The Meteorological Magazine

Vol. 66

(Twelfth of the New Series)

1931

Published by the Authority of the Meteorological Committee. Air Ministry. Meteorological Office.

LONDON: PUBLISHED BY HIS MAJESTY'S STATIONERY OFFICE.
To be purchased through any Bookseller or directly from
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2007

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M.O. 339.

The Meteorological Magazine

Air Ministry :: Meteorological Office

Vol. 66

Feb., 1931

No. 781

LONDON: PUBLISHED BY HIS MAJESTY'S STATIONERY OFFICE

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Tree Growth and Rainfall

By C. E. BRITTON, B.Sc.

At 11.20 on Sunday, November 2nd, 1930, the town of Shoeburyness was struck by a squall of destructive violence. *Inter alia*, it uprooted and felled an old elm tree, some 70 to 80ft. high, situated about 50 yards within the main gate of the New Ranges. If size is a criterion this elm must have been the oldest tree in the neighbourhood. To clear away the debris of the fallen trees at the spot, this elm was sawn across near the root, the cut being about 3ft. above the original ground level. Old elms usually prove rotten, but this tree, at this section, had only just begun to deteriorate. Another section about a foot higher up showed considerable degradation at the centre, and still higher up the trunk little wood remained beyond, say, the last 50 years' growth.

On hearing of this occurrence, Dr. C. E. P. Brooks suggested that some correlation of the annual growth with rainfall might be attempted. Similar investigations have already been made in respect of trees in the Forest of Dean, where the climate is rainier than in eastern England.* The results of that inquiry were, on the whole, negative, in the sense that there appeared to be little correlation between tree growth and rainfall. It was thought that results of interest might be obtained by a similar investigation of a tree which flourished in the drier climate of

* *Meteorological Magazine*, 63, 1928, pp. 29-33.

(92938) P.S.14/89 1,100 2/31 M. & S. *Gp.303*

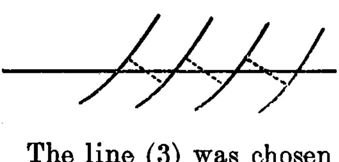
Shoeburyness. Accordingly, Colonel E. L. Bond, Superintendent of Experiments, was good enough to arrange for the provision of a section of this tree from which the measurements in this note were secured.

A casual glance at the section shows at once that the growth was regular for the first sixty years of life. About 1730 the trunk was of a good cylindrical shape, but after that date the growth began to become more irregular, and latterly it has been extremely irregular. The growth has indeed been so irregular that it has been very difficult to decide in many places what actual amount of growth of the trunk as a whole is to be credited to a particular year. The wood is most sound in respect of the growth for the period 1900 to 1930. The total growth on the north side during this period is about 14.0cm. On the south side, the growth during the same 30 years is barely one-third of that amount. For the decade 1870 to 1880 the northerly growth of the tree was very great, amounting to more than 8mm. per annum; at the same time on the south side the growth was less than 2mm. per annum. In many places the growth rings are so compressed together that it is impossible to sort them out accurately. There is also considerable distortion of the rings in several places due to inclusions in the wood, apparently trunks of climbing plants which have been absorbed. In other cases several adjacent rings which are quite distinct in some parts of the circle coalesce into featureless bands in other parts. There are also places where rings bifurcate and run together in an apparently arbitrary manner. Thus the task of obtaining a continuous record of annual growth from the rings is by no means easy, and a great degree of accuracy has not been obtainable. Near the centre measurements are impossible owing to the degradation of the wood.

The procedure adopted in this note is to take the annual growth—

(1) towards the north (greatest growth),
(2) towards the south (least growth),
(3) towards the east-north-east (most even growth),

as accurately as the material would permit. Along the lines (1) and (2) the rings frequently cut the radius vector at angles differing largely from 90 degrees. The width of a ring has been taken to be the distance across the ring, perpendicular to its boundaries, and centering on the radius vector.

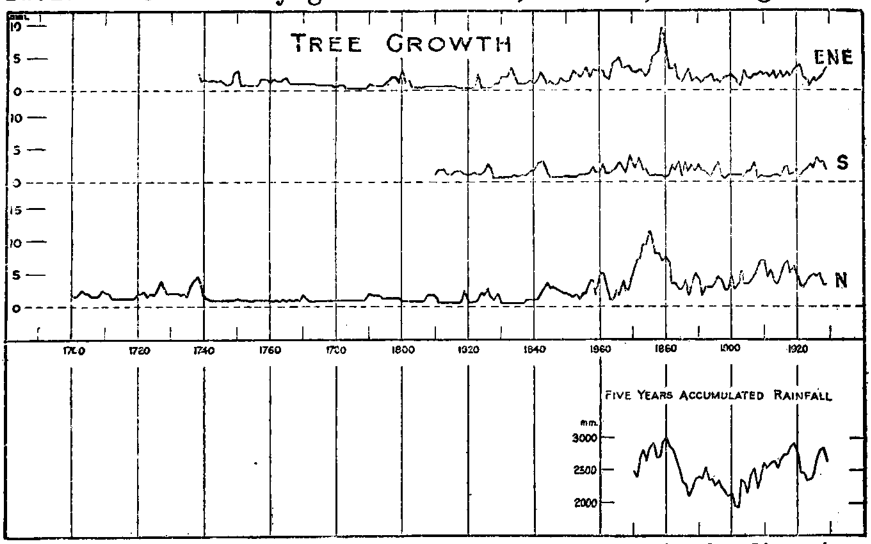


The line (3) was chosen as giving a radius vector along which the rings are reasonably concentric to the centre and along which there were no distortions and few abnormal growths. Appended to this note are tables giving the annual growth in millimetres along these three lines as far back as possible, and also a table giving the annual rainfall of Shoeburyness for the period 1866 to 1928.

As a first essay, the correlation coefficient was computed between the annual rainfall and the growth in the same year along each of the chosen radii vectors. The figures obtained were—

Growth to the north	+0.44
,, south	+0.17
,, east-north-east	+0.21

The period used in each case was 1866 to 1928, local rainfall observations being available for the whole of this interval. This confirms the result obtained from the Forest of Dean trees, that there is little correlation between the rainfall of any particular year and the growth in the same year. This, indeed, is clear from a graph of the annual growth and the rainfall. The wettest year in the series was 1872. The northerly growth was not, however, at its greatest



in that year. The maximum growth in the northerly direction occurs in 1875, which, although a wet year, was considerably exceeded in raininess by several years in the series. Towards the south, the growth attained its maximum value in the years 1872 and 1869. The first of these two years happens to be the one with maximum raininess, but 1869, which saw as much growth in this direction as 1872, was a year of practically normal rainfall. Similar anomalies appear if dry years are examined. All that can be said after a study of the crude data is that this elm tended to grow more in wet years than in dry but that the correlation is not strongly marked.

It is probable that the effect of rainfall on the growth of a tree is not well marked until some time after the season in which it occurred. Overlapping five yearly means of growth have therefore been computed and correlated with the rainfall of the first year of the lustrum. The correlation, however, proves to be very little different, as far as the northerly growth is concerned, from the correlation with the growth of the same year; it comes out to be +0.36.

A closer relationship was obtained as a result of a suggestion of Dr. Brooks. The growth in each year was correlated with the rainfall of the year added to that of the preceding four years, that is, with the accumulated rainfall of five years. The figures obtained were—

Growth to the north	+0.59
,, south	+0.13
,, east-north-east	+0.55
Mean of north and east-north-east growth	+0.67

These results confirm that the growth appears to be greatest in wet groups of years.

It is noteworthy that the trees examined in the Forest of Dean appeared to have their greatest growth in dry groups of years. The trees in that investigation were chiefly yews, but there is a suggestion that the optimum rainfall for tree-growth in this country is to be found between the 30 inches per annum of the Forest of Dean and the 20 inches per annum of Shoeburyness.

Finally, in order to utilise as long a series of the measurements as possible, the northerly growth was correlated with the rainfall figures computed for England for the period 1727 to 1927 by Dr. Glasspoole.* These figures give an estimated rainfall for the whole of England expressed as a percentage of the 1881 to 1915 mean. Again the correlation is small; it works out at +0.23.

The truth no doubt is that rainfall is merely one of the factors affecting tree growth, and it is conceivable that there may be others more important than rainfall. Temperature and sunshine play a part in the processes underlying tree growth, and these may be of greater importance than rainfall. Treatment of the soil, too, would be of some account. This tree grew in life at the edge of a field which during the last 12 years has been under pasture. This field, however, may have been under crops during a part of the last 250 years, and it is conceivable that the operations of ploughing and manuring may have affected the growth of the tree. It is notable that the field was on the north and west sides of the tree.

Annual totals of rain for Shoeburyness.

Year.		0	1	2	3	4	5	6	7	8	9
192	...	491	283	489	509	613	557	511	624	546	407
191	...	536	476	513	501	505	652	574	514	618	570
190	...	440	320	389	750	409	370	525	464	456	624
189	...	517	412	547	376	529	395	511	424	309	465
188	...	650	478	573	422	374	492	431	382	568	513
187	...	405	519	844	525	361	582	605	627	537	585
186	...	—	—	—	—	—	—	605	541	414	523

* *Meteorological Magazine*, 63, 1929, p. 4.

ANNUAL GROWTH TO THE NORTH IN MILLIMETRES.

Year.		0	1	2	3	4	5	6	7	8	9
192	...	5.0	3.5	2.9	3.7	4.5	5.0	4.7	5.1	3.3	3.3
191	...	7.0	4.5	5.5	4.1	3.5	5.0	6.2	7.0	5.0	6.2
190	...	4.5	2.5	3.2	5.5	3.5	3.5	4.0	4.8	6.0	7.0
189	...	3.8	1.5	3.0	3.0	3.0	3.8	4.5	4.0	2.5	2.5
188	...	7.5	6.8	3.5	3.5	2.7	2.7	4.0	1.7	4.0	5.0
187	...	5.0	7.0	7.3	9.5	9.5	11.7	9.5	8.0	8.0	6.8
186	...	5.0	5.0	3.5	1.0	1.0	2.5	1.7	5.0	2.7	2.5
185	...	2.0	1.7	1.5	1.8	1.0	2.0	2.0	4.0	4.0	1.8
184	...	1.0	1.0	2.0	2.8	3.8	2.8	3.0	2.7	2.5	2.0
183	...	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	1.0	1.0
182	...	0.7	0.5	0.7	0.8	2.1	1.8	2.8	1.5	1.0	2.0
181	...	1.8	0.6	0.6	0.6	0.6	0.6	0.6	0.6	0.6	2.5
180	...	0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.8	1.8	1.8
179	...	2.0	1.8	1.8	1.8	1.2	1.2	1.2	1.2	1.2	1.2
178	...	0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.8	1.0
177	...	1.8	1.2	0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.8
176	...	1.0	0.9	1.0	0.9	1.0	0.9	1.0	0.9	1.0	0.9
175	...	1.2	1.0	1.0	1.0	0.8	0.8	1.0	1.0	1.0	1.0
174	...	1.8	1.1	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0
173	...	2.0	2.0	0.9	0.7	1.0	1.5	3.0	3.8	4.5	3.5
172	...	1.8	2.0	2.3	1.5	2.0	1.8	2.8	4.0	2.7	2.0
171	...	2.2	2.0	1.2	1.2	1.2	1.2	1.2	1.2	1.2	1.2
170	...	1.7	1.5	2.0	2.5	2.0	2.0	1.5	1.5	1.5	2.5

ANNUAL GROWTH TO THE SOUTH IN MILLIMETRES.

Year.		0	1	2	3	4	5	6	7	8	9
192	...	2.0	0.7	1.5	1.0	2.5	2.0	3.5	3.0	3.0	1.7
191	...	0.7	0.7	0.7	1.0	1.0	0.7	2.0	2.3	1.0	1.2
190	...	1.0	1.0	1.0	1.0	0.7	1.5	1.5	3.0	0.5	1.0
189	...	2.5	1.6	1.6	1.2	0.7	2.0	3.0	1.0	0.5	1.0
188	...	0.7	1.0	2.5	1.7	3.0	0.7	3.0	1.5	2.5	1.5
187	...	3.2	2.0	3.7	1.7	2.0	0.9	0.9	0.9	0.9	0.9
186	...	1.2	2.5	1.2	1.2	1.5	2.0	3.0	2.0	1.5	4.0
185	...	0.7	0.7	0.7	0.7	1.0	1.0	1.0	1.3	2.2	1.5
184	...	1.7	2.7	3.0	3.0	2.0	0.6	0.6	0.6	0.6	0.6
183	...	0.6	0.6	0.6	0.6	1.0	0.8	0.8	1.0	1.0	1.5
182	...	1.0	1.0	1.4	1.1	1.0	1.6	2.6	2.0	0.5	0.5
181	...	1.0	1.8	1.8	1.8	1.0	1.0	1.5	1.5	1.5	1.0

ANNUAL GROWTH TO THE EAST-NORTH-EAST IN MILLIMETRES.

Year.		0	1	2	3	4	5	6	7	8	9
192	...	3.5	4.0	2.0	1.6	0.7	2.0	1.5	2.0	2.3	3.5
191	...	2.3	2.5	2.0	3.0	1.7	3.0	2.0	2.7	2.0	3.0
190	...	2.3	1.8	1.0	0.7	3.0	2.0	1.8	2.5	2.3	2.8
189	...	1.7	1.0	1.7	2.0	2.5	1.2	1.5	1.0	2.0	2.0
188	...	6.5	3.7	3.0	4.0	1.8	1.3	2.3	3.3	1.3	1.7
187	...	2.8	2.7	3.0	3.0	2.0	3.0	5.0	5.5	6.0	9.5
186	...	3.0	3.0	2.0	1.8	4.0	4.5	5.0	3.5	3.5	3.7
185	...	1.2	1.5	3.0	2.5	2.0	2.8	3.5	1.8	3.3	3.0
184	...	1.0	1.5	2.8	1.7	1.0	1.2	1.0	0.8	1.7	1.5
183	...	2.0	2.0	2.0	3.5	2.0	1.0	1.0	1.0	1.2	1.5
182	...	0.3	0.3	0.3	2.5	0.4	0.4	0.4	0.4	1.0	1.0
181	...	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.3	0.3	0.3
180	...	3.0	1.0	1.5	0.4	0.4	0.4	0.4	0.5	0.5	0.5
179	...	1.0	0.7	0.7	0.7	0.7	1.0	1.3	2.0	2.0	1.0

ANNUAL GROWTH TO THE EAST-NORTH-EAST IN MILLIMETRES.
(*continued*)

Year.		0	1	2	3	4	5	6	7	8	9
178	...	0.5	0.8	0.8	0.3	0.3	0.3	0.3	0.3	0.3	0.3
177	...	1.0	1.0	1.0	1.0	0.9	0.9	0.9	0.9	0.9	0.5
176	...	1.0	1.7	1.5	1.5	1.7	2.0	1.0	1.0	1.0	1.0
175	...	3.0	0.7	0.7	0.7	0.7	0.7	0.7	1.7	1.7	1.5
174	...	1.5	1.3	1.5	1.5	1.3	1.5	1.0	0.7	1.0	2.7
173	...	—	—	—	—	—	—	—	—	2.7	1.3

Aeronautical Meteorology

The first edition of "Aeronautical Meteorology" was published in 1925, when civil aviation in the United States was in its infancy. Since its publication federally established air routes have been organized, and the airman of to-day realises more than ever before how successs and safety in the sphere of civil aviation are dependent upon the help and protection which meteorology can give him. The meteorologist is no less cognizant of the help which aviation can bring towards the solution of many of the problems which confront him, and no reader of the book under review can fail to realise the possibilities in this direction. The development of aviation in the United States since 1925 has brought to light much that is new, or at least was not then fully appreciated, in the application of meteorology to aviation. In the second edition of "Aeronautical Meteorology"* the author has profited by the experience gained since 1925 to bring the book thoroughly up to date. It has been completely revised and rewritten. A feature of the book is that the author has had the assistance of eight other prominent American meteorologists, who contribute chapters or sections of chapters on the branches of the subject with which their experience makes them best qualified to deal. Five of these authorities are in charge of the meteorological offices at important stations on the air routes, and their contributions on such subjects as fog, ceiling, and visibility, in their relation to flying, should most certainly prove useful. R. H. Weightman, Senior Meteorologist and District Forecaster at Washington, D.C., contributes the chapter on "Weather Forecasting"; R. N. Covert, of the Instruments Division, U.S. Weather Bureau, writes as a specialist on "Instruments and Methods of Observation"; while "Airship Meteorology" is written by Lieut. F. W. Reichelderfer, U.S.N., Meteorologist Officer of the U.S.S., *Los Angeles*.

The purpose of the book is stated to be to give in concise form the esential facts of the upper air, and to point out their

* By W. R. Gregg. 2nd Edition (revised and enlarged). Size 8¾ × 5⅞in., pp. xvi + 405, *Illus.* New York, The Ronald Press Co. 1930. Price $4.50.

relation to the development and safety of aviation so that pilots may be able to benefit to the fullest extent from every vicissitude of wind and weather. In this aim the author appears to have been singularly succesful. The known facts which bear a direct or indirect relationship to flying have been indicated and discussed. Theory is not neglected, but it is discussed only when it is helpful in its practical application to flying. The author comes to the point throughout with a refreshing lack of unnecessary preamble.

A feature of the book is its wealth of illustration. Representative cloud types have been singularly well chosen and are excellently reproduced, while the many charts and diagrams leave nothing to be desired as regards clearness. As in most modern works on meteorology the units difficulty is always prominent. The author has endeavoured to surmount this difficulty as far as possible by using both English and metric units in the text and tables. Many of the illustrations are taken from papers previously published in technical journals. Here the units originally used are shown but the appropriate conversion factors are appended.

There are in all 14 chapters and six appendices. Chapter 1 contains a brief outline of world meteorology. Chapter 2 is devoted to a description of the instruments and methods of observation employed at airport stations. The illustrations are good, and the concise explanation of each instrument should make them easily understandable even to the novice. Two of the very few misprints appear in this chapter; plate VII is unfortunately inverted, while the vertical lever for removing the pen from the chart on the barograph is stated to be for the adjustment of the pen pressure on the chart! Chapter 3 deals with the vertical structure of the atmosphere as regards temperature, humidity and pressure. The study of wind variations, an essential part of the vertical structure of the atmosphere, is deemed worthy of a special chapter. This branch is well treated and contains useful frequency tables of variations in direction and velocity. Information of this kind constitutes an important factor in the arrangement of flying schedules. A pilot who studies the explanation of turbulence and gustiness in this chapter will have no difficulty in appreciating the cause of "bumps." There are maps of the United States showing "resultant" winds at various heights. These should be found useful and suggestive when it is realised that it has been shown that the resultant wind at 500 metres between New York and Chicago agrees closely with the average difference in time maintained by planes in eastward and westward flights. Chapters 5 to 7 deal with fog, clouds, ceiling (height of cloud base) and visibility. These are undoubtedly the elements, apart from wind, which most directly concern the efficiency and safety of air services, and in these chapters all the essential information available has been concentrated. " Fog " is well explained, the inevitable cloud height and visibility frequencies are clearly set out, while 23 pages are devoted to a detailed analysis of the variation of ceiling and visibility in different sections of the United States. A chapter is devoted to " Thunderstorms." This is again well illustrated and contains valuable and instructive frequency tables and charts. The chapter on " Cyclones and Anticyclones " probably errs on the side of brevity. A little more detailed description of the changes which take place as well-marked pressure types pass over a station would have had more practical value. Chapter 10 gives a general description of the Forecast Service in the United States, with paragraphs on " The Bjerknes' Method," " Line Squalls," and " Local Forecasting." Chapter 11, on " Airship Meteorology," is entirely new. It is the longest chapter in the book and deals at some length with the weather phenomena which apply particularly to the design and operation of airships. Wind structure and the vertical temperature distribution are fully discused in their relationship to the handling of airships on or near the ground, while there is an instructive section on airship navigation in relation to storm structure. Those who are interested in trans-Atlantic or trans-Arctic flights will find much food for thought in the chapter on " North Atlantic and Arctic Meteorology." Interesting tables are given showing the frequency of days favourable for trans-Atlantic flights, while synoptic charts of the North Atlantic are reproduced for the days on which certain flights have taken place. Those who anticipate a regular trans-Atlantic service will find poor consolation in Table 21, which shows that the average number of favourable days in the year for a west to east flight is 127, for an east to west flight, 17! Chapter 13, " Ice formation on Aircraft," also breaks new ground. It is now generally acknowledged that the formation of ice on aircraft is one of the greatest obstacles to regular flights in winter, in northern latitudes. Its danger is realised and explanations are found for its formation, but so far no practical remedy has been forthcoming. The final chapter gives a brief summary of the United States organization for supplying weather information for aviation. In its basic features this organization is similar to that in our own and in most European countries.

The book concludes with a series of six appendices giving representative questions and topics for students, details of the distribution of reports and forecasts by wireless, a list of Weather Bureau Stations, a list of the Meteorological Services of the world, a carefully selected bibliography, and a series of constants and conversion factors and tables.

This book should prove invaluable to American pilots and should also be very helpful to all those in our own country who have the interests of aviation at heart.

There is one important and surprising omission in such a comprehensive and well-written book. The reviewer searched in vain for any mention of the influence of pressure changes on the accuracy of altimeter readings. Pressure may vary considerably between two places on a given route, causing errors of alarming proportions in altimeter readings. Valuable help in this respect can be given to pilots by meteorologists with access to synoptic charts. May ignorance of the influence of pressure changes on altimeters not have been the cause of some of the fatal attempts to cross the North Atlantic?

G. R. Hay.

Discussions at the Meteorological Office

The subjects for discussion for the next two meetings will be :—

February 23rd, 1931.—"*Moist labile*" *rainfall.* By Anfinn Refsdal. (Oslo, Geofys. Publ. 5, No. 12, 1930.) (In German.) *Opener*—Mr. C. K. M. Douglas, B.A.

March 9th, 1931.—*New results on cosmic rays.* By R. A. Millikan and G. H. Cameron. (Washington, Ann. Rep. Smiths. Inst., 1928, pp. 213-31.) *Opener*—Dr. G. M. B. Dobson, F.R.S.

Royal Meteorological Society

The Annual General Meeting of this Society was held on Wednesday, January 21st, at 49, Cromwell Road, South Kensington, Mr. R. G. K. Lempfert, M.A., F.Inst.P., President, in the Chair. The Report of the Council for 1930 was read and adopted, and the Council for 1931 duly elected, Mr. R. G. K. Lempfert, M.A., F.Inst.P., being re-elected President. The Buchan Prize, which is awarded biennially for the most important original papers contributed to the Society during the previous five years, was presented to Dr. C. E. P. Brooks.

Mr. R. G. K. Lempfert delivered an address on "The Scientific Work of the Meteorological Office, Cardington."

The address gave an account of the work of the Meteorological Office at the Royal Airship Works, Cardington, of which Mr. M. A. Giblett, who lost his life in the disaster of the R 101, was in charge. Though undertaken as part of the official airship programme, the work will form an important contribution to meteorological knowledge when the investigations now in progress are completed, and it was this aspect that was stressed throughout the address.

The weather charts constructed from all available material for the study of the conditions over the area between this country and India were described and specimens shown. They provide for the first time, material for studying the region as a whole. The special climatological summaries prepared at Cardington were also described.

The greater part of the address was, however, given over to describing the experimental investigation of atmospheric turbulence which is still in progress. Four anemometer stations have been set up at Cardington separated from one another by distances of about 700ft. Each station is equipped for recording the direction and velocity of the wind on a very open time scale, so that the variations of wind from second to second can be examined. Comparison of these detailed records from the four stations will furnish important information regarding the extent and intensity of the eddies which are always present in the wind. The importance of the eddying character of the air movement which we call wind is being more and more recognised both in the theory of meteorology and in the applications of the science. The stresses and strains to which structures are exposed during gales are due to the eddies. Fog formation equally depends on eddy motion, though on a different scale, so does the distribution of atmospheric pollution.

