microns in diameter. Also, in droplets of this size, the electric charge present on one ion might be effective in checking coalescence, while its repulsive force would be overcome by the inertia of heavier drops. It would be interesting to know if an appreciable number of the droplets in a turbulence cloud bear an electric charge, and if a fair proportion of them are less than 5 microns in diameter.

If there is anything in these speculations one would expect to find that below a certain size cloud particles would be very reluctant to coalesce, but when this was once passed, they might do so very readily. In turbulence clouds, the growth of the drops when once formed must be very slow. In rain clouds all evidence points to the fact that it can be very rapid. My own observations have shown that, although it varies in degree, the transparency is a most consistent property. The proportion of small drops present probably varies to some extent inversely with the rate of condensation.

R. F. T. GRANGER.

Attenborough, Notts. November 4th, 1929.

Weather Lore amongst the Italian Peasantry

From time to time attention has been called in the *Meteorological Magazine* to the strange beliefs about the weather held by various uncivilised peoples or by the inhabitants of Europe in the Middle Ages. A recent book, *Through the Apennines and the Lands of the Abruzzi*, by Estella Canziani (Heffer and Sons, 1928), reveals the fact that the twentieth-century Italian peasant can quite hold his own as regards fantastic ideas about the weather.

Take, for example, the ideas current about hail. According to the peasants, hail is formed by clouds joining, one the male, making the rain wind pass between them; the other, the female, freezing the rain into hail. "Once a priest who was passing the Palena mountain saw a male and female spirit making hail, and to stop them he put the largest hailstone he could find on the palm of a child under seven years old (the most innocent of the family) because he believed the tempest would last only the time the hailstone took to melt." In Lanciano, devils and bad spirits make the hail, and the more snow there is on the mountains the more hail there will be because the devils have more material to work on! Lightning is the work of lost souls.

Whirlwinds arise on the spot where anyone has been murdered. Or else they are the work of *La mazzamarelle*, which apparently correspond to the English elves. Innocent children can see them. Waterspouts are the work of mischievous spirits (*li scijjinne*). When sailors see one coming, the correct procedure is to turn towards it uttering certain words and to cut the air with a knife with a black handle, also to make the sign of the Cross. The story goes that one St. Peter's Day, a certain boat encountered a waterspout, one fisherman tried to cut it with his knife, but failed, and the boat capsized. When the man who had cut the air returned home, he found his wife with a cut finger. He was convinced that she was the waterspout and that now she was "*libera*," liberated from that form, he so ill-treated her that she died!

This information was collected by Signora Canziani in 1913.

CICELY M. BOTLEY.

Guildables, Holmesdale Gardens, Hastings, June 19th, 1929.

Ancient Hindu Meteorology

The *Vedas*—the most ancient work of recorded human experiences—are full of astronomical notes, *e.g.*, the comparison of the motion of the heavens to that of a wheel and the rotation of the celestial vault round an axis pointing to the pole overhead. The idea which is widespread in Indian literature is the six months' duration of the day and the night of the Gods and descriptions of long tantalizing dawns. These accounts suggest an arctic home of the ancient Aryans. The migrations to the south are illustrated by the gradual increase in the number of months during which the sun was visible. There were seven months in very ancient texts, but this number increased to ten and finally to twelve in later literature. Evidences of the glacial destruction of this polar home at the end of the last interglacial epoch are abundant in the oriental scriptures, and are recorded as deluge or continuous rain and snow which drove the primitive Aryans to more congenial homes southwards.

There are references in the Parsi Scriptures to the effect that after the destruction of the first paradise of the Arctic the second best habitation had to be established in the south. Fifteen such creations, each corresponding to the different countries of settlement are mentioned. From each of these the unfortunate people were eventually turned out by the pranks played by the Devil, until at last a safe haven in the sixteenth, *i.e.*, Persia, was found.

The arctic theory of the polar home of the ancient Aryans is of general interest because it implies that in the past an equable climate prevailed in that region salubrious enough to make it one of the centres of human evolution. The explanations of long-period climatic changes given by astronomers and by meteorologists like Humphreys, Brooks and Wegener may be supplemented by the researches of Mr. Tilak given in his book entitled " The Arctic Home in the *Vedas*," published by Messrs. Tilak Brothers, Gaikwar Wada, Poona City, India.

M. V. Unakar.

Meteorological Dept., Ganeshkhind Road, Poona, June 14*th*, 1929.

NOTES AND QUERIES

Sir John Moore

Sir John Moore, M.A., M.D., D.Sc., of Dublin, who recently attained his 84th year, may be regarded as one of the G.O.M. in both Medicine and Meteorology. To his many other distinctions he has just added that, a very rare one, of reaching his diamond jubilee as an observer for the Meteorological Office. For a period of 60 years Sir John has contributed, almost without a break, a complete second order return, and for well over

50 years has sent in a weekly return. His meteorological activities did not commence with his official connexion with the Office. The rainfall measured at Fitzwilliam Square in 1868 was published in *British Rainfall*, and for the three previous years, that measured at South Anne Street.

Although for some Irish stations, such as Phœnix Park and Markree Castle, observations extend over a longer period than those of Sir John Moore, Dublin has the distinction of being probably the only station which has been under the direct supervision of, and where most of the observations have been taken by one and the same person at the same place for so long a period.

Among Sir John's published works, mention may be made of *Meteorology, Practical and Applied*, which appeared in 1904, and of which a second and enlarged edition was published in 1910.

C. A. Bracey.

An Old Weather Diary and a Tornado in Dublin in 1850

Sir John Moore has recently brought to the Meteorological Office for inspection a manuscript book kept by his father, William D. Moore, A.B., M.B., at Dublin from October 2nd, 1848, to March 24th, 1851. The book is entitled *Chemical Analyses—Book No.* 2, and contains for the most part notes of chemical tests of a medical nature. From the beginning, however, readings of a thermometer and of a barometer are given at intervals, together with general remarks on the weather, whenever this was at all abnormal.