Closely associated with the details of wind structure is the distribution of temperature in the vertical and the arrangements made at Cardington and also at Ismailia for keeping this important meteorological factor under constant observation up to a level of 200ft. were described and some typical records shown.

Correspondence

To the Editor, *The Meteorological Magazine.*

Cyclones and Anticyclones

Dr. Kidson was good enough to send me a copy of the letter which you published in your January issue demurring to my use of the word cyclone for the excavation of air on the left-hand side of the flow of an air-current in a hypothetically still environment; and I have also on my file Colonel Gold's remonstrance in the December number about the generalisation of my letter in your October issue that velocity was responsible for pressure gradient in an anticyclone or a cyclone. My purpose was to deal with the question of the formation of cyclones and anticyclones as one problem rather than two in the most general way, hoping that the details of the picture might be filled in somehow elsewhere.

I had better restate my general proposition. In working at meteorological problems I had always regarded a wind equivalent to the gradient as the maximum possible. In the maps to which I was accustomed the wind was practically always less than the gradient with deviation from the isobar to the low pressure; and, with what I believe amounts to meteorological habit, if a wind appeared on the map too strong for the gradient I should have regarded it as a mistake on the part of nature or the observer, or perhaps have classed it as katabatic. That view, however, is " superficial," it belongs to the surface. What I was thinking about when I wrote in October was horizontal motion, not at the surface but in the free air.

I take as established facts, (1) that, starting from a hypothetical condition of rest, pressure-gradient can only be produced by the displacement of air, (2) that the formation of an ordinary cyclonic depression means the excavation of some five hundred thousand million tons of air from within the area of the depression and the dumping of it somewhere outside that area, (3) that the formation of an ordinary anticyclone means the dumping, within a boundary-line of normal pressure, of a like amount of air excavated from somewhere else.

My next point is that having done the excavation and dumping, if the depression and anticyclone are to be maintained they must be surrounded by a suitable run of air, counter-clockwise in the one case clockwise in the other. To preserve the *status quo* in either case the velocity and its direction must be adjusted to the gradient.

What then will happen if the velocity does not balance the gradient?

We are all agreed that at the surface when the velocity is not enough to balance the gradient there will be leakage of air from high to low—the currents will re-adjust themselves to the new condition, or, in my way of looking at it, the earth's rotation will set things in train to bring about a re-adjustment of the pressure to the velocity. But what if the velocity is in excess of the figure required to retain the " high " and protect the " low "? The rotation of the earth is no respector of meteorological terminology; it will insist upon a re-adjustment of the gradient to the velocity, which in effect will be a transfer of air from the " low " side to the " high " side.

If that general proposition be approved all the relations of " highs " and " lows " on the map may be explicable—wherever a current appears in a quiescent atmosphere excavation will be taking place on one side and dumping on the other. Dr. Kidson must forgive me for calling that rudimentary excavation the digging of a cyclone; it was mass that I was thinking about; a cyclone is a matter of shape more than of mass. The pressure-waves which Dr. Kidson wishes to investigate must be the result of a different exercise in the same art of excavation and dumping, and anyone who wishes to carry out his suggestion would be well advised to look out for currents as causes; and may I add also for deformations of an isentropic surface as indices?

But then there is Colonel Gold's difficulty about the difference between one form of depression, like a tropical revolving storm with all the excavation and dumping incidental to it, and the ordinary fluctuations of pressure. That question really wants a chapter to itself. In my letter it was merged in the question—Is it possible by what I will call natural means to get velocity in excess of the gradient?

I mentioned three originating causes of velocity, the downward flow of cold air along a slope, the upward travel of saturated air in a suitable environment, and the conservation of momentum in the convergence of air towards a central axis of rotation whether of the earth or of a tropical revolving storm. In each one of those cases, so far as I know, the moving air pays little or no attention to gradient, but leaves the gradient (a horizontal idea) to adjust itself to the horizontal velocity. Here, of course, a new influence, namely convection, comes in, which I take to be a working partner in the excavation and dumping process.

Here again is a curious feature which is generally disregarded by "superficial" observers. We can quite understand that we can get vigorous horizontal motion from the downward impulse of water in a river, or of cold air on a slope; but we do not often recognise that the same sort of thing "inverted" must happen with the air in upward convection. If there were no "ceiling" for the rising air and no means of removing the air when it gets to its ceiling, the low pressure could not even be maintained, much less developed; indeed, that is what is implied in the Norwegian term "occlusion." And the only means of removing the air when it arrives at its ceiling is the horizontal air-motion which is maintained there. So that indirectly in the maintenance of the low pressure by removal at the ceiling and directly in the conservation of momentum during the convergence at the foot, the pressure distribution is controlled by air-motion and velocities greater than the equivalent gradients are produced.

At the surface an area of low pressure is an "advective" region; in the upper air it is "divective," but not anticyclonic.

A corresponding problem in ordinary domestic experience is whether the distribution of pressure in the whirl of water in a basin with a hole in the bottom is due to the velocity of the water or the velocity to the pressure-distribution. The two adjust themselves so automatically that it is difficult to disentangle one as cause and the other as effect. The same may be said of the free atmosphere, the adjustment of pressure to velocity is really automatic. It seems quite possible that in the concentration of our attention on centres, the real dynamical agencies have passed us in the currents. I will not go further into details. I shall, however, be much disappointed if any reader should happen to think what by analogy I have called a ceiling is truly horizontal lath-and-plaster surface. My "ceiling" may have complications and even convolutions.

These views may not recommend themselves to those who are accustomed to disregard the dynamical relation between surface-wind and sea-level pressure. I should be inclined to use the word "superficial" again with regard to that practice; but the discussion of the question is too technical for this letter.

NAPIER SHAW.

10, *Moreton Gardens, S.W.*5. *January* 30*th*, 1931.

In a note in your October number headed "Cyclones and Anticyclones," Sir Napier Shaw raises the question as to whether the winds of the atmosphere are responsible for the pressure distribution, or whether the pressure is responsible for the wind distibution, and holds the view that the former statement is nearer the truth. Actually it seems that the problem would be affected to an equal extent by a third interdependent factor, namely, air density, or its associate, temperature, and any theory intended to account for the building up of a certain pressure distribution from an initial wind system must at the same time involve the temperature distributions that are invariably met with in cyclones and anticyclones. Hence although Sir Napier's suggestions may be suitable to an atmosphere with temperature gradients everywhere zero (at least in horizontal directions), it is difficult to see how they can explain the complicated state of the real atmosphere. Thus his suggestion, that when a wind exists which is somewhat in excess of that required to produce the strophic balance, a cyclone will be dug on the left-hand side and an anticyclone piled upon the right-hand side of this current (except at the equator), seems unable completely to account for the complexity of the actual case. There is, however, little doubt that this tendency does occur, but if the order of magnitude of the various effects were calculated, it might appear that a cyclone and anticyclone built up in such a way would have dimensions insignificant compared with those of real ones; or, put another way, that the time required to build up a cyclone and anticyclone of normal dimensions would be far too great for a result of the required magnitude ever to be produced. Such a result would, it seems, require the unbalanced component to be reasonably large; but if this is the case, Sir Napier's hypothesis of the practically complete balance of forces, with which he has worked for so long, could hardly have been tenable.

It seems unreasonable to try to trace the origin of the meteorological problem to any one of the terrestrial meteorological elements, for they are all intimately interdependent; all, however, owe best part of their existence and variation to solar radiation, which, as it cannot be affected by the other meteorological elements, is the only independent one, and forms a suitable subject to bear the burden of all other meteorological phenomena.

Experience in forecasting, in which as full a use as possible of the Bergen method of " fronts " is used, tends to make one attribute the direct blame for atmospheric motions to the interaction of masses of air of different characteristics (especially density), which are in juxtaposition, and to the influence on these of gravity and the earth's rotation. We may here instance two methods of procedure in regard to forecasting, applicable on different occasions and for different purposes. With the first, one observes certain masses of air moving with certain velocities, and is able, in consequence, to predict changes in the pressure distribution; in the other, one may observe pressure changes produced under the influence of, say, radiation, and then predict changes in the movements of air masses, *i.e.*, in the wind distribution—this is, roughly, what is in the mind of a forecaster when, for instance, he inquires into the seasonal variation of pressure and wind over a continent. In practice, therefore, a foreseen change in pressure leads to a forecast of wind, and *vice versa*, the temperature forecast usually following too, and there is no apparent reason for always ascribing the first move of any variation to the same particular terrestrial element. Rather the contrary, as on Sir Napier's hypothesis this would imply, for example, that in the spring the general clockwise circulation round the Siberian winter anticyclone decides to slow down, resulting in a fall of pressure over central Siberia in order to preserve the approximate balance between the forces concerned; but actually no one would doubt that this fall of pressure is due indirectly to the increasing solar radiation. This is, or should be, one of Sir Napier Shaw's gods, and I think the only admissible god, a god in this connexion presumably being defined as an external factor; but exactly how radiation produces the observed results is really one of the points in dispute, although to me it appears highly probable that temperature, pressure and wind are affected simultaneously, owing to their mutual dependence and the capacity of any of them to make an automatic adjustment simultaneously with an externally induced change.

Sir Napier Shaw's letter arose out of a remark by Captain Douglas in the September number to the effect that the problems of anticyclones and cyclones are very closely analogous and will probably be solved together; and now Sir Napier expresses his opinion that these are two aspects of a single problem, namely, the production of velocity in the atmosphere. I also am of the opinion that there is really only one problem, but suggest that that is in the first place the movement of air-masses, the expression air-mass being interpreted in accordance with the Bergen ideas of weather analysis. Certainly, this is a far more complex idea than that of the "production of velocity," on which it is largely dependent, but it marks an important stage in the development of the theory of cyclones and anticyclones, a theory which from the practical point of view will probably be "completed" independently of the more fundamental problem of velocity. This kind of analysis has met with considerable approval and success in regard to cyclones, but in regard to anticyclones has hardly received the attention it deserves. Here admittedly the problem is more difficult—perhaps partly owing to the slower circulation of an anticyclone, which together with the often very extensive air-masses involved, permits more heterogeneity to develop in one air-mass than is usually met with in cyclones, and this changing in the air-mass itself has to be allowed for; also perhaps because conditions in the upper air above an anticyclone are less easily discerned, or less understood, than those above a cyclone: for it is not only air-masses which reach the ground that have to be recognised, but also others confined to the upper air. It is felt that the present imperfect state of our knowledge of cyclones and anticyclones is due not so much to lack of understanding of the possible processes involved, as to the absence of sufficient systematic and frequent observations from the upper air.

A. F. Crossley.

42, *Waterloo Road, Bedford. November 29th,* 1930.

Thunderstorm, August 28th, 1930

In the following notes, written in consultation with Dr. Goodchild of Threlkeld, Keswick, I make the attempt to describe the growth of a vast thunder cloud above Teeshead to the east of Crossfell and Little Dunfell, Westmorland.

The Crossfell sector of the Pennine Range represents the highest plateau in England. The plateau has an elevation of 2,500 feet or more over an unbroken area of some two square miles, and though mainly limestone bears a large amount of heather—particularly on the gentle eastern slope. Its western flank descends very abruptly from Crossfell, 2,930 feet to the valley of the river Eden, 300 feet along the line of the great Pennine fault. Under easterly conditions this formation causes a characteristic local wind phenomenon called "The Helm" from the cloudcap which covers the summit, and extends for a few miles westward. Under these conditions a very strong and cold wind, sometimes amounting to a howling gale, sweeps down and continues westward for a few miles, after which it apparently turns upward, leaving calmer conditions beyond.* The effect appears to be due to an overflow of cold air from the plateau

* See "The Helm Wind," by J. G. Goodchild, late of H.M. Geo. Survey. *Trans. Cumberland and Westmoreland Association,* xiv, 1890.

which pours down the steep slope and develops a wave-like surge against the mass of relatively still air in the valley. This phenomenon is mentioned as showing a powerful source of energy which found outlet in a different way in the disturbance now to be described.

The point of observation was about one mile from the base of the escarpment. The time was about 4 p.m.

The day had been very hot, bright with slight haze and almost windless with puffs from W and NW. During the afternoon a layer of small detached clouds appeared above the summit, and these by degrees threw up small ostrich-plume extensions of thundery character. One or two towering cumulus formations were also visible far away to the south-west over Cumberland.

We had taken out our fishing rods but met with no success, and about 4 p.m. we noticed that some of the scattered clouds had coalesced into large and threatening masses, and we therefore struck westward for shelter. As we got away from the base of the hill we were able to see that two of these masses lying rather behind the edge of the plateau had assumed very definite and strikingly contrasted forms. The less imposing, which appeared to be one to two miles south-east of the summit of Crossfell showed a vast surging cumulus of irregular shape. The boiling effect was very marked—the cloud constantly and rapidly changed shape, mounting up rapidly and throwing out sharply defined protuberances which were quickly overshot by new ones. The effect was that of a vast explosion or volcanic eruption. The cloud was very dark below and brilliantly white above and extraordinarily solid looking. By itself this would have gained our somewhat anxious interest, but our attention was speedily concentrated on the greater wonder to the north, *i.e.*, a little to the east of the summit of Crossfell, where out of a base of which I have no clear memory—it was perhaps partly screened by the edge of the escarpment—rose a huge column of cloud—steadily increasing in height—perhaps half a mile or more in diameter and capped by an immense mushroom top. This top was not so well defined as was that of the cloud first described, and it had patches of mist about its surface. The effect generally was of overflow at the top and descent at the upper margin resulting in a building up process. The column below was not smooth or spiral as in pictures of tornadoes and waterspouts: it was composed of vast "vortex rings," which increased in number as the whole edifice grew, until there were at least five. We estimated the height of these rings at about 500 feet each—they were closely touching and rotating visibly at a high speed. The rotation was outwards from the top and downwards, and we thought that the surface velocity might certainly be not less than 60 m.p.h. Their surface was in some cases sharply grooved and sharply defined, they had almost the appearance of a pile of balloon motor tyres with convex-shaped ribs crossing the treads. They increased, however, in general dimensions towards the top where they merged in the great canopy.

The whole spectacle was some miles away, and we were agreed that surface movements generally were at "express train" speed—indeed, this was the most remarkable feature of the phenomenon, for probably less than an hour covered the period from its genesis until it lost its sharply-defined form. Our impression was that the wet surface of the upper plateau—there had been a good deal of rain a few days previously—had been heated up, and that a layer of warm damp air was forcing its way upward through a colder and drier stratum above. This ascent in the first case described was irregular; in the second an actual column was formed which developed the "vortex rings" through friction as it mounted up. The friction between the rings themselves must have been immense, since they were all rotating in one way so that adjacent surfaces were moving in opposite directions at the high speed described.

No lightning or thunder was noted, but the cloud evidently formed one of a number which produced the spectacular display in the Lothian and Border district that night.* We had the impression that we were witnessing the building up of an immense "influence machine" rather too closely to be pleasant.

The sketch (see frontispiece) is from memory after an interval; it is probably rather diagrammatic, but does not exaggerate the ring effect, which was vividly clear. The total height of the whole may have been 10,000 feet. It was much foreshortened from our relatively close view point, but, even so, quite dwarfed the normally impressive mass of Crossfell.

F. C. MEARS.

Thunderstorms of November 2nd, 1930

Referring to Mr. Dight's interesting article in the December *Meteorological Magazine*, it should be stated that storms occurred much farther north than Leafield and Cardington.

Here, we had two, the first between 9.25 and 9.35 a.m., the second coming exactly three hours later and lasting half an hour. Total rainfall 0.11in.

G. C. WOOLDRIDGE.

Ellerslie, Coventry Road, Market Harborough. December 21st, 1930.

Halo Complex

On Sunday, November 9th, 1930, halo phenomena were seen which are very rare in New Zealand. At Cape Palliser at the extreme southern end of the North Island, Mr. W. H. Atack saw a complete horizontal circle, the halo of 22° and brilliant

* See *Meteorological Magazine,* 65, 1930, p. 184.

parhelia where the two intersected. The halo of 22° was never complete, various portions appearing at different times.

On the same day, at Russell near the other extremity of the North Island, Mr. Lloyd Mandeno observed the halo of 22° and a large portion of the circumzenithal arc.

The weather at the time was of the westerly type, a series of inverted V-depressions moving rapidly eastward in southern latitudes. The trough-line of one of these depressions had passed on Saturday afternoon and the next followed on Tuesday morning.

EDWARD KIDSON.

Meteorological Office, Wellington, New Zealand. November 12th, 1930.

Temperature observations in fog at Kew Observatory

I gather from the article under the above title by Mr. L. H. G. Dines in the January number of the *Meteorological Magazine* that one of the criteria for a fog employed is that of saturation. In view of work that I have recently published* showing that fogs occur frequently at all kinds of stations, town, rural or seaside, with unsaturated air (sometimes distinctly unsaturated air), I would ask whether that criterion is really sound, and whether the fact that saturation is not apparently necessary for a fog may not explain some of the difficulties mentioned by Mr. Dines.

WILLIAM H. PICK.

33, *Brunswick Square, London, W.C.*1. *January 22nd,* 1931.

In reply to Mr. Pick's criticism, it would have made the subject clearer if I had given some indication in my article of the density of the fogs in which observations were made. They were almost without exception thick fogs, in which the range of vision at the surface did not exceed two or three hundred yards, often much less.

The ultimate test of having reached a point above the thick fog has been, as Mr. Pick suggests, that of non-saturation, but the immediate object of quest is an inversion, which in the type of fog investigated seems always to be associated with a fall in relative humidity. This inversion had a mean value of at least 10°F. in the fogs investigated. If we assume the vapour pressure to be the same in and above the fog it follows that the relative humidity above must be of the order of 70 per cent.—too low for any appreciable fog to exist.

Another point which may be mentioned is that the fogs investigated were almost all pre-eminently radiation fogs. The general impression given by such fogs as they form is that they

* See *Meteorological Magazine*, 1929, p. 209 and (more fully) *London Q.J.R. Meteor. Soc.* 55, 1929, pp. 305-6.

have a pretty definite upper limit, an impression which is strengthened by the fact that an appreciable breeze is often found above the inversion, while below is a nearly quiescent mass of fog.

As Mr. Pick points out it is not possible to assert that above the inversion the visibility is over the 1,100 yards limit, but there seems to be a marked change in the visibility at the level of the inversion, and it is the height of this point of discontinuity which is tabulated in my article on page 279.

L. H. G. DINES.

NOTES AND QUERIES

Driving in Fog

The recent fogs have induced many motorists to buy special lamps and devices for increasing the distance they can see in these trying circumstances. One of these devices—the yellow filter—seems to me to be based on a fallacy, and to be practically useless. The idea is that the longer the wave-length of the light source, the better will it be transmitted, and the less will it be scattered by the fog particles; and that therefore, by shifting the colour of the source towards the red end of the spectrum, one will obtain better penetration and less confusion from illuminated fog.

With indifferent visibility conditions, the obscuring particles in the atmosphere may be sufficiently small to produce this colour effect—indeed the sun and other sources of light often do appear redish, and also we are familiar with the blue "haze" which sometimes suffuses a landscape. But when the visibility becomes so poor that motoring is interfered with, the particle size is much too big for this effect to obtain to any appreciable extent.

The reason why many people, who have used these filters, believe in them, is, I believe, due to an illusion. The filters not only alter the colour of the light, but also cut down its intensity, and with it the brightness of the fog itself. The sensation of being up against

"A wall of nothing at the world's last edge,

. . . .

Shutting the visible (road) in like a well"

is thereby relieved. Practical observation on a number of occasions, has, however, convinced the writer that one cannot actually see any further.

The best solution to the problem of driving in fog, is to have as intense a light as possible, focused into a much narrower beam than is usual in ordinary head lights, fixed as low and as far forward as possible; and the driver should sit as high as possible, so that he is looking at a big angle to the beam and not along it. The narrowness of the beam, and the direction in which it is sent, should be adjustable according to the degree of fog. With this arrangement the objects ahead (or on the near side of the road) are illuminated as brightly as possible. Further, the illuminated fog within the beam (which tends to swamp the reflected light from the object) appears less bright when viewed from a high angle, so the confusion from this cause is minimised. This is the scheme adopted on the L.G.O.C. buses, and its superiority over other arrangements is shown by the fact that so many car drivers find it convenient to follow the buses when there is thick fog about.

M. G. Bennett.

Tornado at Suva, Fiji

An interesting report of a tornado at Suva was forwarded by Capt. Twentyman, Harbourmaster, with the meteorological return for February, 1930. The observations were made by Mr. V. Osborn.

"On Friday night, February 21st, 1930, weather conditions were very unsettled and there appeared to be a cyclonic disturbance north-west of Suva, apparently moving south-south-east. Very heavy rain fell during the early hours of Saturday morning. There was a fairly rapid fall in the barometer after 10 a.m. Saturday, but at 5 p.m. it commenced to rise. Squally winds from ENE. and rain were experienced during the day. At 5.40 p.m. the barometer suddenly fell from 29·65in. to 29·44in. and rose again to 29·65in. in approximately one minute. At the same instant a whirlwind or tornado struck the Government slip and Messrs. Terry & Son's works. It moved in a southwest direction, passing close to this office, where the maximum velocity of wind recorded by the Dines anemometer was 77 m.p.h. This whirlwind appeared to originate near the Tamavua hills and crossing the harbour disappeared over the reef a short distance southeast of the pile light.

Trees in the path of the whirlwind were uprooted or had their branches ripped off, a cement electric light post was broken in two; two new heavy wooden doors were blown away from the Shell Oil Co.'s new store; the auxiliary ketch *Helena* (59 tons) was lifted bodily off the Government slipway and blown against a shed approximately 10 yards away from the slip; several Government offices were unroofed, also workshops; half of Messrs. Terry & Son's works was demolished; two dinghies were seen to be lifted up in the centre of the whirl and carried away and other minor damage was done to small craft and buildings at Walu Bay." A tracing of the Suva barogram by Mr. Osborn shows that by 3.30 p.m. on the 22nd pressure had fallen about two-tenths of an inch (nearly 7 mb.) from the value prevailing in the early part of the 21st. The effect of the tornado appears as a momentary dip in the trace of about two-tenths of an inch, interrupting the regular diurnal rise of pressure."

Polar and other Fronts

In a recent paper by one of the Bergen school of meteorologists, the name dynamical climatology* is proposed for the study of "collective processes" which can be treated dynamically and thermodynamically as units, examples quoted for the tropics or for regions where orography exerts a strong influence being trade winds, monsoons, the scirocco, föhn, bora, chinook. In the latitudes of unperiodic weather variations attention might be directed to the study of quasi-stationary weather types. Whereas in ordinary climatology we have tables and maps of the distribution of the meteorological elements, in dynamical climatology we would have tables and maps of frequency and intensity of well-defined systems.

Although this theme gives the paper its title, it is only one of a rather bewildering variety of topics touched on, and when the paper was discussed at the "Monday evening discussion" at the Meteorological Office on January 26th, interest was centred mainly on the part dealing with the general circulation of the atmosphere. The analogy of the atmospheric heat engine appears to exert a great fascination for the Norwegian meteorologists, and we find now that the number of closed vertical circulations or vertical toothed gears in the engine is multiplied some threefold, as compared with the design originally set out by V. Bjerknes. It is difficult to see how the atmospheric circulation can be maintained by these vertical gears and, particularly how air exchange between poles and equator is provided for, while the estimated ratio of the driving force available in polar and equatorial regions requires confirmation. Bergeron sets out an ideal scheme of atmospheric circulation on a symmetrical distribution of land and sea, obtained by a "re-arrangement" of Eurasia. His ideal globe has three meridional continental zones, presumably three of Köppen's ideal continents now equipped with atmospheric gears. It is not clear what can be gained by such an attempt to modernise old theories of atmospheric circulation—the amount of upper air investigation which has been carried on over the oceans in the last 10 years is sufficient to justify rather an attempt at describing the upper circulation as it actually is, not as it might be on some rearranged globe. The fact that Bergeron omits to explain completely the minutiæ of his diagram makes it difficult to discuss his scheme in detail, but it may be noted that the diagram is stated to be for a mean season, about October, whereas on

* Richtlinien einer dynamischen Klimatologie. By Tor Bergeron. *Meteor. Zs. Braunschweig*, 47, 1930, pp. 246-62.

examination it appears to show winter conditions equally developed in both hemispheres simultaneously. The circulation apparently depends entirely on the troposphere. Bergeron also develops an idealised scheme of pressure distribution in the part of the northern hemisphere bounded west and east by the Rocky and Ural Mountains, with arctic, temperate and equatorial fronts. He proceeds, however, to show how these fronts can be traced on Köppen's maps of the air circulation over the Pacific. Tropical revolving storms are stated to be produced, by some process of which details are not given, when the equatorial front is at its farthest from the equator.