From October 2nd, 1849, the observations of temperature, barometer and weather are made regularly every day, usually early in the morning at from 6 a.m. to 8 a.m. The genesis of these notes is explained by one dated October 28th, 1849, which reads as follows:—

> "Last night at 10½ o'c, thermometer stood in this room, all doors and windows being open and no fire or gas alight, at 59°. The extreme cold at the commencement of the month induced me to mark the temperature daily, and the great warmth is now equally remarkable."

At the beginning of 1850, there is a remark "Thermometer placed outside"; and thereafter the daily observations consist of readings of a thermometer outside, a thermometer inside, a barometer and remarks on the weather. It is clear that the observations of temperature made in 1849 were readings of a thermometer placed indoors. In this connexion two remarks are of interest, viz., "Dec. 3rd, 1849. Fires begun," and "No fires since 25th March, 1850." From the week commencing January 6th, 1850, a printed meteorological journal for each week containing daily values of maximum and minimum temperature, barometer, rainfall and wind direction made by George Yeates, 2, Grafton Street, Dublin, and extracted from some newspaper are pasted in the volume.

The meteorological observations of Dr. William Moore can be regarded as the beginning of the series which has been continued ever since in Dublin, either by himself or his son, the present Sir John Moore.

One of the most interesting of the phenomena referred to in the volume is a remarkable tornado, full descriptions of which are contributed, one by Dr. William Moore in his own handwriting, the other (a newspaper cutting) by the Rev. Dr. Lloyd, D.D., President of the Royal Irish Academy.

The tornado occurred on April 18th, 1850, and passed over Dublin. The following is an extract from Dr. Moore's account. "At about 3.30 p.m. the sky got dark, distant peals of thunder were heard, shortly after flashes of lightning succeeded each other in extremely rapid succession, followed by heavy rain. Large hail stones began to fall, and a terrific hurricane, at one time apparently blowing from east to west, then from west to east, set in. This continued for about an hour when it completely subsided; the sun shone out, and the evening was very fine. The damage done was enormous—the glass in almost all windows looking towards the west was nearly all destroyed; slates, tiles, &c., were blown off the houses, many chimnies blown down, and the tents erected for the Cattle Show at the Royal Dublin Society were prostrated, killing one man and seriously injuring two others. The cattle broke loose and became furious, leading to fearful confusion. Many houses lost from 100 to 150 panes of glass. Several trees were blown down in the College Park, Leinster Lawn, &c., and the ground in Stephen's Green was covered with leaves and branches of trees. Several of the hail-stones were as large as pigeons' eggs. . . . . . This dwelling house D.G. escaped almost entirely—stable roof much injured, laboratory skylight blown in—study, 2 panes of glass (broken), little laboratory 5, house 1. Every house on east side of green lost probably every front pane. The appearance of the city is awful, as if it had been sacked. Several chimnies down and roofs carried off. The storm was very partial; nothing of it was known at Merrion—in Merrion Square, Lower and Upper Fitzwilliam Street, it committed great damage—from Lower Mount Street to about Mr. Nun's house every pane of glass was broken, from that up scarcely one was broken."

Dr. Lloyd, in his paper before the Royal Irish Academy, stated that the tornado arrived at 4 p.m., that the gale sprang up from the SE., and then suddenly and apparently in an instant, shifted to the point of the compass diametrically opposite and blew with increased violence from the NW. "In less than 10 minutes the storm had passed. The wind returned to a gentle breeze from the SW. and the weather became beautiful. All the phenomena—the direction of the gale perpendicular to that in which the storm cloud was advancing and the sudden reversal of that direction, seem to prove that it was a true tornado, whose centre passed directly over the place of observation. It is evident, on comparing the direction of the wind when the whirl first reached this part of the town with that of the progressive motion of the vortex itself, that its rotatory motion was retrograde, or in an opposite direction to that of the hands of a watch."

Dr. Lloyd goes on to state that in the College Park and adjoining garden 19 trees were rooted up and prostrated, of which ten fell from the southeast and nine from the northwest. The transition of wind direction from SE. to NW., it is concluded, must have been immediate. In one place two large trees were found lying side by side although they had fallen from opposite directions.

Eye observations of the barometer gave the following values :—

1 p.m.	29·964 inches.
4 p.m.	29·930 ,,
7 p.m.	29·944 ,,

but Dr. Lloyd adds that he has good authority for stating that a sudden and considerable fall of the barometer took place shortly before the storm. "The fall of rain and melted hail amounted only to 0·596 inch; but it is probable that the hail was driven out of the receiver of the gauge by the wind."

Tornadoes, though rare in these islands, are by no means unknown. A full description of one which occurred on October 27th, 1913 in south Wales and the west of England, was published by the Meteorological Office as *Geophysical Memoirs* No. 11. It is there stated that the *Meteorological Magazine* gives references to forty tornadoes, more or less violent, which occurred in the British Isles in the years 1866 to 1895.

R. CORLESS.

The Rainfall of November, 1929

While the rainfall of November, 1929, exceeded twice the usual amount over the greater part of southern and central England and Wales, there was less than the average over much of the northern half of Scotland and at Newcastle. The monthly percentage values showed a remarkable range, varying from 350 in parts of Devon, Dorset and Sussex to 75 in the neighbourhood of the Moray Firth. Practically the whole of the south-west of England and Wales, stretching as far inland as Birmingham and Wellingborough, recorded more than 250 per cent of the average.