The idea of a front between the NE. and SE. trades was introduced in this country ten years ago,* early in the history of the Polar Front theory, and has recently been mentioned again† as one of the results of aerological work carried out by the German research ship *Meteor*, while definite frontal phenomena have been observed in the doldrums region.‡ Whether we shall have to abandon the term "doldrums" is apparently not yet settled, but meanwhile writers of text books might be asked to refrain from publishing any more diagrams of continuous belts of trade winds extending right round the globe. It is to be hoped that later Bergeron will set out at greater length the ideas contained in his paper and show how his claim to bring the origin, life history and tracks of cyclones in all latitudes under a uniform view is borne out. The present paper is valuable in that it draws attention to the need for a thorough revision of our ideas of the general circulation of the atmosphere, and if the reviser wishes to head his remarks with a quotation he might well take a pithy saying by Coyecque§—"La légende du pic de Ténériffe doit être détruite."

S. T. A. MIRRLEES.

Reviews

On the distribution of Earthquakes in the Netherlands East Indian Archipelago. II, 1920-1926, with a discussion on Time Tables, by Dr. S. W. Visser. K. Ned. Mag. Meteor. Obs., Batavia, Verh. No. 22. Size $10\frac{3}{4} \times 7\frac{1}{4}$in., pp. 116. *Illus.* Weltevreden, Batavia, 1930.

The East Indian Archipelago is one of the centres of frequent seismic activity; it is fitting, therefore, that the earthquakes of this region should have received such detailed study as has

* The clash of the trades in the Pacific. By C. E. P. Brooks and H. W. Braby. *London, Q.J.R. Meteor. Soc.* 47, 1921, pp. 1-13.

† Weickmann (quoting results by Defant) in Gutenberg's Lehrbuch der Geophysik, Berlin, 1929.

‡ Höhenwindmessungen. . . . zwischen Hamburg und dem La Plata. By J. H. Soltau. *Hamburg, Aus. d. Arch. Seewarte*, 49, 1930. Nr. 1.

§ Notions de météorologie générale et nautique. Paris, 1925.

been given by Dr. Visser. The frequency of earthquakes which were strong enough to have been felt was about 470 a year but only about seven per cent. had an inland origin; the great majority of epicentres were situated on the slopes of ocean deeps. On the average one earthquake a year caused severe damage. That part of the paper which is devoted to a discussion of the time tables of the various types of earthquake waves is of great interest. Dr. Visser finds that the times of travel of the longitudinal wave which passes through the earth's central core agree better with Gutenberg's table than with the times used in the International Seismological Summary. In the case of reflected longitudinal waves the evidence appears to favour the idea that the reflexion occurs at the surface of discontinuity at 40Km. depth. On the other hand for reflected waves which start as a longitudinal disturbance and finish as a transverse wave ("Wechselwellen") the author suggests that the reflexion takes place at the outer surface and that the change to transverse motion occurs when the reflected ray passes the 40Km. layer. Further evidence on the point is required from other parts of the world. Dr. Visser is to be congratulated on the thoroughness with which he has dealt with the observations at his disposal.

F. J. SCRASE.

Obituary

We regret to learn of the death on February 8th, at the age of 79, of Mr. Henry Harries, formerly Acting Superintendent of the Marine Division of the Meteorological Office.

The Weather of ~~August, 1930~~ January, 1931.

Pressure was below normal over Canada, north-eastern United States, Bermuda and most of Europe (except the extreme north and east) and the Iberian Peninsula, the greatest deficits being 9.3mb. at Lat. 60° N., Long. 110° W. and 13.6 mb. at Bornholm. Pressure was above normal over south-western United States, most of the North Atlantic, north-west Africa, the Iberian Peninsula, Iceland, Spitsbergen, northern Scandinavia, north and east Russia and western Siberia, the greatest excesses being 8.5 mb. at Stykkisholm and 7.7 mb. at Ekaterinburg. Temperature was above normal at Spitsbergen, northern Norway, central and southern Europe, the excess being as much as 9°F. at Spitsbergen, and slightly below normal in southern Scandinavia. Precipitation was deficient in Spitsbergen, Norway and west Sweden, and in excess in southern Scandinavia and central Europe, being about twice the normal in east and south-east Sweden.

Over the British Isles much sunshine and many gales were experienced during January, and also early in the month, much mist and fog in England; precipitation was irregular in distribution and temperature about normal. During the first three or four days a complex low pressure system passing eastwards across the British Isles dominated conditions. Showers of rain, hail, and in the north of sleet and snow occurred generally, but sunshine records were good on the 2nd, and in the north also on the 1st, though mist or fog were general in the south-east. On the 4th the belt of high pressure to the west of the British Isles moved eastwards, and cold anticyclonic weather prevailed with much mist and fog. Sunshine records, however, were good at places unaffected by the fog, 7.0hrs. were recorded at Littlehampton and Eastbourne on the 5th and Plymouth on the 7th. Day temperatures remained below 32°F. at a few places on the 6th, 7th and 8th, 27°F. was the maximum at Renfrew on the 6th, while the lowest minimum temperatures for the month were recorded on the 7th and 8th, Rhayader registering 16°F. in the screen on the 7th and 7°F. on the grass on the 7th and 8th and Dundee 11°F on the grass on the 7th. On the 8th there began a general southerly drift of the anticyclone, depressions passed eastwards from Iceland, and a considerable rise of temperature ensued with unsettled weather and slight rain most days. On the 14th, however, an anticyclone off our western coasts spread partly over the country, and much sunshine was experienced in the south-west, while severe frost occurred at night. Snow and sleet fell heavily in the north on the 13th and 14th, and slightly as far south as Cambridge and Dublin. By the 15th, however, the northern depression was again the predominating influence, and a stormy period ensued between the 15th and 17th, when south-westerly gales occurred with local gusts of 70 m.p.h. or more. Mild unsettled weather continued until the 31st, the highest temperatures of the month being recorded from the 16th to 19th and on the 31st, 54°F. was reached at Waterford on the 16th, 18th and 19th. Snow fell in Scotland and north England on the 18th and 19th, and heavy rain in England on the 22nd, when 2.39in. was measured at Borrowdale, Cumberland, and 1.93in. at Llynfawr (Glamorgan). Another stormy period occurred from the 23rd to 25th, when westerly gales were general. The 24th to 27th were mainly sunny days, over 7hrs. bright sunshine being recorded at several places, and on the 26th as much as 8.0hrs. at Ross-on-Wye. On the 31st there were further gales and heavy snow in the north and west. Dundee and Dumfries reported snow lying to a depth of 6in. and Durham to a depth of 5cm., while Dalwhinnie had drifts 4ft. deep. Rainfall was heavy in the south on that day and also in Ireland on the 30th, 2.39in. was measured at Fofanny (Co. Down) on the 30th and 2.32in. at Tynywaun (Glamorgan) on the 31st. The distribution of bright sunshine for the month was as follows:—

	Total (hrs.)	Diff. from normal (hrs.)		Total (hrs.)	Diff. from normal (hrs.)
Stornoway	32	+ 4	Liverpool	61	+ 6
Aberdeen	63	+ 15	Ross-on-Wye	76	+30
Dublin	73	+ 16	Falmouth	81	+23
Birr Castle	59	+ 10	Gorleston	56	0
Valentia	48	0	Kew	54	+11

The special message from Brazil states that the rainfall in the northern and central regions was generally scarce with averages 1.14in. and 2.68in. below normal respectively and irregular in the southern regions with 0.35in. below normal. Six small anticyclones passed across the country. Crops were generally in good condition except that the cane and cotton crops of the north-east were suffering from lack of rain. At Rio de Janeiro pressure was 0.2mb. below normal and temperature normal.

Miscellaneous notes on weather abroad culled from various sources. Heavy snowfalls in Denmark and Sweden early in the month caused interruption to traffic and a breakdown in the the electric supply in southern Jylland. About the middle of the month intense cold was experienced in northern Italy, Spain, Switzerland and Bavaria, while snow fell on the 16th in Algiers for the first time for several years. Many passes in northern Italy were closed by snow, which at some points was 7ft. deep, and several rivers in Bavaria and Switzerland were frozen over. Later in the month many large avalanches fell in the Alps, causing several disasters.—(*The Times.*)

Torrential floods occurred on the Wadi Itham in the Hejaz about the 8th. Half of the village of Akaba was washed down to the Red Sea. Intense cold was experienced in Shanghai early in the month.—(*The Times*)

Heavy rain in the Transvaal at the beginning of the month brought the drought which has been prevailing there to an end. —(*The Times.*)

A typhoon swept over the Philippines about the 4th; about 82 people were killed and some 50 were missing.—(*The Times.*)

Temperature was high in the Missouri Valley and the northern part of the Mountain Region of the United States during the whole month, and abnormally so during the first and last weeks. For the week ending the 27th the mean temperature for Williston was as much as 25°F. above normal. Rainfall was exceptionally heavy in the Argentine amounting to over 3½ times the normal.—(Washington, U.S. Dept. Agric., *Weekly Weather and Crop Bulletin.*)

Rainfall, January, 1931—General Distribution

England and Wales ...	103	per cent of the average 1881-1915.
Scotland	128	
Ireland	88	
British Isles	107	

Rainfall: January, 1931: England and Wales

Co.	Station	In.	Per-cent. of Av.	Co.	Station	In.	Per-cent. of Av.
Lond .	Camden Square	1·34	72	*Rut* .	Ridlington	1·58	85
Sur .	Reigate, Alvington	2·33	97	*Linc* .	Boston, Skirbeck	2·42	149
Kent .	Tenterden, Ashenden	2·24	104	,, .	Cranwell Aerodrome	2·17	126
,, .	Folkestone, Boro. San.	3·02	...	,, .	Skegness, Marine Gdns	1·90	110
,, .	Margate, Cliftonville	1·59	96	,, .	Louth, Westgate	2·54	117
,, .	Sevenoaks, Speldhurst	1·85	...	,, .	Brigg, Wrawby St.	2·15	...
Sus .	Patching Farm	2·59	100	*Notts* .	Worksop, Hodsock	2·13	120
,, .	Brighton, Old Steyne	2·14	88	*Derby* .	Derby, L. M. & S. Rly.	1·59	79
,, .	Heathfield, Barklye	2·84	105	,, .	Buxton, Devon Hos.	6·84	153
Hants .	Ventnor, Roy. Nat. Hos.	2·57	100	*Ches* .	Runcorn, Weston Pt.	3·51	148
,, .	Fordingbridge, Oaklnds	2·56	93	,, .	Nantwich, Dorfold Hall	2·82	...
,, .	Ovington Rectory	3·08	114	*Lancs* .	Manchester, Whit. Pk.	4·63	184
,, .	Sherborne St. John	1·36	58	,, .	Stonyhurst College	6·79	158
Berks .	Wellington College	1·29	65	,, .	Southport, Hesketh Pk	3·43	135
,, .	Newbury, Greenham	1·98	86	,, .	Lancaster, Strathspey	4·57	...
Herts .	Welwyn Garden City	1·76	...	*Yorks* .	Wath-upon-Dearne	1·48	77
Bucks .	H. Wycombe, Flackwell	1·68	...	,, .	Bradford, Lister Pk.	2·56	89
Oxf .	Oxford, Mag. College	1·19	69	,, .	Oughtershaw Hall	6·88	...
Nor .	Pitsford, Sedgebrook	1·46	78	,, .	Wetherby, Ribston H.	2·12	103
,, .	Oundle	·97	...	,, .	Hull, Pearson Park	2·31	128
Beds .	Woburn, Crawley Mill	1·24	72	,, .	Holme-on-Spalding	2·20	...
Cam .	Cambridge, Bot. Gdns.	1·51	101	,, .	West Witton, Ivy Ho.	3·11	98
Essex .	Chelmsford, CountyLab	1·84	120	,, .	Felixkirk, Mt. St. John	2·61	131
,, .	Lexden Hill House	1·77	...	,, .	Pickering, Hungate	2·43	116
Suff .	Hawkedon Rectory	2·21	127	,, .	Scarborough	2·81	140
,, .	Haughley House	1·45	...	,, .	Middlesbrough	1·70	106
Norf .	Norwich, Eaton	2·42	123	,, .	Baldersdale, Hury Res.	3·94	...
,, .	Wells, Holkham Hall	...	...	*Durh* .	Ushaw College	2·11	103
,, .	Little Dunham	2·62	74	*Nor* .	Newcastle, Town Moor	2·51	123
Wilts .	Devizes, Highclere	1·78	82	,, .	Bellingham, Highgreen	2·29	80
,, .	Bishops Cannings	1·90	82	,, .	Lilburn Tower Gdns.	2·65	125
Dor .	Evershot, Melbury Ho.	3·99	115	*Cumb* .	Geltsdale	2·80	...
,, .	Creech Grange	2·69	83	,, .	Carlisle, Scaleby Hall	2·59	104
,, .	Shaftesbury, Abbey Ho.	2·04	78	,, .	Borrowdale, Seathwaite	11·25	85
Devon .	Plymouth, The Hoe	3·23	97	,, .	Borrowdale, Rosthwaite	9·93	...
,, .	Polapit Tamar	...	...	,, .	Keswick, High Hill	5·07	...
,, .	Ashburton, Druid Ho.	...	...	*West* .	Appleby, Castle Bank	3·32	104
,, .	Cullompton	3·51	108	*Glam* .	Cardiff, Ely P. Stn.	3·41	90
,, .	Sidmouth, Sidmount	2·30	80	,, .	Treherbert, Tynywaun	10·18	...
,, .	Filleigh, Castle Hill	4·92	...	*Carm* .	Carmarthen Friary	3·77	86
,, .	Barnstable, N. Dev. Ath.	3·66	112	,, .	Llanwrda	6·02	113
Corn .	Redruth, Trewirgie	4·52	119	*Pemb* .	Haverfordwest, School	5·34	116
,, .	Penzance, Morrab Gdn.	5·32	140	*Card* .	Aberystwyth	3·32	...
,, .	St. Austell, Trevarna	5·28	123	,, .	Cardigan, County Sch.	3·60	...
Soms .	Chewton Mendip	3·22	84	*Brec* .	Crickhowell, Talymaes	4·10	...
,, .	Long Ashton	2·25	79	*Rad* .	BirmW.W.Tyrmynydd	7·71	122
,, .	Street, Millfield	2·14	...	*Mont* .	Lake Vyrnwy	6·25	111
Glos. .	Cirencester, Gwynfa	2·06	82	*Denb* .	Llangynhafal	2·77	104
Here .	Ross, Birchlea	1·59	66	*Mer* .	Dolgelly, Bryntirion	9·10	160
,, .	Ledbury, Underdown	1·11	50	*Carn* .	Llandudno	2·29	89
Salop .	Church Stretton	2·57	102	,, .	Snowdon, L. Llydaw 9	20·85	...
,, .	Shifnal, Hatton Grange	1·72	89	*Ang* .	Holyhead, Salt Island	2·61	90
Worc .	Ombersley, Holt Lock	1·36	71	,, .	Lligwy	2·38	83
,, .	Blockley	1·72	...	*Isle of Man*			
War .	Birminghm, Edgbaston	1·99	99		Douglas, Boro' Cem.	6·04	180
Leics .	Thornton Reservoir	1·61	81	*Guernsey*			
,, .	Belvoir Castle	1·79	101		St. PeterP't. GrangeRd.	3·99	136

Rainfall : January, 1931 : Scotland and Ireland

Co.	Station	In.	Per-cent of Av.	Co.	Station	In.	Per-cent of Av.
Wigt	Pt. William, Monreith	4·22	129	*Suth*	Loch More, Achfary	14·29	196
,,	New Luce School	6·42	158	*Caith*	Wick	3·13	127
Kirk	Carsphairn, Shiel	10·07	146	*Ork*	Pomona, Deerness	5·30	154
Dumf.	Dumfries, Crichton, R.I	4·20	...	*Shet*	Lerwick	4·70	110
,,	Eskdalemuir Obs.	5·06	94	*Cork*	Caheragh Rectory	3·16	...
Roxb	Branxholm	2·52	92	,,	Dunmanway Rectory	3·18	51
Selk	Ettrick Manse	3·17	67	,,	Ballinacurra	1·63	41
Peeb	West Linton	2·71	...	,,	Glanmire, Lota Lo.	2·23	52
Berk	Marchmont House	2·38	106	*Kerry*	Valentia Obsy	3·20	58
Hadd	North Berwick Res.	2·04	119	,,	Gearahameen	8·90	...
Midl	Edinburgh, Roy. Obs.	1·94	113	,,	Killarney Asylum	3·93	66
Lan	Auchtyfardle	2·55	...	,,	Darrynane Abbey	3·42	68
Ayr	Kilmarnock, Agric. C.	4·49	131	*Wat*	Waterford, Brook Lo.	1·99	54
,,	Girvan, Pinmore	8·22	174	*Tip*	Nenagh, Cas. Lough	3·13	79
Renf	Glasgow, Queen's Pk.	3·32	100	,,	Roscrea, Timoney Park	2·52	...
,,	Greenock, Prospect H.	6·62	97	,,	Cashel, Ballinamona	3·24	85
Bute	Rothesay, Ardencraig	...	...	*Lim*	Foynes, Coolnanes	3·30	87
,,	Dougarie Lodge	5·14	...	,,	Castleconnel Rec.	3·47	...
Arg	Ardgour House	11·46	...	*Clare*	Inagh, Mount Callan	6·51	...
,,	Manse of Glenorchy	11·11	...	,,	Broadford, Hurdlest'n.	2·93	...
,,	Oban	5·72	105	*Wexf.*	Gorey, Courtown Ho.	2·54	81
,,	Poltalloch	6·49	128	*Kilk*	Kilkenny Castle	2·20	69
,,	Inveraray Castle	8·45	103	*Wic*	Rathnew, Clonmannon	2·35	...
,,	Islay, Eallabus	8·68	185	*Carl*	Hacketstown Rectory	2·97	83
,,	Mull, Benmore	...	...	*Leix*	Blandsfort House	2·41	73
,,	Tiree	...	...	,,	Mountmellick	2·90	...
Kinr	Loch Leven Sluice	1·88	60	*Off'ly*	Birr Castle	1·85	65
Perth	Loch Dhu	6·70	74	*Kild'r.*	Monasterevin	1·93	...
,,	Balquhidder, Stronvar	4·79	...	*Dubl*	Dublin, FitzWm. Sq.	1·30	57
,,	Crieff, Strathearn Hyd.	3·47	86	,,	Balbriggan, Ardgillan.	2·08	91
,,	Blair Castle Gardens	3·47	104	*Me'th*	Beauparc, St. Cloud	2·08	...
Angus.	Kettins School	3·26	138	,,	Kells, Headfort	...	...
,,	Dundee, E. Necropolis	2·94	151	*W.M.*	Moate, Coolatore	2·27	...
,,	Pearsie House	2·54	...	,,	Mullingar, Belvedere	2·87	89
,,	Montrose, Sunnyside	3·36	169	*Long*	Castle Forbes Gdns	2·29	69
Aber	Braemar, Bank	4·27	134	*Gal*	Ballynahinch Castle	5·07	81
,,	Logie Coldstone Sch.	2·69	122	,,	Galway, Grammar Sch.	2·69	...
,,	Aberdeen, King's Coll.	3·06	140	*Mayo*	Mallaranny	6·55	...
,,	Fyvie Castle	3·53	149	,,	Westport House	5·12	110
Moray.	Gordon Castle	2·70	134	,,	Delphi Lodge	10·63	136
,,	Grantown-on-Spey	...	...	*Sligo*	Markree Obsy	5·02	128
Nairn.	Nairn, Delnies	...	...	*Cav'n.*	Belturbet, Cloverhill	2·43	81
Inv	Kingussie, The Birches	2·93	...	*Ferm*	Enniskillen, Portora	3·69	...
,,	Loch Quoich, Loan	10·31	...	*Arm*	Armagh Obsy	2·74	109
,,	Glenquoich	13·23	96	*Down*	Fofanny Reservoir	9·12	...
,,	Inverness, Culduthel R.	3·08	...	,,	Seaforde	3·15	100
,,	Arisaig, Faire-na-Squir	5·48	...	,,	Donaghadee, C. Stn.	2·58	102
,,	Fort William	7·43	...	,,	Banbridge, Milltown	2·07	...
,,	Skye, Dunvegan	7·62	...	*Antr*	Belfast, Cavehill Rd.	3·91	...
R & C.	Alness, Ardross Cas	5·64	148	,,	Glenarm Castle	6·00	...
,,	Ullapool	8·44	185	,,	Ballymena, Harryville	4·41	119
,,	Torridon, Bendamph	11·17	119	*Lon*	Londonderry, Creggan	5·95	165
,,	Achnashellach	11·86	...	*Tyr*	Donaghmore	3·49	...
,,	Stornoway	7·64	...	,,	Omagh, Edenfel	3·49	99
Suth	Lairg	6·52	199	*Don*	Malin Head	3·96	...
,,	Tongue	6·61	168	,,	Dunfanaghy	5·08	...
,,	Melvich	5·97	...	,,	Killybegs, Rockmount.	7·46	133

Climatological Table for the British Empire, August, 1930.

STATIONS	PRESSURE: Mean of Day M.S.L. (mb.)	PRESSURE: Diff. from Normal (mb.)	TEMPERATURE: Absolute Max. (°F.)	TEMPERATURE: Absolute Min. (°F.)	TEMPERATURE: Mean Values Max. (°F.)	TEMPERATURE: Mean Values Min. (°F.)	TEMPERATURE: Mean Values ½ max. and min. (°F.)	TEMPERATURE: Mean Values Diff. from Normal (°F.)	TEMPERATURE: Mean Wet Bulb (°F.)	Relative Humidity (%)	Mean Cloud Am'nt (0—10)	PRECIPITATION: Am'nt (in.)	PRECIPITATION: Diff. from Normal (in.)	PRECIPITATION: Days	BRIGHT SUNSHINE: Hours per day	BRIGHT SUNSHINE: Percentage of possible
London, Kew Obsy.	1013·0	− 2·3	89	48	70·9	54·7	62·8	+ 1·2	56·4	86	5·9	2·82	+ 0·58	15	7·1	49
Gibraltar	1016·7	0·0	93	64	85·5	68·3	76·9	+ 0·9	67·4	84	5·4	0·00	− 0·13	0	..	..
Malta	1016·7	+ 1·4	92	66	83·1	71·5	77·3	− 1·8	70·6	72	1·1	1·52	+ 1·38	1	11·7	87
St. Helena	1017·8	+ 1·3	63	52	59·0	53·5	56·3	− 1·6	54·2	94	9·5	2·94	− 0·78	23	..	..
Sierra Leone	1015·0	+ 2·3	85	68	81·1	70·8	75·9	− 2·0	74·1	89	8·7	23·09	− 13·48	25	..	..
Lagos, Nigeria	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..
Kaduna, Nigeria	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..
Zomba, Nyasaland	1016·4	− 0·4	83	47	74·3	53·7	64·0	− 0·9	..	74	3·2	0·02	− 0·35	1	..	..
Salisbury, Rhodesia	1016·8	− 0·5	84	36	73·2	45·6	59·4	− 0·8	48·8	41	1·0	0·00	− 0·08	0	10·2	89
Cape Town	1020·8	+ 0·6	77	38	65·1	47·6	56·3	+ 0·7	48·8	91	5·2	2·45	− 0·92	11	..	..
Johannesburg	1021·9	− 0·3	76	32	63·1	41·4	52·3	− 2·0	40·7	45	1·9	0·66	+ 0·15	1	9·8	87
Mauritius	1021·7	+ 1·2	77	55	73·9	61·5	67·7	− 0·8	63·1	68	5·1	1·42	− 0·93	16	8·0	70
Bloemfontein	..	..	..	..	..	..	..	..	..	..	..	0·13	− 0·34	..	..	..
Calcutta, Alipore Obsy.	1000·9	− 0·1	92	76	88·3	79·0	83·7	+ 0·7	79·2	90	8·8	14·67	+ 1·98	19*	..	..
Bombay	1006·3	+ 0·4	88	74	85·1	76·5	80·8	+ 0·1	75·9	85	8·7	6·64	− 7·81	13*	..	..
Madras	1005·3	− 0·2	101	73	96·0	78·0	87·0	+ 1·1	75·1	67	7·4	3·70	− 0·94	6*	..	..
Colombo, Ceylon	1010·4	+ 0·7	86	72	85·3	76·0	80·7	− 0·4	76·6	77	6·5	1·93	− 1·20	13	7·9	64
Hongkong	1005·7	+ 0·6	92	73	86·9	78·5	82·7	+ 0·6	78·6	83	6·4	6·07	− 7·98	10	8·3	64
Sandakan	..	..	92	73	89·9	75·1	82·5	+ 0·7	77·1	81	..	8·21	+ 0·15	6	..	..
Sydney, N.S.W.	1015·7	− 2·5	79	42	65·0	47·9	56·5	+ 1·5	49·8	72	3·1	1·12	− 1·89	9	7·5	69
Melbourne	1015·8	− 2·3	70	34	57·5	44·2	50·9	− 0·2	46·7	71	6·8	2·94	+ 1·13	20	4·1	38
Adelaide	1017·6	− 1·7	73	40	61·4	46·2	53·8	− 0·2	48·5	65	7·7	3·52	+ 1·01	18	4·9	45
Perth, W. Australia	1018·7	− 0·1	72	41	63·8	49·7	56·7	+ 0·8	52·9	78	5·9	4·89	− 0·73	20	5·5	50
Coolgardie	1019·1	− 0·2	79	36	64·8	43·1	53·9	+ 0·3	49·3	66	4·0	1·61	+ 0·59	7	..	..
Brisbane	1018·1	− 1·1	82	42	71·6	50·5	61·1	+ 0·7	54·0	61	2·8	1·75	− 0·38	7	8·2	74
Hobart, Tasmania	1012·0	− 1·6	62	35	55·5	41·4	48·5	+ 0·5	43·5	74	6·0	1·43	− 0·41	13	5·0	48
Wellington, N.Z.	1015·4	+ 0·3	64	36	53·0	43·1	48·1	− 0·5	45·9	85	7·9	4·52	+ 0·03	17	3·5	33
Suva, Fiji	1014·9	+ 0·6	90	61	77·4	67·0	72·2	− 1·5	67·2	74	6·5	1·81	− 6·43	17	5·1	44
Apia, Samoa	1011·9	− 0·3	88	69	83·8	73·4	78·6	+ 0·8	74·4	72	4·5	0·31	− 2·84	3	7·8	67
Kingston, Jamaica	1014·0	+ 0·5	93	72	90·1	74·3	82·2	+ 0·7	72·4	79	2·4	1·58	− 1·97	7	8·9	70
Grenada, W.I.	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..
Toronto	1015·6	+ 0·2	95	46	79·6	58·6	69·1	+ 2·5	60·6	68	4·4	0·89	− 1·88	7	7·9	56
Winnipeg	1016·1	+ 2·2	92	44	82·1	56·8	69·5	+ 6·5	57·5	85	3·7	0·97	− 1·47	9	10·1	70
St. John, N.B.	1016·3	+ 0·9	80	48	70·4	54·4	62·4	+ 1·8	58·7	83	5·6	4·54	+ 0·68	10	7·8	55
Victoria, B.C.	1017·2	0·0	78	51	68·4	53·5	60·9	+ 0·8	57·0	79	0·4	0·14	− 0·51	2	10·5	73

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

M.O. 339.

The Meteorological Magazine

Air Ministry :: Meteorological Office

Vol. 66

Mar., 1931

No. 782

LONDON: PUBLISHED BY HIS MAJESTY'S STATIONERY OFFICE

To be purchased directly from H.M. STATIONERY OFFICE at the following addresses: ADASTRAL HOUSE, KINGSWAY, LONDON, W.C.2; 120, GEORGE STREET, EDINBURGH; YORK STREET, MANCHESTER; 1, ST. ANDREW'S CRESCENT, CARDIFF; 15, DONEGALL SQUARE WEST, BELFAST; or through any Bookseller.

Exceptional Rain in the Libyan Desert

By L. J. SUTTON, M.A., F.Inst.P.

On December 28th-30th, 1930, rainstorms of remarkable severity occurred in the Libyan desert of Egypt, and in particular near the Mediterranean Coast of the Western Desert Province. The region of heavy rainfall extended into the desert at least as far as the Oasis of Siwa, 250 kilometres inland, while there was during the same period very heavy rain from southern Greece across the Mediterranean to Africa. The rain which fell in Egypt was associated with two depressions each of which had a well-marked cold front. In the morning of the 28th a deep depression was situated over Crete and a shallow one in the Libyan Desert near Siwa Oasis. The latter depression travelled in an easterly direction over middle Egypt, the trough passing Cairo at 4 a.m. on the 29th. The former moved south to the Egyptian coast, deepened considerably on the 29th, and turned north-east to Cyprus, the trough passing the meridian of Cairo at 3 a.m. on the 30th.

A rain gauge was first installed at Siwa Oasis about the end of 1919. Although rain is by no means of rare occurrence in the winter and spring it is usually very light so far in the interior of the desert. In the eleven years over which records extend there were 93 occasions on which rain was noted, but these include 63 occasions when the amount was less than a tenth of a millimetre. Throughout 1923 there was an entire absence of

(93246) P.S.14/89 1,100 3/31 M. & S. *Gp.303*

rain. Until last December the largest fall in a single day during the past eleven years was 10 mm., and the largest amount for any year slightly under 20 mm.

On December 28th, 1930, light rain began to fall at 8 a.m. It became heavier at noon, accompanied by thunder and lightning, and continued heavy until 8 p.m. There was precipitation until 2 a.m. on the following day. In the 24 hours ending 8 a.m. on the 29th the amount registered was 28 mm. A strong south-west wind blew nearly all day on the 29th, and a further rainfall of 7 mm. was registered. Siwa lies in a large depression 25 metres below sea level. The water in the lakes is salty and nearly all the wells are brackish. As a result of the storm about ninety houses which were built of mud bricks containing a considerable amount of salt were destroyed. At Sollum on the coast, on the frontier of Egypt and Tripoli, the course of the storm was similar, rain falling incessantly from 8 a.m. on the 28th to 4 a.m. the next day, when strong winds arose and blew off some of the roofs of the houses. The rainfall amounted to 37 mm., and owing to the wind and rain most of the houses received damage. The storm was most severe at Mersa Matruh, on the coast almost halfway between Sollum and Alexandria, the rainfall there being of intensity phenomenal in Egypt. Between 8 a.m. and 8 p.m. on the 28th 35 mm. were recorded, and in the next twelve hours an additional 64 mm. fell. There was then a fine interval until the afternoon, when it again began to rain heavily, and 21 mm. fell by 8 a.m. on the following day. At Ras el Dabaa on the coast halfway between Matruh and Alexandria, 40 mm. fell on the 29th.

The extent and severity of this rainfall are quite extraordinary. The amount of 99 mm. at Matruh constitutes with one exception (see later) the largest fall for a single rain day at any station in Egypt for which records exist.

Observations of rainfall have been made at Matruh for 25 years, and this station previously held the record for Egypt, with 77mm. on December 12th, 1923, for the highest rainfall in one day. It was, however, followed closely by Sidi Barrani, 130 kilometres to the west, with 76 mm., and Borollos Lighthouse, the most northerly point of the Delta, and Faqus, near the eastern boundary of the Delta, 50 kilometres west-north-west of Ismailia, with 75 mm. These amounts are very large, when it is considered that the normal rainfall at Alexandria, the rainiest place in Egypt as far as is known, is only slightly more than 200 mm. for the whole year. At Matruh the normal yearly rainfall is 165 mm., but in 1908 rainfall amounted to 383 mm. and in 1930 to 380 mm. In the coastal strip there are a number of Bedouin tribes which subsist chiefly by cultivating patches of rain-grown barley sufficient to support them, while the short grass and herbage which spring up after rains provide subsistence for their camels, sheep and goats. On the rainfall, small as it is, they depend almost entirely for their existence, and late rains are particularly welcome.

At Alexandria the largest rainfall in any year since 1869 is 326 mm. in 1897. With the exception that for December 9th, 1888 (it is noted that a waterspout occurred in the neighbourhood on that day) an amount of 279.9 mm. appears in the records, the largest fall there on any single day in the last 47 years, is only 55 mm.—on December 20th, 1914. The largest day's rainfall in Cairo since 1887 is 43 mm., but steady precipitation lasting practically continuously for 36 hours on December 8th and 9th, 1921, gave 52 mm. of rain.

It may here be mentioned that drainage of storm water in Cairo is a lengthy and difficult operation owing to the flatness of the land. Apart from damage to houses, many of which in the native quarters are built of mud bricks, serious inconvenience and heavy expense are caused by the sand which is washed down from the neighbouring desert by sudden severe storms. A single storm (45 mm.) in 1919, for example, flooded the electric railway between Cairo and its suburb Heliopolis, and caused the suspension of the service for a fortnight. After the storm 40,000 tons of water had to be pumped out of the railway cutting at Qubbah, a few kilometres from Cairo, and when this was done there remained to be removed twenty thousand tons of sand, which had been washed down from the adjacent desert. In May, 1923, a storm (25 mm.) lasting only an hour, deposited in the cutting about the same amount of water, and ten thousand tons of sand.

Experiences of a Meteorological Observer at T'ung Ch'uan, Szch'uan, West China

In 1912, at the suggestion of a friend, I began to send reports of the weather conditions to the Meteorological Office, London. I found it a most interesting study (though it was only temperature and rain), being altogether different from England. On my return from furlough in December, 1916, I brought back a hygrometer and aneroid barometer, and had the regulation screen for the thermometers, &c., standing on one side of the lawn facing north-east. The atmosphere was clear, no smoke and no high buildings, the Chinese homes being more like huts, only ground-floor and roof-in places open to the heavens—hills and mountains all around one—the altitude 1,200ft. above sea-level.

I took my observations at 8 a.m. and 8 p.m. or as near as possible, as sometimes I was busy in the hospital. At times when there was no wind perceptible I used my handkerchief to find the direction, but often it would remain limp, and the sky be clear blue with a few cirrus and light cumulus floating. Other times, some breeze and heavy nimbus would be seen, then again, heavy storm-clouds or a dust-storm. The last mentioned was a great trial, everything would be covered with a coating of thin dust, though it was not perceptible to the naked eye. The sunrises were at times very beautiful, especially when travelling on the road, for we started at daybreak, and it was a glorious sight to see the beautiful pink cloud in the east, and the golden orb appearing through it; the dewdrops on grass, trees, plants, hills, sparkling and glistening; the birds waking into song, and rising into the air. Truly, the beauty of nature was there in those early morning hours. Sometimes there would be mist and the sun would make his power felt, and you would see the mist gradually rise and disappear, leaving a sky of deep blue. During the hot summer days there was often not a cloud in the sky.

What impressed me most were the glorious banks of pinky-red cumulus cloud with the blue sky. The former were always more glorious when thunder was about. Many evenings I have stood on the open plain, in the garden, or on the verandah of my study-bedroom, and watched the sheet-lightning playing around the hills; then, a distant roll reverberating round the hills, and, silence again, only the sheet-lightning playing. At other times the sky would darken, and the storm draw nearer, till only the lightning gave light, for in that part of China there was no artificial lighting. It is not easy to describe the grandeur of it all; and, perhaps ten minutes later, drenching rain and blackness—rain came in sheets at times, lightning incessant, and thunder crashing. Storms sometimes occurred in the winter months, but did not last long, nor was there the grandeur.

There was one thing I was thankful for, and that was the cooler nights than in many places during the summer months. There was no twilight, darkness was on you very quickly. Some sunsets were very glorious, others stormy, with great purple-looking clouds. The barometer was low compared with this country, not much above 29·50in. as far as I remember now. The moonlight effects were often very beautiful though cold, but, it was weird travelling by it, for if there is a moon, the Chinese rarely carry a lantern. When called for illness it was really pleasant to have the moon and not to have to trouble with lanterns. The open sky, the fields of corn or rape, &c., the absolute silence of all around; the closed cities with their high walls and locked gates that you crept round, the silent coolies, the lapping of water when crossing rivers; not a sound except, maybe, an insect or a cicada grating. On one went at a steady pace till dawn broke, and you saw the earth clothed in a mantle of dew, and the sun just peeping. Perhaps nearing a city you saw the gates being opened and coolies pouring out to market with their loads of vegetables, &c.

The winter was pleasant, hoar frost and rime were beautiful. I remember seeing snow only once and that was in Chengtu, the capital of Szch'uan. It was a glorious morning, and one awoke to see the earth covered with a pure white mantle, sun just rising, hardly a cloud in the sky; trees, grass, plants, houses, &c., all white. Then as the sun rose higher and made his power felt, a steady drip, drip, and very soon all the beauty gone—just a thing of the past.

Wind was terrible at times, it seemed to roll up from the valleys as the waves of the ocean roll in, and burst with pent-up fury, and then at other times, a gentle breeze. Sand or dust-storms were perhaps the most trying. Fortunately, they did not last long, but everything would be covered with a fine dust; it got in your eyes, your mouth, ears, &c. Rain-clouds were at times striking, because scattered, and often would blow away without any rain falling.

In Suining, a city of lesser altitude, I remember one thunder-storm of about three-quarter of an hour's duration, when the compound was flooded to a depth of two feet, and to get to hospital one had to be carried in Sedan chairs. Rain like that can do a lot of damage to homes built of mud and straw, where there are only tiles overhead—many a home was washed away at that time. This was not in T'ung Ch'uan, but in a city two days' journey away, and we were outside the city walls. At times like that the river rises rapidly, and as huts are built near the bank they are often washed away before anyone has time to try and save anything.

At T'ung Ch'uan I remember one time very clearly. It was a very dark night in the early summer, and, while sitting preparing some Chinese lessons for the next day, I with others, heard cries of "Help," "Chiu min," in English, "Save life." We got up on to the city wall between East and South Gates and looked over. All we could see was water creeping up; people climbing trees calling for help. The river had suddenly risen and was creeping across the fields. It reached the moat outside the city wall, filled it, and crept under the East Gate, although all the gates had been closed at dusk. All the huts under the wall were washed away; people and children were drowned, crops spoiled, &c. It stopped rising about 10 p.m. Next morning it was a pitiable sight, trees rooted up, coffins, furniture, &c., lying in the water, which had receded quite a bit during the night, and mud was left. The Chinese looked on it as fate, but it was very sad to think of so many lives and homes being lost.

The river is a tributary of the mighty Yangtze, which takes its toll of human life yearly. The South Gate was about half a mile from the river; the East Gate a little nearer.

AMY S. MARRS.

Royal Meteorological Society

The monthly meeting of this Society was held on Wednesday, February 18th, at 49, Cromwell Road, South Kensington, Mr. R. G. K. Lempfert, M.A., F.Inst.P., President, in the Chair.

Leonard J. Sutton, M.A.—Note on Haboobs.

This note is a revision and extension of a paper which appeared in the Society's Journal in 1925 on the subject of haboobs—severe dust storms—which occur in the north and central Sudan, chiefly during the rainy season. The statistics, which are drawn mainly from the records of Khartoum, include frequency of occurrence, direction, diurnal variation and average velocity. Examples are given of four representative haboobs, with some photographs and autographic records for Khartoum. Most of the haboobs appear to be due to a current of relatively cold air undercutting warm air, probably in many cases connected with the diurnal variation of temperature which in the summer causes a depression to form during the daytime over the hot arid region between Khartoum and the Nubian Desert.

Prof. S. Chapman, F.R.S. and Miss M. Hardman, M.Sc.—The lunar atmospheric tide at Ocean Island.

The lunar atmospheric tide at Ocean Island, in the Pacific, has been determined from hourly data extending, with gaps, from 1904 to 1912, or the equivalent of about five years continuous data. The annual mean semi-amplitude of the tide is found to be 71 microbars, and maximum pressure occurs at about 20 minutes after lunar transit.

A. C. Best, B.Sc.—Horizontal temperature differences over small distances.

The temperature differences over two intervals of 25ft. and 50ft. at a height of 4ft. above the ground were recorded for nearly three months. It was found that during the daytime the air was not homogeneous. The temperature fluctuated rapidly at any one spot, the amplitude being as much as 1·5°F. under conditions of low wind velocity. This non-homogeneity decreased as the wind increased. There is some evidence that the state of the sky also affects the amplitude of the temperature fluctuations

At night the fluctuations became much slower and temperature differences up to 1·5°F. persisted for periods up to 30 minutes, usually under conditions of low wind velocity. The daytime periods and the night periods were usually connected by a short period of one or two hours when the air at 4ft. was very homogeneous with regard to temperature.

E. Ll. Davies, M.Sc.—A portable temperature gradient indicator

This paper deals with the design and development of a simple portable vertical temperature gradient indicator. The method consists essentially of measuring the differences in resistance of two platinum elements exposed at different heights above the ground. The advantages and disadvantages of three types of housing for resistance elements are given in detail. With the electrically aspirated housing and a good galvanometer (sensitivity about 2mm. of scale per microampère), differences of temperature to within 0·1°F. are measurable.

Correspondence

To the Editor, *The Meteorological Magazine.*

Frost and strong winds

I was surprised this morning to find a small patch of ice about a square foot in area on a paving stone in my garden at about 9.25 a.m. G.M.T. There had been a high wind all night and it was still blowing fresh at the time. The air temperature was 39°F. at a height of about 4 ft. above the ground. The preceding evening temperatures had been about 45°F. generally in the London area and had fallen during the night to 36° or 37°F. at most stations. The fall was gradual though not regular. At 1 a.m. Croydon's temperature was still 41°F. Exceptionally a minimum in the screen of 31°F. was recorded at Hampstead, of 29°F. at Harrow, and of 32°F. at Rickmansworth.

I was inclined at first to attribute the persistence of the ice to a low wet bulb temperature. I find, however, from an examination of the records from other places that the wet bulb temperature was almost certainly between 34° and 35°F. and the dew point about 26° or 27°F.

The presence and persistence of the ice could not therefore have been due to the low wet bulb temperature alone. There must have been still an appreciable balance of outward radiation from the stone equivalent to the heat convected to the surface of the ice from the air. There was no question of a layer of cold air forming and remaining stagnant on the top of the ice; the stone is in a situation much too exposed for that.

It is so frequently assumed, and in most cases rightly assumed, that the existence of a strong wind during the night will prevent frost, that the occurrence this morning seemed to me to be worthy of note. The dryness of the air was naturally a very important contributory factor. That dryness is in itself remarkable in view of the fact that the air which arrived here during the night had travelled more than 1,000 miles over the sea before it reached our western coasts.

E. GOLD.

8, *Hurst Close, Bigwood Road, N.W.*11. *February* 12*th*, 1931.

Circumzenithal Arc

A circumzenithal arc was seen here this morning soon after 10 o'clock, the colours being very vivid. There was a very faint halo of 22° with an upper arc of contact, the area of contact being very bright, and there was a very bright mock sun to the west of the sun for a short time, but no other halo phenomena. The circumzenithal arc disappeared remarkably suddenly; it was as bright at 10.30 as it had previously been, but one, or perhaps two, minutes later it could only just be made out; this may have been due to thin cirrus drifting below the sheet that caused the halo. During the phenomena, and for some time previously, a quantity of rippled cirrus drifted from the north.

C. J. P. CAVE.

Stoner Hill, Petersfield. February 24th, 1931.

Summer Thunderstorms.

It is proposed to commence the census of the thunderstorms occurring in the six summer months of each year, for this purpose called "Summer Thunderstorms," on April 1st, 1931. The records will form a sequel to the winter investigation which was originated by Mr. C. J. P. Cave, carried on over a number of years, and finally concluded in March, 1929. It is probable that the new census will extend over the summers of 1931 to 1936, in order that sufficient data may be available for comparison with the winter material already obtained.

Details of Observations.—The main details required are the place, date and time of the occurrence, between April 1st and September 30th, of thunder, lightning or hail, with the direction in which the lightning was seen, especially at night.

It is essential that the position from which the observation is made should be specified by mentioning the approximate distance and direction from a railway station or other point which may be identified on a large scale map. Please state whether the times are those shown by Public Clocks or Greenwich Mean Time.

In the case of actual thunderstorms additional information, for which the following are suggestions, will be welcome :—

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

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

Records should be sent on postcards to the undersigned at Langley Terrace, Oakes, Huddersfield, and not to the Meteorological Office.

S. MORRIS BOWER.

NOTES AND QUERIES

The Influence of Forests on Climate in Kenya and Uganda

In discussing the question whether afforestation can increase the rainfall of any region, although it is possible to lay down certain general principles of theory, the various factors are so nicely balanced that local conditions may easily turn the scale in one direction or the other. This seems to be especially true in the tropics, and two papers* by J. W. Nicholson, Forest Adviser to the Governments of Kenya and Uganda, are therefore welcome contributions to the subject. One of the difficulties with which Mr. Nicholson had to contend was the inadequacy of the meteorological records for the districts about which he writes, hence his opinions can rarely be supported by statistical data. With his remarks about "miscellaneous influences," however, few will disagree. He believes that in the tropics forests have, compared with open land, lower mean temperature, smaller annual and diurnal ranges, a much smaller range of soil temperature and a higher relative humidity. It is with the influence of forests on rainfall that he enters the real controversy.

The first important local condition is that Kenya and Uganda almost fall into the category of enclosed basins, for only about a tenth of the rain finds its way into the Nile or the Indian Ocean. The remaining nine-tenths must ultimately be re-evaporated or transpired. Moreover, the relief of the country is such that oceanic air cannot readily penetrate into some parts, in which the rainfall must be derived almost entirely from land sources. Hence the importance of such sources is much greater than in countries open to oceanic winds. The second condition is that rains alternate with periods of drought. The author states that "there is not the slightest doubt but that in East Africa trees and deep-rooted shrubs give off far more moisture than herbaceous vegetation as during seasonal periods of drought the latter is not transpiring." He also supposes that forest transpiration exceeds evaporation from bare soil, though admittedly without any evidence. The excess of water given off by forests enables the moisture brought by oceanic winds to penetrate further inland than it would otherwise do, and therefore greatly increases the rainfall of the inland districts at the expense of the coastal rivers. Later, he somewhat neutralises this argument by pointing out the value of trees as wind-breaks to lessen the evaporation from the soil and crops which they shelter, and it seems very doubtful whether the transpiration from trees can be so excessive that partial

* Kenya, Forest Department Pamphlet No. 2. The influence of forests on climate and water supply in Kenya. By J. W. Nicholson. With a foreword by A. Walter; Entebbe 1930, and

Supplement to the above: Note on the influence of forests on climate and water supply in Uganda.

afforestation would make any appreciable difference to the rainfall to leeward.

That sums up one side of the author's case, namely, that forests give back to the air more moisture than any other form of surface. The other side is that forests also take from the air more moisture than crops or bare ground. The types of rainfall which he believes to be affected are "occult precipitation" or deposit of mosture from fog or dew, and instability rain. With regard to occult precipitation he writes: "Phillips' investigations at the South African Forest Research Station have shown that occult precipitation can amount to at least 25 per cent. of the annual rainfall." This somewhat vaguely worded quantitative estimate he adopts as valid for Kenya. The Wheel Wagon Gap experiment,* however, which is by far the most definite ever made in this connexion, entirely rules out any such figure, although the site would appear to have been especially favourable for its occurrence. The only alternative to supposing that occult precipitation is negligible is that it is given back to the air on the spot, within a few hours of its receipt, in which case it can equally well be left out of the discussion.