Over England and Wales the total rainfall during November exceeded 4 inches everywhere, except in east Anglia and along the north-east coast from Hull to Berwick. More than 10 inches was recorded over practically the whole of the Devon-Cornwall peninsula, most of Wales and the English Lake District and, what is more remarkable, in view of their normally lighter rainfall, in parts of Dorset, Hampshire and Sussex. More than 30 inches was recorded locally in Snowdonia and the English Lake District.

November, 1929, was the wettest November during the last 60 years at practically every station to the south of a line drawn roughly from Crewe to Lincoln (but excluding both the east coast of England and the west coast of Wales), as well as in the English Lake District and the south-east corner of Ireland. At stations as far apart as Ashburton, St. Austell and Ross, November, 1929, was the wettest month of any name during the last 60 years. At Southampton, Cardiff and Church Stretton (in Shropshire) there was only one wetter month in a similar period.

Over the British Isles as a whole November, 1929, with 188 per cent of the average, was easily the wettest November in the last 60 years, the next wettest Novembers being those of 1926 and 1877 with 155 per cent. Over England and Wales, November, 1929, with 232 per cent was also the wettest November on record. Over Scotland with 130 per cent there were 8 wetter Novembers, while over Ireland, with 151 per cent, only those of 1900 and 1890 were wetter, with 154 and 169 per cent respectively.

It will be recalled that the total rainfall over the British Isles for the 9 months, January to September, 1929, was less than that of any similar period in the last 60 years (although there was very little more in 1870, 1887 and 1921). By the end of September the general rainfall over the British Isles was 20·4 inches, or 7·9 inches short of the average of that period. October was moderately wet and November very wet, so that by the end of November the general rainfall was 33·8 inches and only 2·9 inches short of the average of that period. In order to wipe out completely the deficiencies of the earlier months, December, 1929, will require therefore a general rainfall of about 8 inches or 170 per cent of the average of that month.

At Camden Square (London) the total for November, 1929, of 5·47 inches, was the largest recorded in any previous November, but there were 11 wetter months in the record back to 1858. The total rainfall, January to November, 1929, was 18·36 inches, or 3·72 inches short of the average for that period.

J. GLASSPOOLE.

The Formation of Surface Inversions of Temperature with Clear Skies in Egypt

The *Meteorological Magazine* for February, 1929 (Vol. 64, p. 8), contains an account of the discussion of a paper by R. Steiner

"On the formation of surface inversions of temperature with clear skies and land breezes." In this paper it was stated that isothermal conditions up to about 600 metres were found about sunset, and that inversions did not form even at the ground until after sunset, but some diagrams exhibited by Mr. Heywood from Leafield showed quite clearly that inversions may form at the ground a considerable time before sunset.

Mr. W. D. Flower now sends us an analysis of some results obtained with the Vertical Temperature Gradient Recorder at Ismailia, Egypt, between February 18th and March 31st, 1929. Only four suitable occasions were found during this period. Details of these are given in Table 1, which shows the numbers of minutes before or after sunset at which the vertical temperature gradient became zero during the process of formation of an inversion. A minus sign indicates that the inversion began to form before sunset, a plus sign that it began to form after sunset.

TABLE I.

Date. 1929.	*Time of zero gradient (minutes from sunset).* 50 *ft.*	150 *ft.*	200 *ft.*
February 18th ...	−18	− 3	+ 1
February 19th ...	−30	−15	−12
February 28th ...	−18	+ 7	+71
March 19th ...	−10	+26	+59

A typical example of the formation of an inversion occurred on February 19th, 1929, and is illustrated in Figure 1. Between 12h. and 15h., G.M.T., the dry adiabatic lapse rate was exceeded between 4 feet and 150 feet, but between 150 feet and 200 feet the lapse rate was about equal to the dry adiabatic. After 12h. the lapse rate decreased rapidly near the ground, but between 150 and 200 feet the decrease was very slow until just before sunset. The inversion set in about 15h. 10m. between 4 feet and 50 feet, just before 15h. 30m. between 50 and 150 feet and about 15h. 30m. between 150 and 200 feet. At sunset the inversion was continuous up to 200 feet, but was most marked between 4 feet and 50 feet and very slight above 150 feet.

It therefore appears that in Egypt on clear afternoons surface inversions can form before sunset.

Review

Climatology and Some of Its Applications. By Prof. Robert De C. Ward. Sci. Monthly, Feb., 1929, vol. 28, pp. 156-171.

The main part of this interesting paper, which was delivered as the introductory lecture in a course on "Man and his climate," given before the Lowell Institute at Boston in 1928, is concerned with the practical applications of climatology. Several striking instances are given, relating both to peace and war, and it is clearly shown that much loss and suffering might have been avoided had the available information about local climate been taken into consideration.

News in Brief

We regret to learn that the American non-magnetic yacht *Carnegie* was destroyed as a result of a petrol explosion on board on November 30th. According to *The Times*, Captain Ault, the commander, died of burns, the cabin boy is believed to be killed, and four members of the crew are in hospital suffering from burns.

The *Carnegie* was especially built for magnetic researches twenty years ago, and at the time of the accident was engaged on a three years' cruise.*

*See *Meteorological Magazine* 63, 1928, pp. 156-60.

We are informed that at the annual general meeting of the London Mathematical Society, held on November 14th, Prof. S. Chapman was elected President of this Society.

Mr. T. Davys Manning, of Newlands, Seaford, Sussex, writes to say that the rainfall at Seaford on November 15th and 16th " is a record reading for this station with the exception of July 9th, 1923." A total of 2·21in. fell in the 24 hours ending 15h. on the 16th. " During the forenoon of the 16th a heavy swell was observed though there was little wind and waves were not crested. At high water, the sea was washing over the sea front opposite the Esplanade Hotel, a very unusual occurrence. At 15h. . . . the wind was NW., force 7-8."