Finally, the author believes that forests materially increase the amount of instability rain. His theoretical argument is that air over forests is moister than that over dry ground; he admits that the air over the latter becomes very much hotter than the forest air but considers that it is too dry to give rain. The relative humidity of forest air is admittedly greater than that of air over neighbouring bare or cultivated ground, simply because the former is the cooler, but apart from the assumed greater transpiration there is no evidence that the amount of moisture is greater. For convective purposes bare ground is surely the most favourable, and forest the least favourable type of uniform surface, though probably a mixture of types is the most favourable of all.

The practical evidence for the most part reduces to the old argument that because more rain falls on forested than on unforested ground, therefore the forests induce the additional rainfall. This is not necessarily a fallacy, provided that all other factors are similar in the two areas, but it is very difficult to prove that the latter condition is fulfilled. The strongest example quoted is the Karamoja Plateau in Uganda, where the rainfall increases rapidly across the boundary between cropland and forest, although the topography gives no obvious reason for such a change.

The author remarks that the influence of forests on instability

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* Washington, D.C. U.S. Weather Bureau. Monthly Weather Review Suppl. No. 30, 1928. Forest and stream-flow experiment at Wagon Wheel Gap, Colo. Final report.

rain is probably very local, so that extensive forest tracts are not as valuable as smaller and more numerous forest tracts, and he recommends blocks of 4,000 acres or so in extent. This advice is probably good, for several reasons. In the first place, it is obviously no advantage for farmers to plant forests to increase transpiration and rainfall if all the increase falls back on the forest itself. The proportion which misses the forest and falls on the crops will be greater, the smaller the forest block. Secondly, the effectiveness of forests is presumably due in part to the differential heating of forested and unforested ground, and this effect would be lost if the forest areas were too large. Thirdly, as the author points out, the value of forests as wind-breaks depends on their periphery and not on their area, so that a square block may be no more effective than a long narrow strip of half the area.

As previously stated, the investigation was greatly handicapped by the absence of adequate meteorological and especially agricultural-meteorological data for East Africa, a defect which we can confidently expect the new British East African Service to supply. In fact Mr. A. Walter, the Director of that service, writes in his foreword to the Kenya paper that "steps are being taken to inaugurate an efficient Service of Stations throughout East African Territories with special reference to the elucidation of some of the problems which have been raised in this pamphlet." The collection of adequate quantitative data combined with experiments under proper control is the only way of arriving at a sure solution of the problems raised, but meanwhile the opinions of scientific officers such as Mr. Nicholson concerned with these problems, based on close personal observation over a wide area, are entitled to the fullest consideration.

C. E. P. Brooks.

The Deepening of Depressions by Day and Night

Two recent occasions when depressions off west Ireland deepened greatly during the night, after showing no great activity up to 6 p.m., and the memory of other cases in the past, raised the question as to whether depressions deepen more readily by night than by day. To test this point the charts for the winter half-year (October to March) were examined for the period from January, 1922, to December, 1930, and cases when depressions or secondaries deepened by 10mb. or more at the centre in 12 hours were noted. The area covered was between latitudes 40° and 60° N., and longitudes 30° W and 10° E., excluding the Mediterranean. The majority of examples occurred to west or south-west of the British Isles and there were none on the continent. Obviously only those cases when sufficient ships' observations were available could be considered. The day and night periods were equalised by interpolating the probable pressure at the centres of the depressions at 6 a.m. The rare cases when a deepening of 20mb. or more took place were also noted, and form the second group given below. The examples in the second group are also included in the first group:—

	Number of cases where depressions deepened by 10*mb. or more*	20*mb. or more*
Day period, 12 hours from 6 am. ...	28	3
Night period, 12 hours from 6 p.m. ...	50	8

In view of the absence of a close network of ships' observations, and the unavoidable necessity of some interpolation, the figures should be treated with great caution, but in all probability they imply something real. A number of marginal cases were rejected, and also all cases when there might have been a rapid movement from west rather than a development, and a considerable majority of the rejected cases were at night. The relation showed up in some winters much better than in others, and did not show at all during the very stormy winter of 1929-30. A small influence would show up best in a period when other factors were nearly balanced, rather than during an exceptionally unstable period. A complete statistical investigation of the deepening of Atlantic depressions is impossible with present data.

It has been pointed out by Prof. W. J. Humphreys* (quoting Mr. C. L. Mitchell of the U.S. Weather Bureau) that in the United States, depressions also deepen more by night than by day. The explanation given was that nocturnal radiation from the ground in the clear parts of a depression increases the horizontal temperature gradient, and also decreases surface frictional resistance. Neither part of this explanation can hold over the open sea. It is stated by Hann and Süring† that precipitation over the open sea has a maximum about midnight and a minimum at noon, though they do not give the data on which the statement is based. They publish hourly values of the rate of rainfall for the average of six coast stations throughout the year, showing a maximum in the early morning and a minimum in the afternoon, the ratio of the maximum to the minimum being 100 to 76. Conditions on the coast and over the open sea are, however, quite different.

The fact that depressions deepen more readily at night over both sea and land suggests that the true cause is in the upper air, not at the surface. Quite apart from this, it is now certain that the development of depressions cannot be interpreted entirely in terms of horizontal temperature differences. In the very stormy December of 1929 the mean temperature difference between Iceland and the Azores was below the normal for December. On

* *Washington, U.S. Dept. Agric., Monthly Weath. Rev.* 55, 1927, p. 496.
† Lehrbuch der Meteorologie, Leipzig, 1926, p. 349.

the other hand the lapse rate of temperature over the British Isles was considerably above the December normal, as shown by aeroplane ascents at Duxford and by frequent thunderstorms in various districts. C. K. M. DOUGLAS.

Gliding and Soaring Flight

A lecture on " the Meteorological Aspects of Gliding and Soaring Flight " was given by Mr. F. Entwistle, Superintendent of the Aviation Division of the Meteorological Office, before the Royal Aeronautical Society, on Thursday, February 26th. Colonel the Master of Sempill was in the chair, and was supported by Mr. E. C. Gordon England, Chairman of the British Gliding Association.

Mr. Entwistle, after enunciating the conditions for gliding and soaring flight, gave an account of the disturbances in the atmosphere which may produce a vertical component in the motion of the air, ranging from the small-scale turbulence, due to friction between the moving air and the ground, to the large ascending currents associated with line squalls and thunderstorms. Some examples of the magnitudes of extreme vertical currents deduced from measurements of the dimensions of hailstones and from air pilots' personal experiences were given. The latter part of the lecture was devoted to the application of the knowledge of wind structure to gliding and soaring flight and to a discussion of the possible use of sailplanes in obtaining more detailed meteorological data.

The discussion which followed the lecture was opened by Sir Gilbert Walker, who dealt more particularly with the phenomenon of " dynamic " soaring in which use is made of temporary fluctuations in a turbulent wind. He was followed by Dr. G. C. Simpson and Mr. Gordon England. Other speakers included Captain Latimer Needham, Dr. Thurston, Dr. F. J. W. Whipple, and Mr. Manning.

Unusual Lightning Phenomena

Mr. E. Kidson, Director of the Meteorological Office, Wellington, N.Z., has sent the following extract from the *Marlborough Express*, Blenheim, November 10th, 1930. The thunderstorm occurred in connexion with a line-squall accompanying the trough of a very rapidly moving inverted V-depression :—

"During the height of an electrical storm which burst over the Wairau Plain on Saturday afternoon (November 8th), the residence of Mr. C. E. Matthews, at Rapaura, was struck by lightning, which caused considerable damage, though very fortunately none of the occupants of the house were injured. The building, though enveloped for a considerable time in a thick cloud of smoke, did not catch fire.

Mrs. Matthews was in town at the time, and Mr. Matthews was attending to his duties on the farm. Those in the house were their little daughters, June and Barbara, their infant son Peter and Miss P. Reeves. The little boy was asleep in his cot, but the girls and Miss Reeves were in the kitchen when the lightning struck a corner of the room, partly wrecking one wall and hurling a fair-sized piece of timber right across the kitchen and through an open door into an adjoining room. How it missed the three girls is beyond explanation.

A series of sharp little explosions followed the major crash which signalised the wrecking of the wall, and the terror of the occasion was added to by the crash of falling glass, as windows in various parts of the house were blown out by the shock of the explosions. The building was immediately filled with thick acrid smoke, through which the occupants were terrified to observe the pale flicker of a blue electric flame which enveloped the whole building. Miss Reeves lost no time in snatching up the sleeping infant and in herding her little charges outside, where, in the pelting rain which followed the discharge, they witnessed an awe-inspiring sight, the whole house being wrapped in blue flickering flame for an appreciable period.

Subsequent investigations seem to establish the fact that the lightning struck a wireless aerial entering the house near its south-eastern corner. Fortunately, Mr. Matthews had "earthed" the aerial when the storm threatened, but the earth wire passed close to one of the pipes of an Aerogen gas plant with which the building is equipped, and it is evident that the current travelled along the gas pipes to various parts of the house, causing damage in all sorts of unexpected places. The wireless aerial had vanished as if it had never existed, being completely burned up by the terrific voltage which it was called on to carry and leaving only the blackened and cracked insulators between which it had been strung. Nearer the wireless set, where the wires were of the insulated variety, the wire core had been completely burned out, leaving the torn insulation like an empty stocking.

The major damage consists of half-a-dozen weather boards wrenched off the outer wall with such force that one of them was flung over an adjacent fence. The interior lining boards were also blown off, a piece of one of them travelling right across the kitchen, as has already been reported. In one of the upstairs rooms a hole was torn in the floor and there are two small holes right through the outer wall, while altogether nine window panes were blown out.

That the lightning struck in more than one place is demonstrated by the fact that two fairly long sections of heavy wire in a fence close to the house were burned right away and a fencing post some distance away was split, while a telephone pole at least 200 yards away from the house was also wrecked.

Several residents in the locality report that their telephone fuses were blown out, with such force, in some cases, that they were hurled to a considerable distance.

Mr. Matthews, who was attending to the housing of some fowls at the time, had an alarming experience. He states that at the height of the storm he felt as if he had been struck a sudden and heavy blow behind the knees. It sent him headlong and he was surprised to find that he was still alive, and still more surprised to discover that he was unhurt. One of the fowls became wrapped in blue flame and was "knocked out," but it subsequently recovered and is apparently none the worse. Mr. Matthews lost no time in rushing to the house, which he observed to be wrapped in smoke, and he was greatly relieved to find his family and Miss Reeves safe.

The smoke clung about the building so thickly and for such a lengthy period that it attracted the attention of neighbours, who thought the house was on fire.

A young man working on the farm also had an alarming experience when his three horses became enveloped in the mysterious blue flame. He succeeded in releasing them without trouble. In other places, it is reported, settlers felt the effect of the discharge, one man having a hammer knocked out of his hand, while several report feeling the mysterious pressure behind the knees which was experienced by Mr. Matthews.

Heavy rain near Whitby, August 20th-23rd, 1930

According to a report in *The Times* of August 24th, 1930, the Whitby lifeboat was used for rescue work at Ruswarp, two miles inland, in floods occasioned by the heavy rains of August 20th to 23rd. This incident was referred to in an article on page 159 of the *Meteorological Magazine* for August, 1930, and again on page 291 of the January, 1931, number. We have now received from R. H. Rastall, Esq., of Turnerdale Hall, Whitby, a letter from which the following is an extract :—

"What really happened was that the very small and flimsy pleasure boats of the present day were found inadequate to remove the inhabitants of certain cottages, as has been done many times in the past with the heavier boats of those days, so some fishermen and, I believe, one or two coast-guardsmen brought a heavier boat by road from Whitby on a lorry.

"I have often seen such 'rescues' in the past, especially at the end of the wet decade 1871-80—I have a vivid recollection of watching a suspension bridge floating down the river on October 28th, 1880, when I was eight years old, and there are records of tremendous floods of the same type in 1866 and 1840. I may say that a large part of the scene of the supposed liftboat episode is my property, and some of my land at Grosmont also suffered considerably. It is well authenticated that at one point on my land about 2 miles below Grosmont the river rose 30ft., but I think that was largely due to the blocking of a railway bridge by floating trees."

Books Received

Meteorological Normals of Calcutta. By V. V. Sohoni (Journal and Proceedings, Asiatic Society of Bengal, New Series, XXV, 1929, No. 1) containing tables and diagrams of normals of pressure, temperature, humidity, rainfall, cloud, sunshine and surface and upper winds mostly for the period 1901-20, together with notes of the instruments and methods of observation.

Jaarboek, Koninklijk Nederlandsch Meteorologisch Instituut 1928. A. Meteorologie, B. Aard-Magnetisme (Nos. 97 and 98), Utrecht, 1929.

Ergebnisse Aerologischer Beobachtungen, 1928. K. Ned. Meteor. Inst. (No. 106A). Utrecht, 1929.

Helligkeitsverteilung über den Himmel im Ultraviolett. By C. Dorno and F. Lindholm (Met. Zs., 1929, pp. 281-292).

Obituary

Mr. Henry Harries.—Mr. Harries whose death in his eightieth year was announced in our last issue, entered the office as a boy clerk in 1875. Up to the year 1903 he served continuously in the Marine Division, where he developed a keen interest in the problems of marine meteorology. His enthusiasm for his work led him to spend many of his holidays at sea in ships big and little, and he thus acquired a practical familiarity with the special difficulties of observing at sea which is given to few landsmen. The knowledge which he gained of the ways of seamen stood him in good stead late in his career when he was called upon to take charge of the Marine Division upon the death of the Marine Superintendent, Captain Campbell Hepworth, early in 1919, pending the appointment of a new Superintendent. It was a time of great stress and difficulty, for the work of observing at sea had been sadly disorganised by the war, and Harries rendered conspicuous service in getting it re-started.

From 1903 to 1919 Harries was attached to the Forecast Division as one of those responsible for the issue of forecasts and gale warnings. Here, again, his knowledge of marine meteorology proved a great asset, for into this period fell the early application of wireless telegraphy in the forecast service in an attempt to collect observations from ships in the North Atlantic and combine them with those from the land stations.

Most of the papers which Harries contributed dealt with the meteorology of the sea. As a disciple of Buchan he held strongly that many of the depressions that visit our islands originate in tropical hurricanes, and he succeeded on one occasion in tracing a storm all the way from the Philippines to Scandinavia, a task which involved no small amount of patient investigation when one bears in mind how scanty and scattered was the material for such investigations in 1882. He was also responsible for papers on the frequency of hail at sea, and for a collection of data regarding the occurrence of hail and thunderstorms in the Arctic regions. Another subject which interested him greatly was the possible connexion between colliery explosions and meteorological phenomena. He assiduously collected data on the subject, and held firmly that periods of high barometer pressure were favourable for the development of dangerous conditions in coalmines.

In 1912, when on one of his many foreign holidays, Harries was granted facilities for a series of experiments with no-lift balloons on the eddy winds around the Rock of Gibraltar. Attention had been directed to the matter by the peculiar character during east winds of the records of the Dines pressure tube anemometer, which had been established on the Rock a few years earlier. The results of this, perhaps the earliest experimental investigation of cliff eddies, are set out in a paper read before the Royal Meteorological Society in 1914.

Harries retired from the Office at the end of March, 1920, his period of service having extended over no less than 45 years. He is remembered by those who served under him as juniors as a strict disciplinarian, an excellent teacher, and as one who had an almost uncanny aptitude for spotting errors in a table of figures! For many years he acted as meteorological correspondent to the *Morning Post*. He was a Fellow of the Royal Meteorological Society from 1887 to 1914.

R. G. K. LEMPFERT.

Mr. Arthur Waters Preston.—We learn with deep regret of the death of Mr. Preston on March 1st, 1931. Mr. Preston rendered many services to the science of meteorology. He started a climatological station at Eaton (Norwich) on October 1st, 1905, and forwarded returns regularly to the Meteorological Office. His observations extend back to 1883 and were made at Thorpe Hamlet, Blofield and Brundall prior to those at Eaton. Mr. Preston was also Secretary of the Norfolk Rainfall Organisation, and collected rainfall records from the district each month for publication in the local press and for subsequent inclusion in *British Rainfall* It is hoped that arrangements can be made for the valuable climatological observations to be uninterrupted and for the Norfolk Rainfall Organisation to continue its useful work.

News in Brief

According to the *Cornish Times*, during the height of a severe thunderstorm at Bolventor, Cornwall, about the 12th, a "ball of flaming fire" swept through the village very early in the morning leaving large pits in the road, killing two pigs and four cows, making a large hole in a granite wall and wrenching the guttering and water-pipes from the school.

Mr. J. Crichton, Assistant Superintendent in the Meteorological Office, has been elected a Fellow of the Royal Society of Edinburgh.

The 12th Annual Soirée of the staff of the Meteorological Office was held at the Portman Rooms, on Friday, February 6th, 1931. The Soirée, which consisted of dancing with two intervals during which "The Benthams" Concert Party entertained, was both a social and financial success. Mr. A. E. Pycock, who is retiring from the office staff at the end of March, sang two humorous songs, which were greatly appreciated.

The Tenth Annual Dinner of the Staff of the Meteorological Office, Shoeburyness was held at the Queen's Hotel, Westcliff, on February 7th. Amongst those present were several past members of the staff now serving at other stations. Mr. D. Brunt, the Superintendent for the Army Service Division, was present as the guest of the staff. In view of the anniversary nature of the occasion, a special souvenir menu was printed in which appeared a brief account of the early history of the station.

On Wednesday, February 25th, a team representing the Meteorological Office defeated, by 6 goals to 0, a team representing the Directorate of Equipment in the final round for the Air Ministry Football Cup. At the close of the match Mr. R. C. Richards presented the Cup to the Meteorological Office team on behalf of the Air Ministry. This is the third successive year and the fourth time in all that the Office has won this trophy.

The Abnormal Weather of Europe during February, 1931.

The distribution of pressure was highly abnormal. A sketch map of the deviations of pressure from normal, drawn from a skeleton distribution of stations, is shown in figure 1. The main features are four: an area with pressure more than 10mb. above normal, including the Azores and central North Atlantic; an area more than 15mb. above normal over western Siberia, the excess reaching 19·4mb. at Sverdlovsk; and areas more than 10mb. below normal near Spitsbergen and over Alaska. The distribution was especially interesting in the North Atlantic and north-west Europe. The Azores anticyclone was of abnormal intensity and displaced to the north of its normal position, while the Icelandic low took the form of a deep trough running north and south from Spitsbergen to the Shetlands. To the west of this trough there were unusually frequent and strong northerly winds, especially over Iceland, where the temperature was 8°F. below the normal for the month. To the east of the trough, on the other hand, Spitsbergen experienced strong southerly winds, heavy snow and unusual warmth, the average temperature being no less than 23°F. above normal. Further south the winds

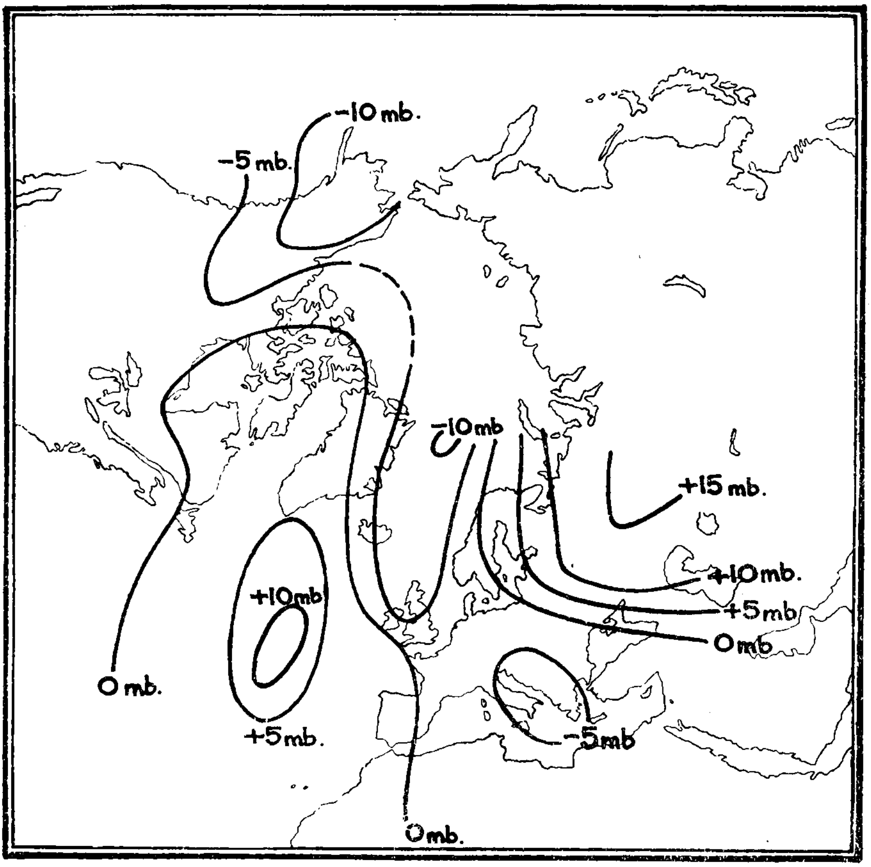


FIG. 1. DEVIATIONS OF PRESSURE FROM NORMAL, FEBRUARY, 1931.

became more south-easterly, owing to the influence of the Siberian anticyclone, and in Scandinavia temperature was only slightly above normal, though there was heavy rain and snow.

In central Europe conditions were more complex, currents of Mediterranean air meeting air from eastern Europe and Siberia. Under these conditions heavy snow was general, especially after the 11th, and extended even to northern Italy and northern Spain, while temperature was rather low. According to *The Times* snow fell in Venice for the first time for many years, while owing to the tremendous snowfalls and drifts caused by violent winds several Alpine regions, including Zermatt, were cut off from the outside world about the 24th. Avalanches were numerous, and many disasters occurred in Switzerland and northern Spain.

The Weather of February, 1931

Squally westerly or north-westerly winds and frequent wintry precipitation were the chief features of the weather of the British Isles during February. A depression passed across the country on the first of the month and gales were experienced generally, Beaufort force 9 occurring at many places in the north and west. By the 3rd conditions had changed, a ridge of high pressure extended across the country, and quiet, cold weather prevailed with a varying amount of sun. Maximum temperatures did not exceed 33°F. at Marchmont on the 4th, and at Durham, Rothamsted and Harrogate on the 5th. Snow occurred generally from the 1st to 7th, slight in the south but lying to some depth in the north; $4\frac{3}{4}$in. were measured at Harrogate on the 7th. On the 7th a deep depression approached from the Atlantic and the weather became mild and unsettled, with westerly winds by the 8th. Temperature rose generally above 50°F., and reached 56°F. at Dublin and 55°F. at Ross-on-Wye on the 9th. Heavy rain occurred in west Ireland on the 7th, and over the country generally on the 9th and 11th, 2·30in. being measured at Llyn Fawr, Glamorgan, on the 9th, and 1·55in. at Oughtershaw, Yorkshire, on the 11th. In the rear of this depression there were strong north-westerly winds reaching gale force at times on the 11th, 12th and 13th, which caused a considerable drop in temperature. Precipitation again took the form of hail, sleet or snow in the north and west, but did not lie to any depth. From the 13th-24th depressions passed across the country and cold weather with squally north-westerly winds, and rain, sleet or snow at times persisted with short breaks. Slight snow occurred even as far south as Margate, Southampton and Bath, and lay to a depth of 5in. at Armagh on the 24th, and of 3in. at Rothesay on the 22nd. Gales were again experienced on the 16th and 17th. The 14th, 21st and 22nd were markedly sunny days, over 8 hrs. bright sunshine being recorded at several places, and 9·4 hrs. at Plymouth on the 21st. On the 24th, the anticyclone over the Bay of Biscay spread northwards, south-westerly winds were general by the 25th, and temperature rose high for the time of year reaching 59°F. at Aberdeen and 58°F. at Cambridge, Waterford and Hull on the 25th. On the 26th, the winds veered north-west and another cold spell ensued, maximum temperature not rising above 32°F. locally in the English Midlands on the 28th. Gales occurred in the north and west in the 28th, and in the evening snow fell generally over the whole country. Thunder and lightning were observed locally in the south and west on the 12th, 20th, 21st and 28th. The distribution of bright sunshine for the month was as follows :—

	Total (hrs.)	Diff. from normal (hrs.)		Total (hrs.)	Diff. from normal (hrs.)
Stornoway	64	+ 6	Liverpool	63	— 5
Aberdeen	82	+ 9	Ross-on-Wye	77	+ 6
Dublin	70	— 3	Falmouth	80	— 3
Birr Castle	62	— 5	Gorleston	41	—40
Valentia	59	— 10	Kew	60	0

In Sweden pressure was generally normal, but 3mb. below in the south and 3mb. above in the north-east. Temperature was likewise normal but for a band over central Norrland, where it was nearly 4°F. below. Rainfall was very irregular, but in the mean only slightly below normal. In Jaemtland, western Lapland and Vestrogothia there was only half the normal rainfall, but in Scania, Waermland, Dalecarlia and Vesterbotten, the excess was more than 50 per cent.