The Weather of November, 1929

The weather of November was unsettled and wet, the month in the southern half of the British Isles, being one of the wettest Novembers on record. At Ross-on-Wye 8·94in. constitutes the largest total fall for any month since rain records began there in 1818, and 9·80in. at Valentia is a November record since 1870. The average pressure for the month was markedly below normal. For the first 9 or 10 days appreciable rain was experienced in the west and north, but in the south and east the falls were usually small and the sunshine records good. The 3rd was a sunny day over the kingdom generally, over 8hrs. bright sunshine being recorded in most parts of the south and only slightly smaller amounts in the north. Among the larger amounts of rain recorded during this time may be mentioned 1·20in. at Aspatria on the 9th and 1·05in. at Falmouth on the 5th. Gales occurred on the morning of the 6th and evening of the 9th in the south. Day temperatures were mostly a little above normal during this period, but sharp ground frosts occurred at night, 14°F. being recorded on the ground at Burnley on the 1st. A secondary depression forming a trough-like extension to a main depression to the north passed across the country on the 11th,* causing a line squall and heavy rain over a wide area. Among the heaviest rainfalls recorded on that day were: 8·3in. at Mardy Reservoir (Glamorgan), 5·25in. at Treherbert (Glamorgan), and 3·17in. at Holne (Devon). With the passing of the line squall there was a considerable drop of temperature and much colder weather supervened until the 18th and the 19th. Maximum temperature failed to exceed 32°F. at several places on the 15th, 30°F. was the maximum at Renfrew and 32°F. at Cranwell, while a minimum of 10°F. was registered on the ground at Burnley and of 12° at Rhayader on the 18th. Snow fell heavily in Scotland, north Ireland, north England and the Midlands and lay to a considerable depth in some districts; rain occurred often further south, but sunshine records were good on many of the days, *e.g.*, over 7hrs. in south England and Ireland on the 17th. Thunderstorms occurred locally on the 10th to 14th and widespread morning mist and fog were experienced on the 14th to 18th, occasionally persisting all day. During the 18th a deep depression spread in from the Atlantic causing a complete change to unsettled mild weather which lasted until the end of the month. Gales and heavy rain were experienced at most places on either the 18th or 19th, rain measurements exceeding 3in. in various places, notably in the southwest, 4·59in. between noon on the 18th and noon on the 19th at Holne (Devon), 3·79in. at Treherbert (Glamorgan). Gales were again experienced at many places on the 23rd and 25th and rain fell over the country generally on most days between the 19th and 30th; the 24-hour totals frequently exceeding 1in. in the south and west; severe flooding resulted in the west. From the 19th onwards the temperature was considerably above the normal, maximum temperature in the south rarely falling below 50°F. and reaching 60° at Greenwich on the 22nd. The distribution of sunshine for the month was as follows:—

	Total (hrs.)	Diff. from normal (hrs.)		Total (hrs.)	Diff. from normal (hrs).
Stornoway	55	−12	Valentia	47	−18
Aberdeen	80	+25	Liverpool	53	− 6
Dublin	70	− 1	Falmouth	71	− 5
Birr Castle	55	− 9	Kew	66	+14

Pressure was below normal over Iceland, Greenland and the whole of western Europe with the exception of the extreme north-east of Norway and the south of the Iberian Peninsula, the greatest deficit being 14·1mb. at Thorshavn (Faroë Islands). Pressure was also above normal at the Azores, Bermuda and Newfoundland. Temperature was above normal over western

* *See* p. 249.

Europe but slightly below normal at Spitsbergen. In parts of central and northeastern Sweden it was as much as 10°F. above normal. Rainfall was deficient in central Europe, northern Scandinavia and Spitsbergen, but abundant in the British Isles and parts of southern Scandinavia, being double the normal in northwestern Gothaland and eastern Norrland.

Gales and heavy rains were experienced in northern France on the 8th. The dry weather which had prevailed in Switzerland since the middle of November ended on the 12th, when there were abundant rains in the low country, and snow fell heavily on the hills down to a level of 2,500 feet. The snowfall continued on the 14th down to a level of 1,500ft. and over a foot of snow is reported from the Engadine and Bernese Oberland. Gales were again experienced in northern France on the 14th.

Rain fell over the northwest and northeast pastoral areas of South Australia during the first fortnight of the month, thus breaking the long drought. Good rainfalls also occurred over the whole wheat belt, greatly enhancing the prospects of the wheat crop and also of grazing, dairying and fruit growing in that area.

Severe gales were frequently experienced over the North Atlantic. At Madeira shade temperatures of over 70°F. were registered during the first fortnight.

In the United States temperature was generally above normal east of the Mississippi river and along the Pacific coast, and below normal in the Plains and Rocky Mountain States for the first three weeks of the month. Later it was below normal over the whole country. Rainfall was heavy except in parts of the mountain regions and along the Pacific coast during the early part of the month and again in the week ending the 19th. Towards the end of the month the distribution was irregular.

The special message from Brazil states that the distribution of rainfall in the northern regions was irregular with an average 0·24in. above normal and that the rainfall was scarce in the central and southern regions with averages 0·51in. and 1·22in. below normal respectively. Four anticyclones passed across the country and the continental depression was unusually active. The crops were generally in good condition except that the tobacco crop in Bahia and the cereals in Rio Grande do Sul were affected by the lack of rain. At Rio de Janeiro pressure was 0·1mb. above normal and temperature, owing to the persistence of southerly winds, 2·2°F. below normal.