Miscellaneous notes on weather abroad culled from various sources

Severe drought was experienced in southern Spain during the month. A storm of great violence broke over the Mediterranean and southern Italy on the 22nd, the centre being over the province of Palermo, where much damage was done. (*The Times*, Feb. 24th, 1931.)

Unusually heavy rains in the south-eastern districts of Queensland caused the worst floods for some years in several coastal towns, but the rains in the upper reaches of the Brisbane river ceased in time to avert the danger of a serious flood in Brisbane, though the low-lying parts of the city were flooded. Heavy rain was also experienced in the north-east of New South Wales. (*The Times*, Feb. 6th-7th, 1931.)

The north and west of the main island of Viti Levu, Fiji Islands, where are situated the chief sugar-growing areas of Fiji, was struck by a hurricane on the 21st and 22nd. Much damage was done, the worst effect being the unprecedented floods; over 100 people lost their lives. (*The Times*, Feb. 27th-28th, 1931.)

Except for the extreme north-east temperature was generally abnormally high in the United States during the first part of the month, while rainfall was about normal. (*Washington, U.S. Dept. Agric., Weekly Weather and Crop Bulletin.*)

Rainfall, February, 1931—General Distribution

England and Wales ...	124	per cent of the average 1881-1915.
Scotland	118	
Ireland	104	
British Isles	118	

Rainfall: February, 1931: England and Wales

Co.	Station	In.	Per-cent. of Av.	Co.	Station	In.	Per-cent. of Av.
Lond .	Camden Square.........	1·83	110	*Rut* .	Ridlington...............	2·72	166
Sur .	Reigate, Alvington.....	2·22	101	*Linc* .	Boston, Skirbeck........	2·53	173
Kent .	Tenterden, Ashenden...	2·65	134	,, .	Cranwell Aerodrome...	2·72	158
,, .	Folkestone, Boro. San..	2·50	...	,, .	Skegness, Marine Gdns	1·69	110
,, .	Margate, Cliftonville...	1·88	136	,, .	Louth, Westgate........	2·32	121
,, .	Sevenoaks, Speldhurst	2·27	...	,, .	Brigg, Wrawby St.....	2·44	...
Sus .	Patching Farm.........	2·24	101	*Notts* .	Worksop, Hodsock.....	2·35	153
,, .	Brighton, Old Steyne..	1·64	81	*Derby* .	Derby, L. M. & S. Rly.	2·72	168
,, .	Heathfield, Barklye....	2·71	115	,, .	Buxton, Devon Hos....	5·19	138
Hants .	Ventnor, Roy. Nat. Hos.	2·42	115	*Ches* .	Runcorn, Weston Pt...	2·77	149
,, .	Fordingbridge, Oaklnds	2·38	95	,, .	Nantwich, Dorfold Hall	2·98	...
,, .	Ovington Rectory.......	2·05	79	*Lancs* .	Manchester, Whit. Pk.	3·82	199
,, .	Sherborne St. John.....	1·72	78	,, .	Stonyhurst College.....	6·16	184
Berks .	Wellington College.....	1·49	79	,, .	Southport, Hesketh Pk	2·79	133
,, .	Newbury, Greenham...	2·01	91	,, .	Lancaster, Strathspey	3·36	...
Herts .	Welwyn Garden City...	1·62	...	*Yorks* .	Wath-upon-Dearne.....	2·16	133
Bucks .	H. Wycombe, Flackwell	1·71	...	,, .	Bradford, Lister Pk....	3·62	155
Oxf . .	Oxford, Mag. College..	1·57	99	,, .	Oughtershaw Hall......	9·46	...
Nor .	Pitsford, Sedgebrook...	2·49	149	,, .	Wetherby, Ribston H.	2·11	122
,, .	Oundle..................	2·11	...	,, .	Hull, Pearson Park.....	2·40	145
Beds .	Woburn, Crawley Mill	1·70	115	,, .	Holme-on-Spalding.....	2·51	...
Cam .	Cambridge, Bot. Gdns.	1·63	127	,, .	West Witton, Ivy Ho.	2·92	102
Essex .	Chelmsford, CountyLab	1·76	119	,, .	Felixkirk, Mt. St. John	1·72	102
,, .	Lexden Hill House....	2·17	...	,, .	Pickering, Hungate....	3·16	182
Suff .	Hawkedon Rectory.....	2·92	192	,, .	Scarborough............	2·01	120
,, .	Haughley House........	2·23	...	,, .	Middlesbrough..........	1·16	89
Norf .	Norwich, Eaton...... ...	...	...	,, .	Baldersdale, Hury Res.	3·15	...
,, .	Wells, Holkham Hall	2·71	183	*Durh* .	Ushaw College..........	1·42	89
,, .	Little Dunham..........	3·04	187	*Nor* .	Newcastle, Town Moor	1·15	72
Wilts .	Devizes, Highclere......	2·25	113	,, .	Bellingham. Highgreen	2·51	99
,, .	Bishops Cannings.......	2·74	129	,, .	Lilburn Tower Gdns....	1·52	78
Dor .	Evershot, Melbury Ho.	2·88	92	*Cumb* .	Geltsdale................	3·52	...
,, .	Creech Grange..........	1·92	67	,, .	Carlisle, Scaleby Hall	3·00	135
,, .	Shaftesbury, Abbey Ho.	2·44	105	,, .	Borrowdale, Seathwaite	13·75	116
Devon .	Plymouth, The Hoe....	3·23	109	,, .	Borrowdale, Rosthwaite	8·47	...
,, .	Polapit Tamar..........	3·56	111	,, .	Keswick, High Hill.....	3·85	...
,, .	Ashburton, Druid Ho.	...	...	*West* .	Appleby, Castle Bank..	2·98	101
,, .	Cullompton.......	3·12	112	*Glam* .	Cardiff, Ely P. Stn.....	3·23	108
,, .	Sidmouth, Sidmount...	2·40	96	,, .	Treherbert, Tynywaun	9·00	...
,, .	Filleigh, Castle Hill....	4·66	...	*Carm* .	Carmarthen Friary.....	4·84	131
,, .	Barnstable. N. Dev. Ath.	3·58	132	,, .	Llanwrda................	5·94	136
Corn .	Redruth, Trewirgie.....	3·52	93	*Pemb* .	Haverfordwest, School	4·90	141
,, .	Penzance, Morrab Gdn.	4·16	125	*Card* .	Aberystwyth............	4·22	...
,, .	St. Austell, Trevarna...	4·17	109	,, .	Cardigan, County Sch.	3·17	...
Soms .	Chewton Mendip........	3·62	107	*Brec* .	Crickhowell, Talymaes	4·40	...
,, .	Long Ashton............	2·27	97	*Rad* .	BirmW. W. Tyrmynydd	6·73	128
,, .	Street, Millfield	2·34	116	*Mont* .	Lake Vyrnwy...........	7·59	167
Glos. .	Cirencester, Gwynfa....	2·40	106	*Denb* .	Llangynhafal............	3·11	138
Here .	Ross, Birchlea...........	1·75	87	*Mer* .	Dolgelly, Bryntirion...	8·54	193
,, .	Ledbury, Underdown..	1·93	106	*Carn* .	Llandudno..............	2·69	129
Salop .	Church Stretton.........	2·28	104	,, .	Snowdon, L. Llydaw 9	16·70	...
,, .	Shifnal, Hatton Grange	2·11	130	*Ang* .	Holyhead, Salt Island	2·39	98
Worc .	Ombersley, Holt Lock	1·88	115	,, .	Lligwy....................	1·97	85
,, .	Blockley..................	2·73	...	*Isle of Man*			
War .	Birminghm, Edgbaston	2·47	146		Douglas, Boro' Cem....	3·61	113
Leics .	Thornton Reservoir....	3·31	199	*Guernsey*			
,, .	Belvoir Castle...........	2·45	147		St. PeterP't. GrangeRd.	3·47	141

Erratum for January. Carmarthen Friary for 3·77/86, read 4·62/105.

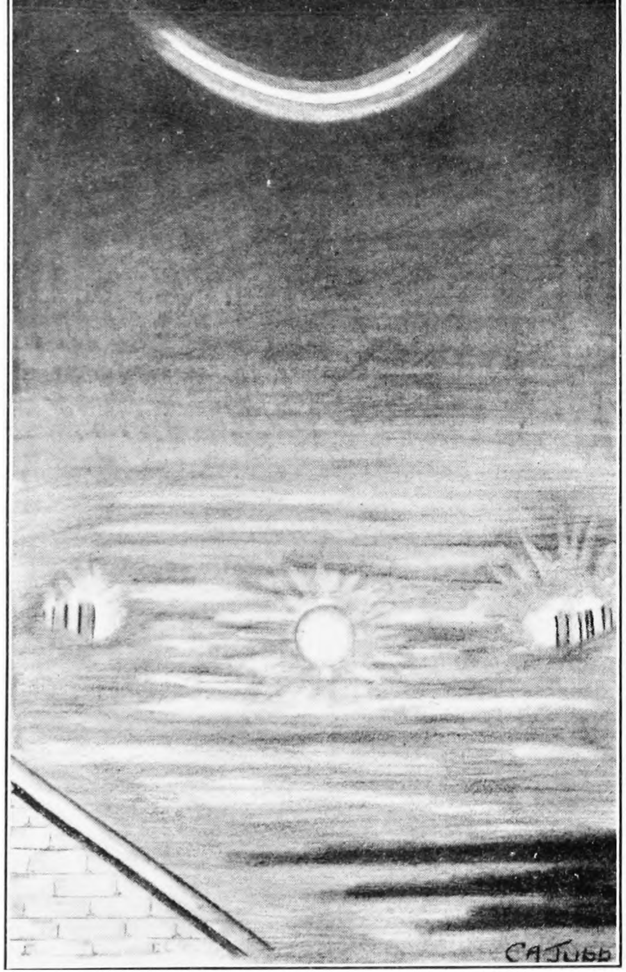
Rainfall: February, 1931: Scotland and Ireland

Co.	Station	In.	Per-cent. of Av.	Co.	Station	In.	Per-cent. of Av.
Wigt .	Pt. William, Monreith	2·79	91	*Suth* .	Loch More, Achfary ...	12·05	183
,, .	New Luce School......	3·80	100	*Caith* .	Wick......................	2·88	127
Kirk .	Carsphairn, Shiel.......	7·61	116	*Ork* .	Pomona, Deerness......	4·33	144
Dumf.	Dumfries, Crichton, R.I	2·47	...	*Shet* .	Lerwick	7·12	225
,, .	Eskdalemuir Obs.......	5·98	121	*Cork* .	Caheragh Rectory......	4·40	...
Roxb .	Branxholm	2·40	91	,, .	Dunmanway Rectory...	3·65	62
Selk .	Ettrick Manse...........	4·61	100	,, .	Ballinacurra.............	2·61	70
Peeb .	West Linton............	3·80	...	,, .	Glanmire, Lota Lo......	3·18	80
Berk .	Marchmont House......	1·76	85	*Kerry*.	Valentia Obsy..........	5·09	98
Hadd.	North Berwick Res.....	1·71	110	,, .	Gearahameen............	8·30	...
Midl .	Edinburgh, Roy. Obs.	1·85	116	,, .	Killarney Asylum......	4·73	90
Lan .	Auchtyfardle,...........	2·97	...	,, .	Darrynane Abbey.......	4·72	102
Ayr .	Kilmarnock, Agric. C.	3·78	132	*Wat* .	Waterford, Brook Lo...	2·16	66
,, .	Girvan, Pinmore..	4·74	111	*Tip* .	Nenagh, Cas. Lough...	4·26	136
Renf .	Glasgow, Queen's Pk. .	3·27	111	,, .	Roscrea, Timoney Park	1·46	...
,, .	Greenock, Prospect H.	6·09	108	,, .	Cashel, Ballinamona...	2·93	91
Bute .	Rothesay, Ardencraig.	6·59	165	*Lim* .	Foynes, Coolnanes......	3·48	109
,, .	Dougarie Lodge.........	3·99	...	,, .	Castleconnel Rec.......	4·12	...
Arg .	Ardgour House	12·20	...	*Clare* .	Inagh, Mount Callan...	7·25	...
,, .	Manse of Glenorchy...	9·08	...	,, .	Broadford, Hurdlest'n.	3·79	...
,, .	Oban......................	5·22	119	*Wexf*.	Gorey, Courtown Ho...	2·30	82
,, .	Poltalloch	6·40	148	*Kilk* .	Kilkenny Castle.........	2·02	80
,, .	Inveraray Castle...	9·57	141	*Wic* .	Rathnew, Clonmannon	1·79	...
,, .	Islay, Eallabus.........	6·94	165	*Carl* .	Hacketstown Rectory..	2·45	82
,, .	Mull, Benmore.........	...	...	*Leix* .	Blandsfort House......	2·37	88
,, .	Tiree	...	...	,, .	Mountmellick...........	3·09	...
Kinr .	Loch Leven Sluice......	1·70	95	*Off'ly* .	Birr Castle..............	2·53	110
Perth .	Loch Dhu................	7·05	95	*Kild'r*.	Monasterevin	2·31	...
,, .	Balquhidder, Stronvar	5·71	...	*Dubl* .	Dublin, FitzWm. Sq...	1·11	59
,, .	Crieff, Strathearn Hyd.	1·86	53	,, .	Balbriggan, Ardgillan.	1·85	94
,, .	Blair Castle Gardens...	2·63	94	*Me'th* .	Beauparc, St. Cloud...	2·19	...
Angus.	Kettins School.	1·16	55	,, .	Kells, Headfort.........	2·79	103
,, .	Dundee, E. Necropolis	1·35	72	*W.M* .	Moate, Coolatore......	2·50	...
,, .	Pearsie House...........	3·23	...	,, .	Mullingar, Belvedere..	3·01	108
,, .	Montrose, Sunnyside...	1·86	101	*Long* .	Castle Forbes Gdns......	3·24	114
Aber .	Braemar, Bank...	2·14	75	*Gal* .	Ballynahinch Castle...	7·98	156
,, .	Logie Coldstone Sch....	1·38	66	,, .	Galway, Grammar Sch.	3·64	...
,, .	Aberdeen, King's Coll.	2·80	136	*Mayo* .	Mallaranny..............	7·49	...
,, .	Fyvie Castle.............	3·33	149	,, .	Westport House.........	5·07	128
Moray.	Gordon Castle...........	2·41	125	,, .	Delphi Lodge............	9·80	114
,, .	Grantown-on-Spey......	2·11	100	*Sligo* .	Markree Obsy...........	4·42	126
Nairn.	Nairn, Delnies	1·86	103	*Cav'n* .	Belturbet, Cloverhill...	2·96	113
Inv .	Kingussie, The Birches	2·67	...	*Ferm* .	Enniskillen, Portora...	3·52	...
,, .	Loch Quoich, Loan.....	11·75	...	*Arm* .	Armagh Obsy............	2·68	121
,, .	Glenquoich..............	10·96	106	*Down* .	Fofanny Reservoir......	5·52	...
,, .	Inverness, Culduthel R.	2·26	...	,, .	Seaforde..................	2·26	74
,, .	Arisaig, Faire-na-Squir	5·39	...	,, .	Donaghadee, C. Stn...	2·59	112
,, .	Fort William...........	7·33	...	,, .	Banbridge, Milltown...	2·09	...
,, .	Skye, Dunvegan........	8·38	...	*Antr* .	Belfast, Cavehill Rd...	3·46	...
R & C.	Alness, Ardross Cas ...	4·37	132	,, .	Glenarm Castle.........	4·67	...
,, .	Ullapool	8·05	186	,, .	Ballymena, Harryville	4·47	138
,, .	Torridon, Bendamph...	7·87	100	*Lon* .	Londonderry, Creggan	5·41	170
,, .	Achnashellach..........	7·79	...	*Tyr* .	Donaghmore............	...	...
,, .	Stornoway..............	6·97	...	,, .	Omagh, Edenfel.........	4·32	145
Suth .	Lairg.....................	5·40	181	*Don* .	Malin Head..............	4·18	..
,, .	Tongue...................	4·65	134	,, .	Dunfanaghy..............	5·17	...
,, .	Melvich..................	4·63	...	,, .	Killybegs, Rockmount.	5·04	101

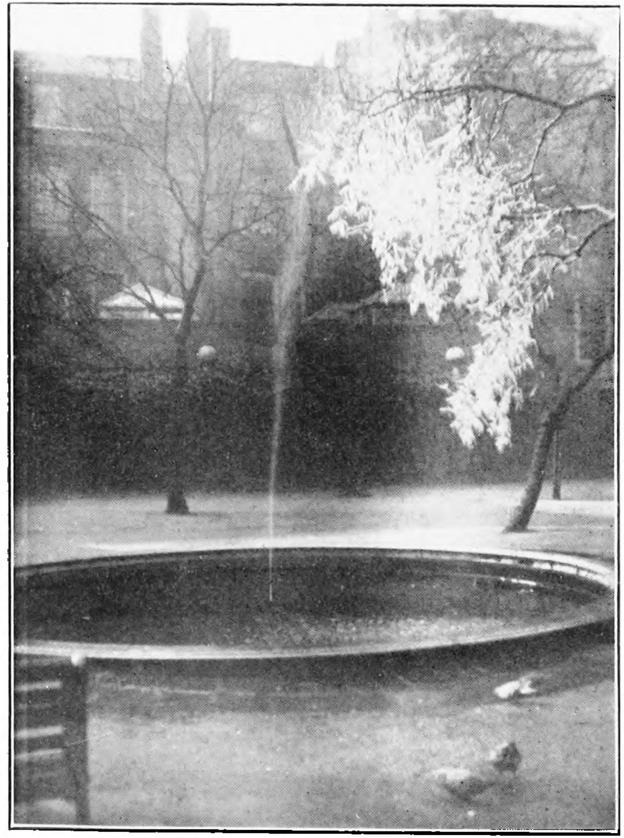
Climatological Table for the British Empire, September, 1930.

STATIONS	PRESSURE: Mean of Day M.S.L. mb.	PRESSURE: Diff. from Normal mb.	TEMPERATURE: Absolute Max. °F.	TEMPERATURE: Absolute Min. °F.	TEMPERATURE: Mean Values Max. °F.	TEMPERATURE: Mean Values Min. °F.	TEMPERATURE: Mean Values ½ max. and min. °F.	TEMPERATURE: Mean Values Diff. from Normal °F.	TEMPERATURE: Mean Wet Bulb °F.	Relative Humidity. %	Mean Cloud Am'nt 0—10	PRECIPITATION: Am'nt in.	PRECIPITATION: Diff. from Normal in.	PRECIPITATION: Days	BRIGHT SUNSHINE: Hours per day	BRIGHT SUNSHINE: Percentage of possible
London, Kew Obsy.	1014·0	— 3·4	76	45	64·8	52·5	58·7	+ 1·6	53·4	91	7·7	2·53	+ 0·66	18	3·9	31
Gibraltar	1017·1	— 0·2	93	61	83·0	66·5	74·7	+ 2·2	65·2	82	4·6	0·04	— 1·35	1	..	..
Malta	1016·1	— 0·8	86	62	79·5	69·3	74·4	— 1·6	68·7	75	3·1	2·51	+ 1·24	3	9·9	80
St. Helena	1017·3	+ 1·2	61	51	58·4	53·2	55·8	— 2·1	53·9	96	9·9	1·89	— 1·13	19	..	..
Sierra Leone	1014·3	+ 2·1	86	69	82·5	71·2	76·9	— 2·2	74·9	89	8·1	28·30	— 0·18	28	..	..
Lagos, Nigeria	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..
Kaduna, Nigeria	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..
Zomba, Nyasaland	1013·0	— 0·7	89	46	80·1	58·2	69·1	— 0·4	..	55	3·1	0·59	+ 0·25	2	..	..
Salisbury, Rhodesia	1012·5	— 0·6	91	35	80·5	52·7	66·6	+ 0·2	51·9	25	1·3	0·15	— 0·11	1	9·7	81
Cape Town	1020·0	+ 0·9	80	40	65·5	49·6	57·5	— 0·4	51·3	85	5·0	5·13	+ 2·89	14	..	..
Johannesburg	1016·5	— 1·4	81	28	70·7	46·7	58·7	— 0·7	44·8	36	1·6	0·00	— 0·96	0	10·3	87
Mauritius	1019·9	— 0·3	81	60	77·5	64·6	71·1	+ 1·0	66·7	67	6·9	1·94	+ 0·64	20	7·5	63
Bloemfontein	..	..	..	..	..	..	..	..	..	..	..	0·00	— 0·90	..	..	..
Calcutta, Alipore Obsy.	1004·8	+ 0·3	94	76	89·7	79·2	84·5	+ 1·5	79·6	89	7·4	7·02	— 2·85	15*	..	..
Bombay	1007·8	— 0·2	92	73	85·7	76·5	81·1	+ 0·3	77·2	89	7·8	43·85	+ 33·17	13*	..	..
Madras	1006·3	— 0·2	99	73	93·6	76·7	85·1	0·0	76·4	73	5·8	3·88	— 1·11	6*	..	..
Colombo, Ceylon	1011·0	+ 1·0	86	71	84·8	76·2	80·5	— 0·4	76·7	79	8·0	6·59	+ 0·37	21	6·7	55
Hongkong	1009·8	+ 1·4	89	73	83·7	76·4	80·1	— 0·9	75·4	90	7·8	28·25	+ 18·26	15	4·6	37
Sandakan	..	..	93	73	89·3	75·2	82·3	+ 0·6	76·9	78	..	13·90	+ 4·51	9	..	..
Sydney, N.S.W.	1017·0	+ 1·0	83	43	69·2	50·3	59·7	+ 0·5	53·5	59	4·0	0·19	— 2·70	7	8·6	72
Melbourne	1016·7	+ 0·9	79	37	64·0	45·7	54·9	+ 0·8	48·2	58	6·3	1·27	— 1·14	18	6·1	51
Adelaide	1018·6	+ 1·3	82	41	67·5	49·4	58·5	+ 1·4	52·2	63	6·4	2·56	+ 0·52	17	6·6	56
Perth, W. Australia	1017·8	— 0·1	82	44	67·5	51·7	59·6	+ 1·3	54·3	70	5·3	4·30	+ 0·90	14	7·6	64
Coolgardie	1017·6	+ 0·5	93	36	73·7	46·5	60·1	+ 1·5	51·0	43	2·3	0·23	— 0·38	2	..	..
Brisbane	1018·8	+ 1·5	85	48	76·1	54·4	65·3	0·0	58·3	58	2·7	0·95	— 1·10	3	9·0	76
Hobart, Tasmania	1009·0	— 1·7	71	37	58·6	44·0	51·3	+ 0·5	45·7	63	6·8	1·51	— 0·62	22	5·7	48
Wellington, N.Z.	1005·9	— 8·7	59	32	52·7	42·4	47·5	— 4·1	45·0	74	7·5	4·82	+ 0·85	19	4·2	36
Suva, Fiji	1013·6	— 0·7	80	58	75·1	65·6	70·3	— 4·2	66·1	76	7·7	7·53	+ 0·55	18	3·6	30
Apia, Samoa	1010·8	— 1·3	86	72	83·3	74·5	78·9	+ 0·7	76·1	77	5·9	3·60	— 1·52	11	6·8	57
Kingston, Jamaica	1012·4	+ 0·2	95	68	91·2	78·4	84·8	+ 3·3	72·3	77	4·9	1·04	— 2·99	8	7·5	61
Grenada, W.I.	1013·0	+ 1·3	90	70	87·0	73·9	80·5	+ 0·3	74·4	78	5·5	6·41	— 1·85	18	..	..
Toronto	1014·5	— 3·3	87	39	72·6	53·6	63·1	+ 3·9	55·1	79	4·1	2·83	— 0·35	8	6·7	54
Winnipeg	1011·9	— 2·9	85	26	65·2	44·5	54·9	+ 1·5	41·8	72	4·4	1·30	— 0·98	7	6·4	50
St. John, N.B.	1013·9	— 3·6	73	44	65·0	51·3	58·1	+ 2·2	53·7	79	6·0	1·47	— 2·27	14	6·0	48
Victoria, B.C.	1015·1	— 1·4	82	46	64·0	51·0	57·5	+ 1·9	54·1	84	4·9	1·04	— 0·97	7	6·9	55

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



Arc of Contact and "mock suns," February 24th, 1931 (see page 63).



Fountain Court, London, E.C.4, March 7th, 1931, 1.20 p.m. (see page 69).

M.O. 339.

The Meteorological Magazine

Air Ministry :: Meteorological Office

Vol. 66.

April, 1931

No. 783

LONDON: PUBLISHED BY HIS MAJESTY'S STATIONERY OFFICE

To be purchased directly from H.M. STATIONERY OFFICE at the following addresses: ADASTRAL HOUSE, KINGSWAY, LONDON, W.C.2; 120, GEORGE STREET, EDINBURGH; YORK STREET, MANCHESTER; 1, ST. ANDREW'S CRESCENT, CARDIFF; 15, DONEGALL SQUARE WEST, BELFAST; or through any Bookseller.

The Cold Spell and Snow of March, 1931

By W. R. MORGANS, M.Sc.

The severe frost and snow experienced in Great Britain during early March had actually started in Scotland on February 26th, and the incidence of the cold period in the south of England is mainly associated with the movement of an anticyclone originally centred over Greenland.

During the latter part of February, depressions to the north of Scotland moved north-east to Scandinavia, between anticyclones centred over Greenland and the Bay of Biscay, bringing in their rear a burst of cold air, which reduced considerably day temperatures throughout the country and in many parts of Scotland, brought them below freezing point. On February 27th a depression to the north of Scotland remained fairly stationary and deepened, while another over southern England moved rapidly eastwards, amalgamating with the former to form a complex depression over the Baltic by March 1st. Snow accompanied the passage of these depressions, and by February 28th and March 1st snow fell generally throughout the country. Dalwhinnie recorded snow drifts of 2 feet, Harrogate 4in. of snow lying and Croydon over 3in., while lightning and hail accompanied the falls in London. With the clearance, favourable to night radiation, in the rear of these depressions, screen and grass minimum temperatures were low generally during the nights of February 28th-March 1st and March 1st-2nd, the lowest

(93699) 107/27 1,075 4/31 M. & S. Gp.303

being 10°F. for the screen and 3°F. for the grass minima at Dalwhinnie.

Between March 2nd and 4th, the anticyclone over Greenland moved east and extended south, forming a ridge of high pressure over the North Sea and eastern Scotland. Severe cold and frost occurred during the extension of the anticyclonic ridge, espe-

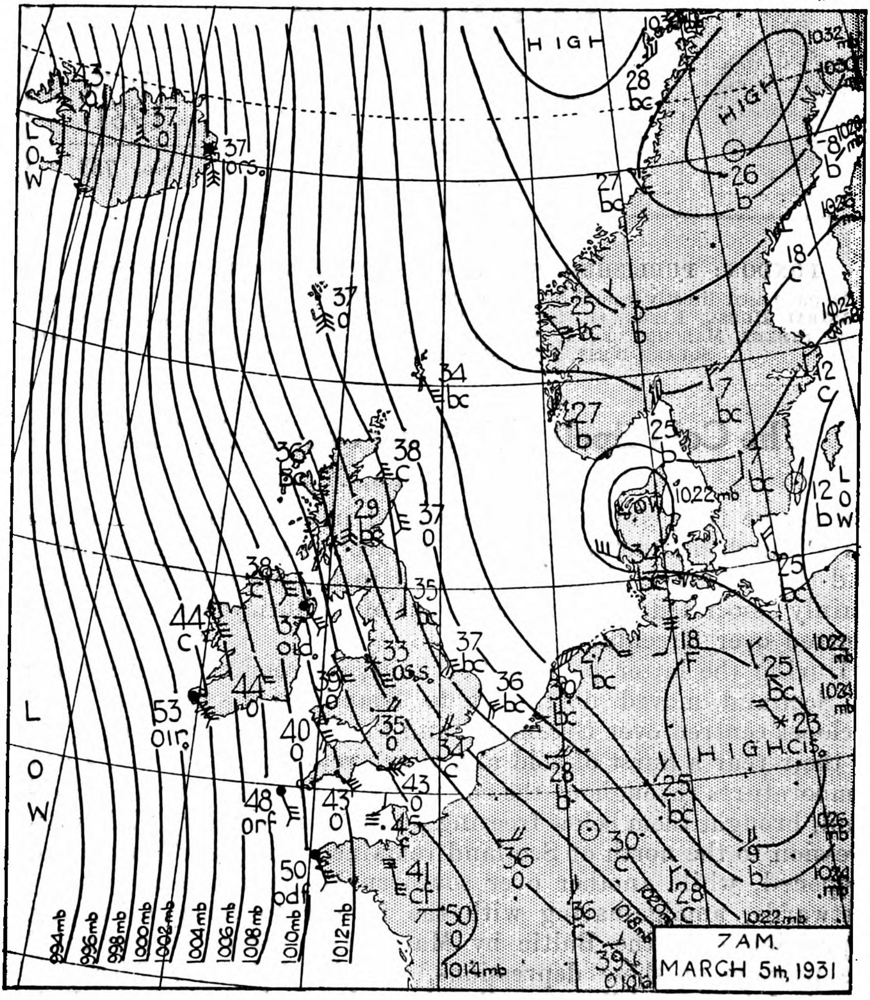


FIG. 1.

cially over Scotland, where day temperatures in many parts were well below freezing point. The maximum temperature on the 4th was 26°F. at Dalwhinnie and 32°F. at Aberdeen; the screen and grass minimum temperatures at Aberdeen on the night of the 3rd-4th were 12°F. and 8°F. respectively.

By the 5th, the Greenland anticyclone had become definitely established over Scandinavia and extended well into central Europe. Fig. 1 indicates the pressure distribution at 7h. on

March 5th, and shows a general current of south-easterly winds over Great Britain. Upper air temperatures taken at Duxford at 8h. and at Kjeller, Norway, at 10h. on the 5th are shown in Fig. 2, numbered (1) and (2), and it is seen that the upper air above Kjeller was much colder and had a much steeper lapse rate of temperature extending up to 15,000 feet than the air above Duxford on the same day. By the 8th, the Scandinavian anticyclone had moved west and built up off Iceland causing a

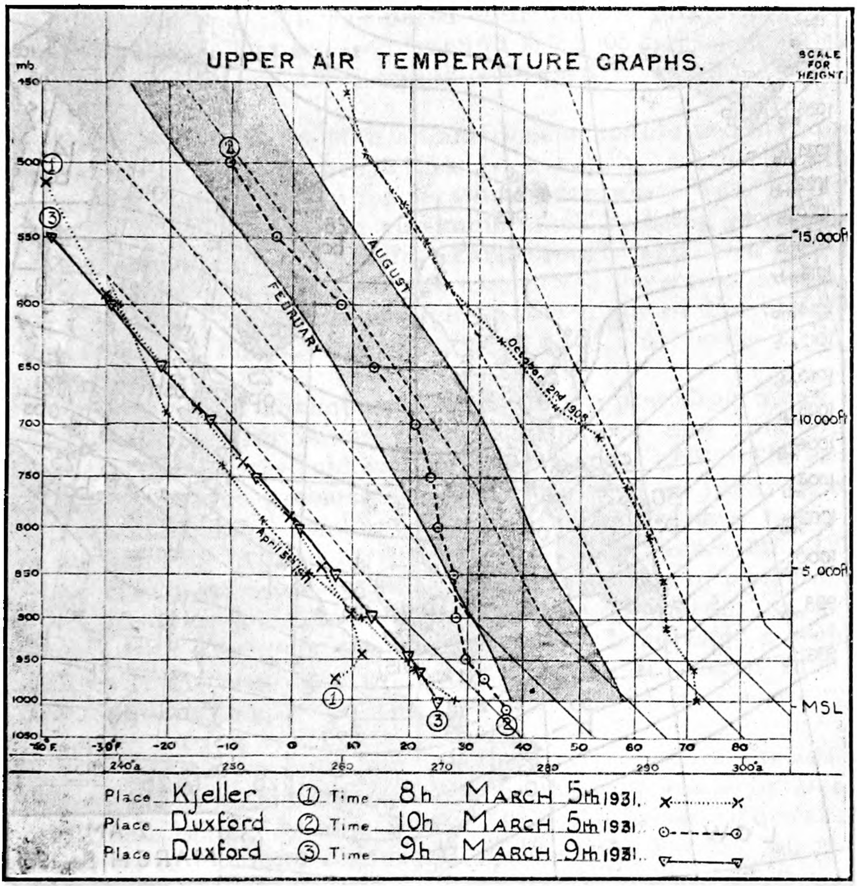


FIG. 2.

general sweep of easterly winds from Russia and Scandinavia across the British Isles. A synoptic chart showing the change in the position of the anticyclone by the 8th and the sweep of easterlies is shown in Fig. 3. An upper air temperature record taken at 9h. at Duxford on the 9th is also shown in Fig. 2 (3) and shows a marked fall of temperature of the upper air at Duxford, with a steep lapse rate of temperature closely comparable to that shown at Kjeller on the 5th. Moreover, from the upper air ascents, it is noticed that the cold air over Norway on the 5th was comparatively dry, but in its passage across the North Sea it had absorbed moisture, so that the humidity was high in the lower layers when it arrived over England. It was this fact, coupled with the steep lapse rate of temperature in the upper air that gave rise to instability and the consequent heavy falls of snow in this country during early March.

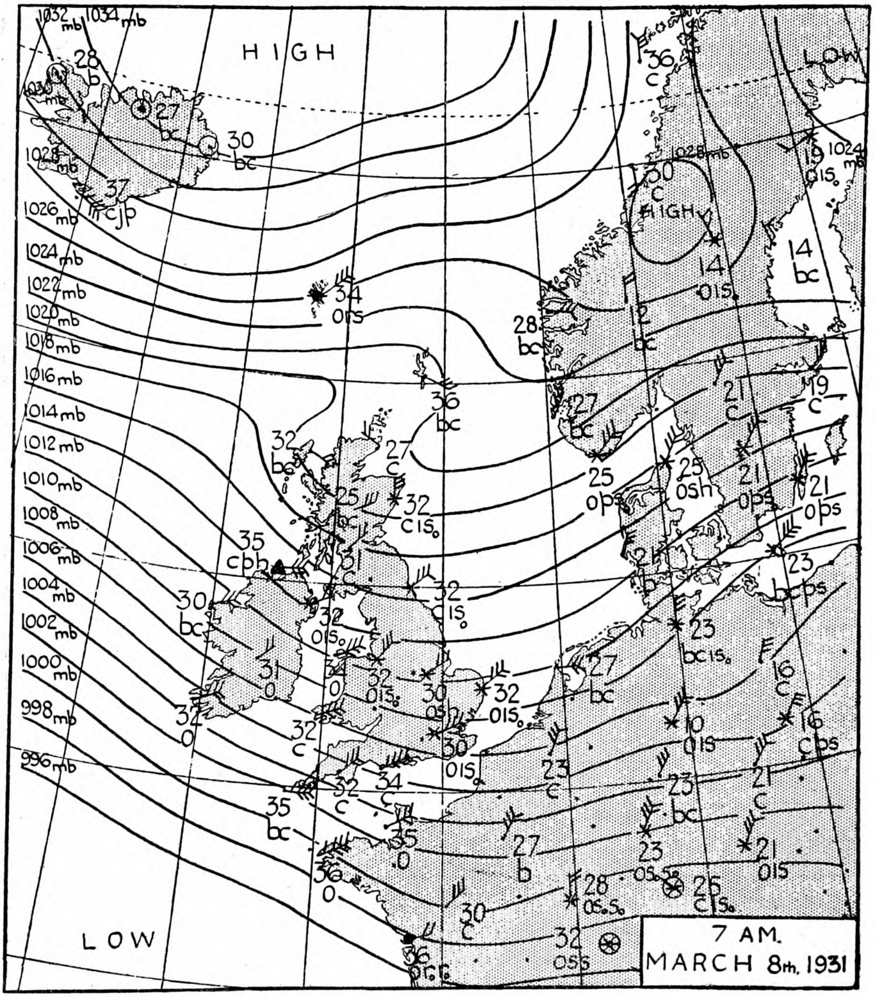


FIG. 3.

With the arrival of the cold air from northern Russia, snow fell generally throughout the country between the 6th and 10th, and kept day temperatures well below freezing point in many parts of the country for several days. On the 10th, the maximum temperature at Lympne was 27°F., and in many places in the south-east of England the maximum never exceeded 30°F. During this period some of the lowest screen minima recorded on the night of the 9th-10th were 13°F. at South Farnborough, 14°F. at Bournemouth and Dungeness, and 15°F. at Winchester, and some of the lowest grass minima on the same night were −1°F. at Lympne, 1°F. at South Farnborough, 4°F. at Kew and Shoeburyness.

The further movement westward of the anticyclone to the north of Iceland with an extension southward, brought fresh northerly winds over Great Britain, and though temperatures still continued low there was a considerable rise in temperature by the 11th and 12th, compared with the preceding days. The really cold spell apart from ground frost at night had finished in England by the 12th, but it continued in Scotland well up to the 15th.

From the 18th to the 20th, an anticyclone maintained high pressure to the east of the British Isles causing southerly winds over the country. Day temperatures everywhere were high for the period of the year, a maximum of 69°F. being recorded at Cardington, 66°F. at South Farnborough and Kew on the 20th. Another extreme for the month was the screen minimum of 13°F. at South Farnborough on the night of the 9th-10th, indicating at Farnborough a range of 53°F. during the 10 days, 10th-20th.

It might be of advantage to compare the preceding upper air temperatures with others taken at Duxford and Linkoping, Sweden, during the cold spell in early March, 1928. The establishment of high pressure over Iceland caused an influx of cold air from north Russia and upper air temperatures taken at Linkoping at 7h. and at Duxford at 11h. on March 9th, 1928, showed extremely cold air, with a steep lapse rate of temperature at Linkoping and much warmer air at Duxford. At 12h., March 10th, the upper air ascent at Duxford indicated a decided fall in temperature and a lapse rate similar to that at Linkoping. During the onset of this cold air snow fell and severe frost occurred during the nights.

The low temperatures (in March, 1931) compare favourably with other low temperatures during the cold spells in March, 1917 and 1928. During March, 1917, the lowest temperatures occurred in Scotland during the night of the 8th-9th, when the sky was clear and the saddle between two depressions was over the east coast. The lowest minima in Scotland were −3°F. at Braemar, −2°F. at West Linton, 0°F. at Balmoral and in England, 8°F. at Alnwick Castle and 9°F. at Hereford. For the grass minima, Balmoral recorded −5°F., West Linton −2°F., Buxton 0°F. and Durham 4°F. On March 13th, 1928, screen minima of 11°F. occurred at Rhayader and East Anstey and 12°F. at Stogursey, and on the night of the 13th-14th a grass minimum of 3°F. occurred at Stogursey and 7°F. at Rhayader.

The South-west Monsoon Drought of 1929 over Ceylon

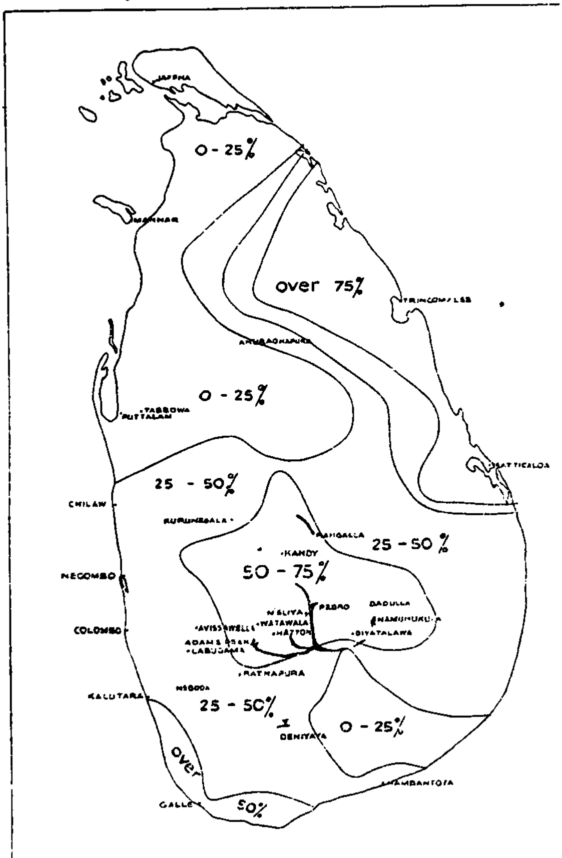
By H. Jameson, M.Sc., F.Inst.P.

There are two well-marked dry seasons at Colombo, centred in February and August, respectively, *i.e.*, after the rainy seasons which usher in the north-east and south-west monsoons have died away, and steady monsoon winds prevail in the neighbourhood of Ceylon. The former dry season usually gives the more severe droughts. The year 1929, which has furnished a number of new records in the weather of Great Britain, has provided at least one at Colombo, for the south-west monsoon drought of 1929 can fairly be described as the worst, for that season of the year, since rainfall observations were started. It has, however, often been exceeded in severity during the other dry season.

The *British Rainfall* definitions of drought are:—*Absolute drought*, any period of at least 15 consecutive days, to none of which is credited ·01in. of rain or more; *partial drought*, any period of at least 29 consecutive days, the mean daily rainfall of which does not exceed ·01in.; *dry spell*, any period of at least 15 consecutive days, to none of which is credited ·04in. of rain or more. At the Observatory in Cinnamon Gardens, no rain fell for 32 days, July 22nd-August 22nd, while there was a partial drought of 54 days, July 10th-September 1st, with a total fall of 0·45in. and a dry spell of 36 days, July 18th-August 22nd; the next highest figures, since 1908, for south-west monsoon droughts being 29, 39 and 29 days respectively. At the Fort, corresponding figures for the roof gauge there, when corrected to ground values, are 30, 53 (with 0·42in.), and 30, while the highest figures, excluding these, since 1870, for the same class of drought, are 29, 45 and 33 days respectively (roof or corrected ground readings).

The liability to rain or drought changes so rapidly from place to place in Ceylon, owing to the nature of the factors on which its climate depends, that absolute comparisons of rain, or the lack of it, at different stations would give no real information about this drought. For example, Chilaw, Puttalam and Tabbowa, 50 to 80 miles north of Colombo, showed much greater drought at that time. These stations, however, are on the borders of the dry zone, which suffers almost a permanent drought during the south-west monsoon, and their figures for this drought cannot be regarded as, comparatively, very high. Again, at Kalutara, on the coast about 30 miles south of Colombo, although the figures registered, absolute drought 26, partial drought 41, and dry spell 26 days, are distinctly less than those at Colombo, compared with past records they seem quite as outstanding. Although Kalutara showed fairly high figures for the drought, at Neboda, only 8 miles inland from it, but among the foot-hills, the lack of rain did not even reach the status of a drought.

A better method is to compare the actual rainfall with the average. As the drought at Colombo lasted over two-thirds of July and the whole of August, I expressed the total rain falling in those two months as a percentage of the average total for July and August together, for about 130 stations, fairly well distributed over the island, all of which had averages of at least 10 years.



RAINFALL OVER CEYLON, JULY AND AUGUST, 1929, EXPRESSED AS A PERCENTAGE OF THE AVERAGE.

The general grouping of these percentages is given in the figure. It shows that the total rainfall over the two months was in deficit over practically the whole island, the only exceptions, among the stations examined, being a few in the Trincomalee district, and one station, Rotawena, near the south-east coast, the latter standing out in marked contrast to neighbouring gauges. In the south-west of the island, the low-country districts showed generally about 40 per cent. of average, the Colombo district with 25-30, giving the lowest figures here, while a coastal strip near Galle showed just over 50 per cent. Up-country gave distinctly higher figures, 50-75 usually, on both the windward and leeward sides of the hills. The north-east coastal districts had the highest percentages, 75 to over 100 per cent., while the north and north-west, and the south-east, had the lowest, a large majority in the north and north-west reporting no rain at all over the two months. The distribution of the figures seems to be roughly symmetrical about a line drawn through the hills, in a direction approximately south-south-west to south-west.

The strength of the monsoon winds over the island was, on the whole, about normal in July, while it was distinctly below at most stations during August. The drought, however, apparently cannot be explained as due to weakness of the monsoon currents here, for the second half of July gave winds of much the same mean strength as the first half, both being about normal. On the south and west coasts, mean dry-bulb temperatures (mean of maximum and minimum) were only slightly above normal, and mean wet-bulb temperatures only slightly below, the mean deviations over the two months, for the group of four stations Puttalam, Colombo, Galle and Hambantota, being + 0·4°F. and − 0·6°F. for dry and wet bulbs respectively, while at the same stations the relative humidities (computed from 9h., 15h., and minimum temperatures), showed, on the whole, practically no change from normal. The drought cannot therefore be explained as due to unusual dryness of the monsoon winds, as far as surface observations are any criterion of this. Taking the island as a whole, the mean direction of the monsoon winds showed no marked deviation from normal, being a trifle west of south-west. It does not seem, therefore, that the drought can be explained in terms of a perceptible change in the general direction of the monsoon drift.

Observations at hill-stations gave no indication of marked deviation from the normal lapse-rate of temperature, the mean temperature offsets from average for low-country stations in the south-west of the island being + 0·3°F. for July and + 0·5°F. for August, while the corresponding offsets for Nuwara Eliya (6,200 ft.) were + 1·2°F. and + 0·7°F., and other hill stations showed similar small offsets, generally positive.

It seems rather remarkable, at first sight, that under steady south-west monsoon conditions in Ceylon, roughly June to September, inclusive, there should be such uniformity in many basic meteorological factors, wind, temperature, humidity, pressure gradient, over the different months, and yet such variations in the orographical rainfall in the south-west of the island. For example, the June and August mean monthly totals are 8·4 and 2·9 in. at Colombo, 18·0 and 9·4 at Avisawella (inland low-country) and 23·6 and 16·0 at Hatton (up-country). The monsoon currents approaching Ceylon must tend to form paths for themselves around the island and, more particularly, around the hills, and a possible explanation of these variations in the rainfall is that they are due to variations in the facility with which such stream-lines can be formed or maintained. The mean wind directions at Ceylon coast stations give distinct evidence of the presence of these stream-lines. Of these stations Galle, owing to its geographical position, shows the greatest deviation from the normal south-west direction of the monsoon winds, to a mean direction roughly west-north-west, and the mean monthly deviation is greatest in July and August, when the mean monsoon rainfall in the south-west of the island is distinctly less than in June or September.