Rainfall, November, 1929.—General Distribution

England and Wales	232	per cent of the average 1881-1915.
Scotland	130	
Ireland	151	
British Isles	188	

Rainfall: November, 1929: England and Wales

Co.	Station	In.	Per-cent of Av.	Co.	Station	In.	Per-cent. of Av.
Lond .	Camden Square.........	5·47	232	*Leics* .	Belvoir Castle...........	4·46	200
Sur .	Reigate, Alvington.....	7·35	236	*Rut* .	Ridlington...............	5·16	...
Kent .	Tenterden, Ashenden...	6·37	211	*Linc* .	Boston, Skirbeck........	4·06	203
,, .	Folkestone, Boro. San..	5·26	...	,, .	Lincoln....................	4·33	230
,, .	Margate, Cliftonville...	3·46	143	,, .	Skegness, Marine Gdns	3·32	154
,, .	Sevenoaks, Speldhurst	7·15	...	,, .	Louth, Westgate........	4·03	156
Sus .	Patching Farm.........	9·01	253	,, .	Brigg, Wrawby St.....	4·24	...
,, .	Brighton, Old Steyne..	8·11	253	*Notts* .	Worksop, Hodsock.....	4·31	220
,, .	Heathfield, Barklye....	10·28	346	*Derby* .	Derby, L. M. & S. Rly.	5·06	232
Hants .	Ventnor, Roy. Nat. Hos.	6·91	215	,, .	Buxton, Devon Hos....	9·20	197
,, .	Fordingbridge, Oaklnds	9·76	285	*Ches* .	Runcorn, Weston Pt...	5·47	197
,, .	Ovington Rectory.......	...	...	,, .	Nantwich, Dorfold Hall	5·82	...
,, .	Sherborne St. John.....	7·22	253	*Lancs* .	Manchester, Whit. Pk.	6·46	244
Berks .	Wellington College.....	4·80	188	,, .	Stonyhurst College.....	7·85	174
,, .	Newbury, Greenham...	8·22	294	,, .	Southport, Hesketh Pk	6·22	198
Herts .	Welwyn Garden City...	4·43	...	,, .	Lancaster, Strathspey	8·06	...
Bucks .	High Wycombe..........	7·37	296	*Yorks* .	Wath-upon-Dearne.....	4·23	207
Oxf . .	Oxford, Mag. College..	5·91	267	,, .	Bradford, Lister Pk....	6·18	211
Nor .	Pitsford, Sedgebrook...	5·65	257	,, .	Oughtershaw Hall......	12·19	...
,, .	Oundle....................	3·00	...	,, .	Wetherby, Ribston H.	3·32	144
Beds .	Woburn, Crawley Mill	5·78	258	,, .	Hull, Pearson Park.....	3·71	169
Cam .	Cambridge, Bot. Gdns.	4·09	211	,, .	Holme-on-Spalding.....	4·19	...
Essex .	Chelmsford, County Lab	4·52	201	,, .	West Witton, Ivy Ho.	5·10	...
,, .	Lexden Hill House....	4·34	...	,, .	Felixkirk, Mt. St. John	3·38	138
Suff .	Hawkedon Rectory.....	4·01	177	,, .	Pickering, Hungate....	3·39	...
,, .	Haughley House........	2·92	...	,, .	Scarborough.............	2·66	108
Norf .	Norwich, Eaton...... ...	3·43	133	,, .	Middlesbrough..........	2·48	117
,, .	Wells, Holkham Hall	3·71	173	,, .	Baldersdale, Hury Res.	...	...
,, .	Little Dunham..........	4·71	182	*Durh* .	Ushaw College..........	2·71	107
Wilts .	Devizes, Highclere......	6·38	240	*Nor* .	Newcastle, Town Moor	2·28	94
,, .	Bishops Cannings.......	6·61	231	,, .	Bellingham, Highgreen	3·57	...
Dor .	Evershot, Melbury Ho.	15·61	356	,, .	Lilburn Tower Gdns....	3·75	...
,, .	Creech Grange..........	9·45	...	*Cumb* .	Geltsdale.................	5·25	...
,, .	Shaftesbury, Abbey Ho.	6·58	204	,, .	Carlisle, Scaleby Hall	4·77	159
Devon .	Plymouth, The Hoe....	12·22	335	,, .	Borrowdale, Seathwaite	29·60	213
,, .	Polapit Tamar...........	12·30	290	,, .	Borrowdale, Rosthwaite	22·74	...
,, .	Ashburton, Druid Ho.	21·20	374	,, .	Keswick, High Hill.....	12·58	...
,, .	Cullompton.......	10·50	305	*Glam* .	Cardiff, Ely P. Stn.....	10·99	263
,, .	Sidmouth, Sidmount...	10·73	344	,, .	Treherbert, Tynywaun	27·11	...
,, .	Filleigh, Castle Hill....	10.85	...	*Carm* .	Carmarthen Friary.....	13·93	280
,, .	Barnstaple. N. Dev. Ath.	8·77	223	,, .	Llanwrda..................	15·68	265
Corn .	Redruth, Trewirgie.....	14·09	289	*Pemb* .	Haverfordwest, School	13·50	...
,, .	Penzance, Morrab Gdn.	12·33	270	*Card* .	Aberystwyth............	9·69	...
,, .	St. Austell, Trevarna...	13·09	258	,, .	Cardigan, County Sch.	11·02	...
Soms .	Chewton Mendip........	10·29	240	*Brec* .	Crickhowell, Talymaes	13·00	...
,, .	Long Ashton............	9·92	...	*Rad* .	Birm W. W. Tyrmynydd	14·42	217
,, .	Street, Millfield	7·31	...	*Mont* .	Lake Vyrnwy...........	15·13	272
Glos. .	Cirencester, Gwynfa....	8·31	279	*Denb* .	Llangynhafal............	6·23	...
Here .	Ross, Birchlea...........	8·55	338	*Mer* .	Dolgelly, Bryntirion...	14·37	232
,, .	Ledbury, Underdown..	8·50	348	*Carn* .	Llandudno...............	5·17	167
Salop .	Church Stretton.........	8·15	277	,, .	Snowdon, L. Llydaw 9	34·40	...
,, .	Shifnal, Hatton Grange	5·33	223	*Ang* .	Holyhead, Salt Island	7·16	173
Worc .	Ombersley, Holt Lock	6·80	298	,, .	Lligwy....................	7·53	...
,, .	Blockley..................	8·16	...	*Isle of Man*			
War .	Farnborough............	7·45	272		Douglas, Boro' Cem....	7·47	158
,, .	Birminghm, Edgbaston	7·12	299	*Guernsey*			
Leics .	Thornton Reservoir....	5·59	247		St. Peter P't. Grange Rd.	9·38	223

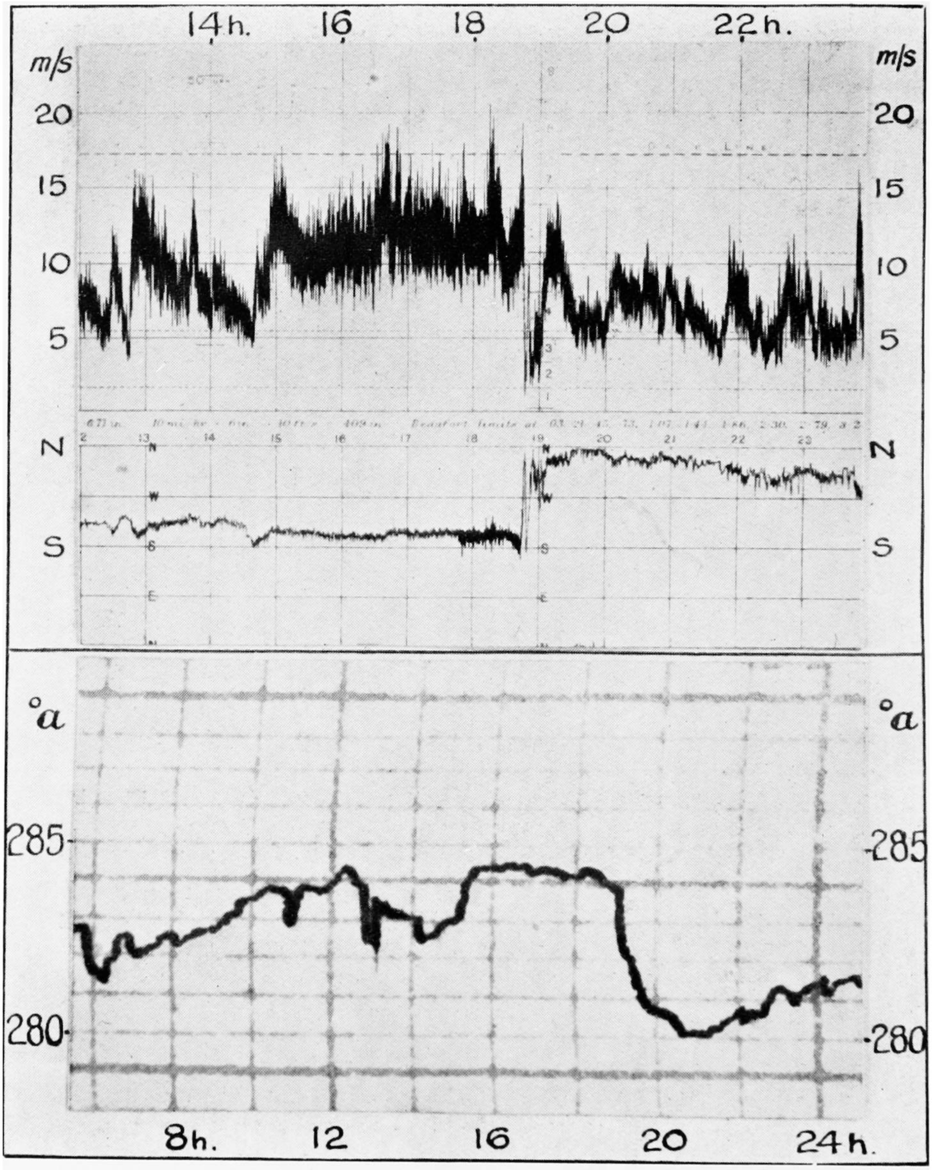
Rainfall : November, 1929 : Scotland and Ireland

Co.	Station	In.	Per-cent of Av.	Co.	Station	In.	Per-cent of Av.
Wigt .	Stoneykirk, Ardwell Ho	6·58	165	*Suth* .	Loch More, Achfary...	9·45	111
,, .	Pt. William, Monreith	6·36	...	*Caith* .	Wick......................	3·20	102
Kirk .	Carsphairn, Shiel.......	14·68	...	*Ork* .	Pomona, Deerness......	4·45	113
,, .	Dumfries, Cargen......	8·33	184	*Shet* .	Lerwick	7·89	186
Dumf.	Eskdalemuir Obs.......	10·92	188	*Cork* .	Caheragh Rectory......	11·58	...
Roxb .	Branxholm	5·26	158	,, .	Dunmanway Rectory...	12·25	198
Selk .	Ettrick Manse..........	...	...	,, .	Ballinacurra.............	6·59	164
Peeb .	West Linton...........	4·96	...	,, .	Glanmire, Lota Lo......	7·25	169
Berk .	Marchmont House......	3·61	120	*Kerry*.	Valentia Obsy..........	9·80	179
Hadd.	North Berwick Res.....	2·42	108	,, .	Gearahameen............	16·60	...
Midl .	Edinburgh, Roy. Obs.	3·60	167	,, .	Killarney Asylum......	7·27	129
Ayr .	Kilmarnock, Agric. C.	6·36	169	,, .	Darrynane Abbey.......	10·04	197
,, .	Girvan, Pinmore..	7·45	140	*Wat* .	Waterford, Brook Lo...	6·90	183
Renf .	Glasgow, Queen's Pk. .	6·26	168	*Tip* .	Nenagh, Cas. Lough...	5·53	137
,, .	Greenock, Prospect H.	10·47	163	,, .	Roscrea, Timoney Park	4·04	...
Bute .	Rothesay, Ardencraig.	7·78	154	,, .	Cashel, Ballinamona...	4·98	142
,, .	Dougarie Lodge.........	7·21	...	*Lim* .	Foynes, Coolnanes......	6·39	157
Arg .	Ardgour House	12·86	...	,, .	Castleconnel Rec.......	5·64	...
,, .	Manse of Glenorchy...	10·61	...	*Clare* .	Inagh, Mount Callan...	10·09	...
,, .	Oban......................	7·04	...	,, .	Broadford, Hurdlest'n.	6·18	...
,, .	Poltalloch	7·99	144	*Wexf*.	Newtownbarry	...	...
,, .	Inveraray Castle...	12·67	150	,, .	Gorey, Courtown Ho...	7·38	211
,, .	Islay, Eallabus.........	8·59	159	*Kilk* .	Kilkenny Castle.........	4·83	157
,, .	Mull, Benmore.........	14·60	...	*Wic* .	Rathnew, Clonmannon	6·70	...
,, .	Tiree	...	...	*Carl* .	Hacketstown Rectory..	6·65	171
Kinr .	Loch Leven Sluice......	5·50	153	*Leix* .	Blandsfort House......	4·67	140
Perth .	Loch Dhu...............	11·40	131	,, .	Mountmellick...........	4·95	...
,, .	Balquhidder, Stronvar	...	...	*Off'ly* .	Birr Castle..............	3·98	128
,, .	Crieff, Strathearn Hyd.	5·43	125	*Dubl* .	Dublin, FitzWm. Sq...	4·85	181
,, .	Blair Castle Gardens...	3·61	103	,, .	Balbriggan, Ardgillan.	4·08	142
,, .	Dalnaspidal Lodge.....	10·49	158	*Me'th* .	Beauparc, St. Cloud...	3·92	...
Angus.	Kettins School.	3·75	134	,, .	Kells, Headfort.........	4·60	135
,, .	Dundee, E. Necropolis	3·78	155	*W.M* .	Moate, Coolatore......	3·68	...
,, .	Pearsie House...........	4·27	...	,, .	Mullingar, Belvedere..	3·84	113
,, .	Montrose, Sunnyside...	3·79	143	*Long* .	Castle Forbes Gdns......	5·02	139
Aber .	Braemar, Bank...	3·58	93	*Gal* .	Ballynahinch Castle...	9·09	152
,, .	Logie Coldstone Sch....	2·25	73	,, .	Galway, Grammar Sch.	5·71	...
,, .	Aberdeen, King's Coll.	3·55	120	*Mayo* .	Mallaranny..............	...	...
,, .	Fyvie Castle............	2·79	...	,, .	Westport House.........	7·19	147
Moray.	Gordon Castle..........	1·88	65	,, .	Delphi Lodge...........	13·94	...
,, .	Grantown-on-Spey......	...	...	*Sligo* .	Markree Obsy...........	6·52	157
Nairn.	Nairn, Delnies	1·35	57	*Cav'n* .	Belturbet, Cloverhill...	3·73	120
Inv .	Kingussie, The Birches	3·71	...	*Ferm* .	Enniskillen, Portora...	4·38	...
,, .	Loch Quoich, Loan.....	...	...	*Arm* .	Armagh Obsy...........	3·51	124
,, .	Glenquoich..............	14·20	117	*Down* .	Fofanny Reservoir......	12·14	...
,, .	Inverness, Culduthel R.	2·50	...	,, .	Seaforde..................	6·05	160
,, .	Arisaig, Faire-na-Squir	5·78	...	,, .	Donaghadee, C. Stn...	4·00	131
,, .	Fort William...........	10·10	...	,, .	Banbridge, Milltown...	2·60	...
,, .	Skye, Dunvegan........	6·80	...	*Antr* .	Belfast, Cavehill Rd...	5·21	...
R & C.	Alness, Ardross Cas ...	3·38	84	,, .	Glenarm Castle.........	6·64	...
,, .	Ullapool	4·39	...	,, .	Ballymena, Harryville	5·11	126
,, .	Torridon, Bendamph...	9·16	99	*Lon* .	Londonderry, Creggan	5·09	124
,, .	Achnashellach..........	8·90	...	*Tyr* .	Donaghmore............	4·35	...
,, .	Stornoway...............	5·86	101	,, .	Omagh, Edenfel........	4·26	112
Suth .	Lairg.....................	3·55	...	*Don* .	Malin Head.............	4·26	...
,, .	Tongue	3·21	70	,, .	Dunfanaghy.............	5·04	...
,, .	Melvich..................	4·95	124	,, .	Killybegs, Rockmount.	8·07	128

Climatological Table for the British Empire, June, 1929.

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.	1016·7	0·0	79	43	66·7	49·8	58·3	− 0·9	51·4	77	6·4	0·88	− 1·27	11	7·0	42
Gibraltar	1017·4	0·0	86	57	80·2	63·5	71·9	+ 1·4	61·3	76	3·0	0·02	− 0·46	1	..	..
Malta	1015·9	+ 0·3	90	63	78·6	66·9	72·7	0·0	66·9	76	3·4	0·00	− 0·09	0	11·1	76
St. Helena	1015·2	+ 2·2	65	55	60·5	56·7	58·6	− 2·4	58·2	98	8·2	3·19	− 0·88	14	..	..
Sierra Leone	1013·3	+ 1·3	87	..	84·5	..	..	..	75·9	89	5·8	27·10	+ 7·06	28	..	..
Lagos, Nigeria	1013·0	+ 0·1	83	70	81·1	73·9	77·5	− 1·8	74·7	88	9·3	19·93	+ 1·28	21	..	..
Kaduna, Nigeria	1015·4	+ 1·6	90	64	85·0	67·0	76·0	− 0·5	69·5	76	..	6·68	− 1·17	21	..	..
Zomba, Nyasaland	1016·5	− 1·0	81	47	73·6	53·3	63·5	+ 0·6	..	70	3·6	0·00	− 0·48	0	..	..
Salisbury, Rhodesia	1018·0	− 0·1	76	39	71·1	44·9	58·0	+ 1·1	51·0	50	0·9	0·01	− 0·04	1	9·5	86
Cape Town	1021·1	+ 1·0	76	39	65·4	49·8	57·6	+ 1·9	50·4	89	3·7	2·85	− 1·65	7	..	..
Johannesburg	1023·0	+ 0·3	71	28	60·4	42·8	51·6	+ 0·9	42·2	56	3·2	2·38	+ 2·24	6	7·9	75
Mauritius	1019·8	+ 0·8	77	58	74·8	63·0	68·9	− 0·5	65·8	76	3·8	2·54	− 0·26	20	7·4	68
Bloemfontein	..	..	..	..	..	..	..	..	..	..	..	1·97	+ 1·50	..	..	..
Calcutta, Alipore Obsy.	998·7	− 1·0	101	76	93·0	79·8	86·4	+ 1·3	80·1	84	7·6	6·74	− 5·16	10*	..	..
Bombay	1003·0	− 1·0	94	73	87·6	77·6	82·6	− 1·3	77·9	86	7·6	25·45	+ 5·58	15*	..	..
Madras	1003·3	− 0·5	105	75	100·3	81·2	90·7	+ 0·6	74·9	57	6·7	1·42	− 0·47	4*	..	..
Colombo, Ceylon	1009·5	+ 0·8	87	72	85·2	77·1	81·1	− 0·6	77·4	80	9·1	9·62	+ 1·65	20	5·0	40
Hongkong	1005·7	− 0·4	91	75	87·1	79·4	83·3	+ 1·9	78·1	78	7·4	4·19	− 11·90	13	6·9	51
Sandakan	..	..	91	73	88·5	74·7	81·6	− 0·1	77·3	83	..	10·93	+ 3·63	14	..	..
Sydney, N.S.W.	1019·0	+ 1·2	74	40	63·1	47·4	55·3	+ 0·7	48·1	70	4·3	2·81	− 1·96	7	6·4	65
Melbourne	1018·8	+ 0·3	64	31	56·7	43·7	50·2	− 0·2	44·3	75	5·9	1·12	− 0·97	14	4·7	49
Adelaide	1020·3	+ 1·3	75	37	61·2	47·5	54·3	+ 0·8	48·2	71	7·9	3·40	+ 0·25	18	3·9	40
Perth, W. Australia	1018·3	+ 0·4	73	38	62·6	48·9	55·7	− 1·1	50·4	74	6·4	9·23	+ 2·31	17	4·4	44
Coolgardie	1018·9	− 0·2	70	33	61·0	41·3	51·1	− 1·6	45·2	70	3·5	1·36	+ 0·13	6	..	..
Brisbane	1018·9	+ 0·8	77	40	68·5	49·7	59·1	− 1·1	52·5	68	4·9	4·40	+ 1·77	9	6·1	59
Hobart, Tasmania	1012·7	− 1·6	62	34	52·5	39·9	46·2	− 0·6	41·1	76	6·2	2·26	+ 0·06	14	4·7	52
Wellington, N.Z.	1011·1	− 3·8	60	37	54·6	45·7	50·1	+ 0·7	47·3	83	6·3	5·56	+ 0·79	15	3·5	38
Suva, Fiji	1014·0	+ 0·4	87	64	80·2	71·3	75·7	+ 0·8	72·9	83	7·0	11·26	+ 5·11	24	3·1	28
Apia, Samoa	1011·6	0·0	87	70	83·9	74·2	79·1	+ 1·3	75·7	74	4·5	3·77	− 1·39	13	5·8	51
Kingston, Jamaica	1013·7	− 0·1	91	72	87·8	74·8	81·3	0·0	72·8	77	6·1	0·44	− 3·66	4	..	..
Grenada, W.I.	1010·5	− 2·6	88	71	86·0	73·6	79·8	+ 0·9	74·6	80	4·7	12·94	+ 4·62	26	..	..
Toronto	1013·7	− 0·6	92	37	74·2	53·4	63·8	+ 1·2	56·5	68	4·0	1·45	− 1·31	8	8·9	58
Winnipeg	1011·6	− 0·9	94	32	74·9	50·2	62·5	+ 0·3	52·0	78	3·9	1·37	− 1·89	10	10·3	63
St. John, N.B.	1013·0	− 1·0	84	41	65·4	48·5	56·9	+ 0·4	52·2	77	7·2	1·95	− 1·32	13	6·7	43
Victoria, B.C.	1015·5	− 1·4	77	44	63·8	49·8	56·8	− 0·2	52·6	75	6·4	0·99	+ 0·06	8	6·9	43

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



ANEMOGRAM AND THERMOGRAM, VALENTIA OBSERVATORY, NOV. 9TH, 1929.
(See p. 291.)