Now the maintenance of these stream-lines will depend on the weather in adjacent regions. Depressions or other disturbances will tend to break them up, and force the air currents to rise over the obstacles in their path, instead of going round them, and the rainfall will increase. It is when the front of the monsoon, where such disturbances are most frequent, is farthest north, that least monsoon rain falls in the south-west of the island.

If this argument is correct, the unusual drought of July and August, 1929, can be explained, as far as the windward side of the island is concerned, on the hypothesis that the stream-lines formed then were even less affected than usual, by weather disturbances in adjacent regions. So much of the neighbourhood is sea, in which meteorological observations are scanty, that it is hardly possible to test this hypothesis directly, by a consideration of the general weather conditions near Ceylon. That the drought was roughly symmetrical with respect to the hills, and in a direction not far removed from the normal direction of the winds, is consistent with this explanation, though also not inconsistent with others.

Wind directions at individual stations give no clear indication of greater avoidance, at that time, of the obstacle of the hills. The observations, however, are few (twice a day, at 9h. 30m. and 15h. 30m.); moreover, it is possible that, even in a wet monsoon, the amount of rain that actually falls is only a small fraction of what could fall, if all the air went straight ahead over the obstacles in front of it, so that comparatively small deviations from the mean behaviour of the stream-lines might make a large difference in the amount of rain or drought.

The rainfall on the leeward side of Ceylon during this monsoon is mainly due to afternoon or evening thunderstorms, the result of local circulations (sea-breezes or mountain winds). The rainfall should therefore depend partly on the area of the wind-shadow caused by the hills, and the distance to which it extends out at sea, while other relevant factors are the humidity of the air in this wind-shadow, and the clearness of the sky above it in the early part of the day. Data about these factors are too scanty to make it worth while attempting any discussion of the 1929 drought in the east of Ceylon.

•Figures for July and August from the stations given in the *Indian Monthly Weather Report* show that the drought did not extend up the Malabar coast, which, on the whole, received about the normal rainfall for the period July-August. The country to leeward of the Ghauts and Cardamum Hills, however, was generally in deficit, which was most marked on the Indian side of the Gulf of Mannar, where percentage rainfalls as small as those on the Ceylon side were obtained.

Royal Meteorological Society

The monthly meeting of this Society was held on Wednesday, March 18th, at 49, Cromwell Road, South Kensington, Professor S. Chapman, F.R.S., Vice-President, in the Chair. As is customary in March, the meeting took the form of a lecture (The Symons Memorial Lecture), which was delivered on this occasion by Commander E. C. Shankland, R.N.R., his subject being:

Navigation from the Viking Period to the Present Day in Relation to Science and Meteorology.

Commander Shankland sketched the probable ideas which lay at the back of the Vikings' schemes for voyaging first westward, then south-westward, and finally making voyages over 2,000 miles, even reaching Luna in Italy by sea through the Mediterranean. The information of climatic conditions existing at the ninth century which we possess from reference to early literature provides an interesting possibility that this was a dry period, and that parts of Greenland now perennially ice covered, were dry and open for exploration. This may have induced the Vikings to venture afield to some remote places overseas. So much of the world's navigation history has been made and adventure commenced in the North Atlantic—either from the British Isles, Scandinavian or Continental seaports—that the use of an elementary sextant to maintain the measurement of latitude by polar star was, in the lecturer's opinion, used prior to the compass or lode stone in Europe. The polar star would not only be a sensitive measurement for latitude but also a meridional bearing for the voyages. The lecturer showed by a projection of the hemisphere having England as the centre, that it contains all the habitable globe except Australia and a small portion of South America. No other hemisphere can be contrived upon the earth having so great a proportion of land concentric to a chosen point as this. Cargoes carried by ships are the product of the land, and any port enjoying trading facilities and relations with the more habitable portions of the earth must be at an advantage if centrally situated. The want of local knowledge of the weather in the North Sea and Irish Sea was probably the greatest meteorological event in our history, as it contributed the loss of the Spanish Armada and so gave Great Britain the freedom of the seas. Matters such as the Gulf Stream and the many weather fallacies which surround the subject were touched upon. Among modern practices the wind pressure on ships, the utility of the barometer in gauging the lifting power of salvage pumps in salvage operations were explained. Ice navigation, fog signals, lights, and their allied meteorological features were also dealt with. Weather warnings, the life-boat service and also the winds and passages of the China Clippers in the 'sixties were described with numerous slides and references.

Correspondence

To the Editor, *The Meteorological Magazine.*

Barbados Rainfall from 1850 to 1930

Records are available from a sufficiently large number of stations throughout the island from 1850 to furnish data for comparison.

The island's rainfall for the eighty-one years from 1850 to 1930 somewhat strikingly divides itself into three periods of twenty-seven years each. The first and last periods are relatively dry, and the middle period relatively wet.

The mean annual rainfall of the island for the entire period, 1850 to 1930, is 60·07in., that for the three periods, 1850-1876, 1877-1903 and 1904-1930, is respectively 57·38in., 68·51in., and 54·31in.

Comparing the island's rainfall of each individual year in each period with the average annual rainfall of the entire period it is observed that during the first period (1850-1876) the annual rainfall exceeds the average in 8 years and is less than the average in 19 years; during the middle period (1877-1903) the annual rainfall exceeds the average in 20 years and is less than the average in 7 years; and during the last period (1904-1930) the annual rainfall exceeds the average in 6 years and is less than the average in 21 years.

Examining the amounts of the annual rainfall during the last period (1904-1930), it is observed that the years in which the average is much exceeded are 1906, 1915, 1918 and 1927, and only once in the last twelve years (1919-1930), namely in 1927, by the small margin of 3·69in., has the average been exceeded.

The three wettest years during the entire period (1850-1930) were 1901, 1896 and 1892 with annual amounts, representing the mean of more than 150 stations in each year, of 91·89in., 89·68in., and 86·46in., respectively. The three driest years in the same period were 1930, 1921 and 1912 with annual amounts of 38·95in., 40·72in., and 41·49in., respectively.

The year 1930 has been remarkable for the inequality of the distribution of rainfall throughout the island and also within very small areas of the island. It is noteworthy that the total rainfall for 1930 at individual stations ranges from 40 to nearly 90 per cent. of the average for the forty-year period, 1890-1929.

C. E. Skeete.

Dept. of Agriculture, Barbados, West Indies. March, 1931.

Arc of Contact and "Mock Suns"

Whilst on duty on the morning of February 24th, 1931, I observed at 9h. the "arc of contact" of the halo at 46°. It was situated in what appeared to be a perfectly cloudless portion of the sky (due no doubt to particularly fine ice-fog) and was of brilliant colouring, showing red, yellow, green and blue.

At 9h. 15m. a " mock sun " appeared to the right of the sun, and at 9h. 22m. one to the left also. The former was exceedingly fine, showing all colours from red nearest the sun to a purple tinge on the outside. That of the left-hand side was less distinct. (See figure forming part of the frontispiece of this number of the magazine.)

These phenomena remained " on view " until 9h. 45m., then faded rapidly. The remarkable thing was, that, during the whole period no trace was visible of the halo of 22°.

Particulars of weather, etc., were as follows:—Wind SW. light. Cloud 5/10th cirro-stratus and fine cirrus all on the sun's level and 1/10th alto-stratus low on the horizon. Visibility 4 miles. Sun's altitude 17°. " Arc of contact " 47° from the sun. The " mock suns " 23° from the sun on either side. Angular measurements were made with a theodolite.

CYRIL A. JUPP.

R.A.F. Station, Upper Heyford, Oxford. February 25th, 1931.

NOTES AND QUERIES

Floods in Arabia and the Western Desert of Egypt, December, 1930

In the *Meteorological Magazine* for March, 1931, was published an article by Mr. L. J. Sutton on " Exceptional rain in the Libyan Desert," December 28th to 30th, 1930. Subsequently the area of heavy rainfall extended further to the eastward, and in response to an inquiry Capt. J. Durward, Superintendent of the Meteorological Section, Middle East Area, received the following information:—

" Heavy rain fell over the whole region Akaba and Gueira on December 29th, 1930, beginning after 15h. 30m. G.M.T. Floods swept away the wall round Akaba, locally called Essadd, many houses fell and considerable damage to property was caused. There were three casualties, two children killed and one man injured. Nearly 100 head of cattle were swept away by the flood. Rain lasted on and off the whole night."

Capt. Durward adds the following comments:—

" On December 28th at 6h. G.M.T. a depression was situated near Crete, with an ill-defined secondary over the Western Desert. During the ensuing 24 hours the secondary moved across Egypt and at 6h. G.M.T. on the 29th it was centered over Sinai. This depression had well-marked warm and cold fronts; for example, in the warm air the temperature at Tor was 81°F. and in the cold air at Ismailia, Heliopolis and Assuit it was about 60°F. The cold front reached Ramleh (Palestine) about 11h. G.M.T. and Amman (Transjordan) about 14h. G.M.T. on December 29th. The air over the whole of Lower Egypt, Palestine and Transjordan was therefore cold air which had crossed the Mediterranean and was in consequence relatively damp.

Meantime the main depression near Crete on the 28th had moved south-eastwards, being centered near Sollum on the 29th, and a supply of still colder air had invaded Western Egypt (for example, at 6h. G.M.T. on the 29th the temperature at Siwa is 13°F. less than at Matruh). The effect of this new supply of cold air was to force the already damp air upwards and cause rain, which was very heavy in the Western Desert, but not very heavy further east in the Cairo and Canal zone.

Some of the rain which fell in Transjordan on the 29th may have been caused by the forced elevation of very warm air from the Red Sea, but most of it was due to the same conditions as caused the rain in the Western Desert on the 28th and 29th. At Ramleh, for example, the heaviest rain fell between 2h. 30m. and 4h. 30m. G.M.T. on the 30th, which is about 16 hours after the passage of the first cold front. The rainfall at Amman up to 6h. G.M.T. on December 30th was only about 4mm. Ma'an reported 10mm., so that the rainfall on the slopes of the wady carrying the Ma'an-Akaba road may have been heavier still. In any case it was sufficient to convert the dried-up river bed into ' a torrent six feet deep.' "

The Deepening of Depressions by Day and Night

In the *Meteorological Magazine* for March, 1931, on pp. 39-41, there appears a note by Mr. C. K. M. Douglas on " The Deepening of Depressions by Day and Night." The following remarks extracted from the conclusions reached in two papers by the present writer (one published four years ago,* the other at present in the press†) are of interest in the same connexion. In the first the conclusion is reached that " at least over the British Isles, phenomena of the warm front and cold front descriptions either show preferences, as to the times of their occurrence, for certain periods, or are more conspicuous when they pass within these periods." In the second paper, amongst other conclusions there are the following, " the rainfalls occurring at warm fronts and cold fronts have characteristic semi-diurnal variations of very considerable amplitude, variations which are much more marked than those in rainfall occurring in homogeneous equatorial or polar currents. The variations are in neither case symmetrically semi-diurnal, but if one averages up the two types of rainfall the times of maxima correspond roughly to those of minima of barometric pressure and *vice versa* in the average semi-diurnal variation of pressure. If the resonance theory of the semi-diurnal oscillation of pressure be accepted, there is some difficulty in seeing why the normal pressure variation should be associated so markedly with the variations of rainfall in the

***Edinburgh, Proc. R. Soc.*, XLVII 1927, pp. 326-58.
†*London Meteor. Office, Geophys. Mem.* No. 53.

locality of discontinuities and less so, if at all, with the rainfall of days which are subject to less disturbance of a local character."

As a result of comparison between sets of data dealt with in the two papers it is noted that—(1) the pressure variation (reversed) on bright days of equatorial air resembles the variation of rainfall on cold front days, and (2) the pressure variation (reversed) on cloudy days of equatorial air resembles the variation of rainfall on warm front days.

And it is finally concluded that the diurnal variation in the rainfall at fronts is controlled primarily—

" (*a*) in the case of cold fronts by the working of insolation and radiation on the more or less clear warm sector in advance of or above the front; and

" (*b*) in the case of warm fronts by the corresponding effects of insolation and radiation on the warm air above the upsliding surface."

In another part of the second paper it is remarked that " it is inevitable that the diurnal processes besides affecting the rainfall, affect the behaviour and subsequent history of the depression; that is, the working of the diurnal events may lead to occlusion of the warm sector and the formation of secondaries or, on the other hand, may lead to a broadening of the warm sector and the deepening or increasing of the speed of propagation of the depression."

Whilst it has not yet been possible to explore fully this last aspect of the question, it will be seen that the feeling of the present writer is that diurnal behaviour of depressions is probably too complicated a matter to be summed up simply by a greater readiness with which they deepen by night, though that must be regarded as a fact applicable to a considerable majority of cases.

The conclusion that a controlling part in the behaviour of both cold and warm fronts lies with the working of the diurnal processes on the warm air is not opposed to the view of Mr. Douglas that the true cause of the more ready deepening of depressions by night lies in the upper air.

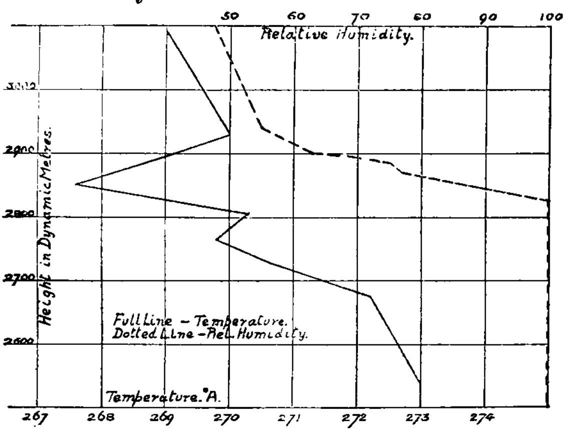
A. H. R. Goldie.

Remarkable Temperature Lapse Rate

A sounding with a registering balloon carrying a meteorograph of the Dines pattern, made from Kew Observatory at 18h. G.M.T. on September 13th, 1930, yielded an unusual record at a height of about 3 kilometres.

The diagram shows an enlarged graph of temperature and relative humidity against height, or more strictly geopotential. For those not familiar with the unit employed it may be stated that 3,000 on the graph corresponds with a height of 3,060 metres, and so on in proportion.

A slight shower of rain fell about 7 minutes before the sounding balloon was released, and at the time of the start the sky was nearly covered with cumulus and strato-cumulus clouds.



UPPER AIR TEMPERATURE AT KEW OBSERVATORY ON SEPT. 13TH, 1930.

An examination of the graph shows a series of exceedingly sudden changes in the lapse rate, combined with a very sudden fall of the relative humidity from a previous state of saturation. The air above 3,000m. was very dry, while both above and below the region considered the lapse rate had a value of about 6° per 1,000m. The salient point to notice is the very rapid fall of temperature between 2,810m. and 2,850m., amounting to a lapse rate of about 50° per 1,000m., combined with a very sudden fall of relative humidity at the same point. Above is a rapid rise of temperature up to 2,930m.

The most probable explanation seems to be that the balloon rose through the centre of a cumulus cloud, and that it emerged from the top at about 2,800m., probably the very cloud which caused the shower a few minutes before the start of the sounding. If the sharply defined hump of saturated air at the top of an active cumulus cloud be rising upwards, there must be just above it a layer of drier air in process of being borne upwards. The temperature of this layer must be lower than that of the saturated air below on account of the difference between the adiabatic lapse rates for saturated and unsaturated air. This layer must also be cooler than the undisturbed air at the same level, unless the general lapse rate be equal to the dry adiabatic rate, which on this occasion there is no evidence was the case. Hence the cold layer will continually slide off the hump and will not be of great thickness.

Such a hypothesis fits in well with the temperature changes shown on the graph; the zigzag at 2,800m. suggests a region of turbulence at the top of the hump, which is not an improbable thing. It is not perhaps wise to attach too much importance to the precise point at which the humidity began to fall; the hygrograph is somewhat sluggish, and the whole sequence of changes of temperature must have taken place within about a minute, working from the known approximate rate of ascent of the balloon. The rate of change of relative humidity shown is much greater than is ordinarily observed in upper air soundings, and indicates some unusual discontinuity.

L. H. G. DINES.

Warm Front Fog

Although fog along the south-west coasts of the British Isles is by no means an uncommon feature when an air-mass associated with a depression spreads to more northerly latitudes, it is usually preceded by a well-marked belt of rain, low-lying cloud and falling pressure. The arrival of the warmer air-mass originating in sub-tropical latitudes is shown on many occasions by a belt of fog stretching sometimes over a large area of sea and coast. Observations from ships often show the presence of the fog some hours before the warmer air reaches the British coasts, and such observations form one of the safest guides in identifying and locating the warm front of a depression. A fog of short duration occurred at Plymouth on November 7th, 1930, associated with the arrival of such an air-mass, but of which very little warning could be given from an examination of synoptic charts.

A shallow occluded depression travelled north-east over the Faeroes during the night November 6th-7th. The remains of its warm sector were indicated over the British Isles at 7 a.m. on November 7th by slight discontinuities in wind direction, while rain (reported as a shower) occurred over the Scilly Isles between 6 and 7 a.m. as the warm front passed. The succession of events at Plymouth is indicated by the following notes supplied by the Meteorological Station at Mount Batten :—

"The visibility during the morning was very variable. Patches of haze diminished the visibility in some directions at 7 a.m. to 2,000 yards, while in other directions it was very good. By 9.30 a.m. the visibility had decreased a good deal towards the land and by 10 a.m. was 700 yards. It was a "thin" fog, the visibility seawards, *i.e.*, south to south-west, being three miles and to the south-east about five miles.

"Between 7 a.m. and 1 p.m. the clouds were of strato-cumulus type, 8/10 to 9/10 of the sky being covered, with the cloud base at about 2,000 feet. The wind was light from NE. at 7 a.m., dropping to a calm at 9.45 a.m., with puffs from a westerly point. Between 7 a.m. and 10 a.m. the temperature rose 8°F to 43°F. and was still rising rapidly at that time, 53°F. being measured at 1 p.m. Pressure changes were very small, the barometer being almost steady after a rise.

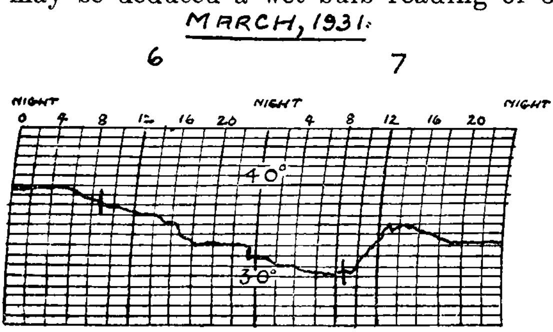
"Slight drizzle occurred at 9.40 a.m. and the fog finally cleared about 10.30 a.m."

The succession of events may be explained by supposing that at 7 a.m. there was a gravitational flow of air from the neighbouring high ground, the air having been cooled by radiation and the flow seawards was assisted by the higher temperature of the sea compared with the land. The air flowing down the valleys into the different channels in Plymouth Harbour would be broken into several streams and this would account for the visibility varying so much in different directions. Mixing would occur between the new air mass and the air mass being displaced, thus producing condensation as shown by the drizzle and fog, The fog would disperse as the air temperature rose and the gravitational flow or air cased." R. S. READ.

Cooling by Evaporation

The dry easterly winds of Friday and Saturday, March 6th and 7th, provided an interesting example of freezing by evaporation in Fountain Court, London, E.C.4. A tree grows near the fountain and at times spray falls over its lower branches.

At midday on the 6th these branches were covered with a thin layer of ice, although the air temperature was above freezing point; the appearance of the twigs was similar to that shown in the illustration on page 53 (Plate III) of the *Meteorological Observer's Handbook*. The temperature on the Air Ministry roof at the time (1 p.m.) was 35·7°F., and the reading of the dry bulb at Kew was 35°F. No wet bulb reading was taken, but the humidity by the hair hygrograph was 54 per cent., from which may be deduced a wet bulb reading of 30°F.



TEMPERATURE AT ST. JAMES' PARK.

To fix more clearly how the ice coating was formed the tree was examined at 9 a.m. on the 7th, and the twigs were perfectly dry and free from ice or frost in any form, although the temperature was 29°F.; the ice coating of the day before had evaporated after the fountain ceased playing at 4 p.m. The fountain recommenced at 11 a.m., by which time the temperature had risen to 32°F., and by 1 p.m. the tree was a delightful sight; thick, clear, shining ice, glistening in the sunshine, covered every twig on the nearer side of the tree.

The 1 p.m. temperature readings on the 7th were, at the Air Ministry, 34°F. and at Kew Observatory 33°F. From the hair hygrograph reading of 47 per cent. the deduced wet-bulb reading was 28°F. The nearest thermograph at 4ft. above ground level is in St. James' Park, and the record shows that the temperature of the air was above the freezing point from 11 a.m.-4 p.m. both on 6th and 7th. During the 6th temperature fell continuously from 39°F. at 4 a.m. to 32°F. at midnight.

The photograph forming part of the frontispiece of this number of the magazine which was taken at 1.20 p.m. on the 7th gives an impression of the effect but lacks the desired definition.

R. M. POULTER.

Review

Medidas definidas de la presión atmosférica. By G. Koschmeider. (Madrid, Anales de la Sociedad Española de Meteorologia. Vol. III, No. 4, 1929, pp. 98—105.)

G. v. Elsner has shown that the values of atmospheric pressure at a mountain station reduced to the level of a lower station generally appear too low, the discrepancy varying according to the wind velocity. Thus, on the Schneekoppe (1610·5m.) with a wind of force 10 the pressure reduced to 396·8m. is too low by an average amount of 2·5mm., but with a wind of force 5 the discrepancy is only 0·1mm. Dr. Koschmeider shows that this difference is due to the dynamical effect of the wind in reducing the pressure, and divides it into two parts, the effect of the building in which the barometer is housed, and the effect of the topography of the mountain summit. He shows that about the round tower of Göttingen the distribution of pressure agrees fairly well with the theoretical distribution about an infinite cylinder; the total effect is a diminution of pressure, and this is communicated through windows to the interior of the tower where it affects the reading of the barometer.

To separate this " edifice effect " from the topography effect, experiments were carried out at the observatory on the Schneekoppe. The pressure inside the building was given by a barograph, that on the summit away from the building by a manometer connected to an orifice in a plate level with the ground at least 25 metres away. The undisturbed pressure (*i.e.*, excluding both topography and edifice effects) was given by the manometer when the wind fell below 12m/s. The edifice effect at high wind velocities closely resembled the theoretical effect on the interior of an infinite cylinder in free communication with the exterior on all sides, and reached 2mm. with a wind velocity of 30m/s. The topography effect on the windward side of the summit was represented closely at velocities exceeding 16m/s., by the equation $\delta p = 0{\cdot}0033\ v^2$ (v in m/s., p in mm. of mercury). The two were not additive, the edifice effect occurring with winds between WSW. and NNW., the topography effect with winds between S. and SW.

This is a paper of considerable interest, calling attention to a source of error which may be important in synoptic meteorology.

Books Received

Falmouth Observatory. Meteorological Notes and Tables for the year 1929, also Table of the mean magnetic declination at Falmouth from 1888 to 1930 by W. T. Hooper. Falmouth, 1930.

Natürliche und künstliche Strahlungen. By Dr. W. Mörikofer (reprinted from Die Medizinische Welt No. 13).

News in Brief

During March the mean minimum temperature at Ross on-Wye was below normal for the first time since September, 1929 (except February, 1930, when it was 0·2°F. below normal), a period of 18 months.

Dr. J. Keranen has succeeded Prof. G. Melander as Director (interim) of the Finnish Meteorological Service.

Dr. J. Lugeon has succeeded Prof. S. Hlasek as Director of the Polish Meteorological Service.

The following telegram, dated Cape Town, April 8th, and addressed Capt. Entwistle, Air Ministry, London, has been received in the Meteorological Office from Lt.-Commander Glen Kidston on the completion of his flight from England: "My sincere thanks your valuable co-operation without which my successful attempt on record would not have been possible (signed) Glen Kidston."

On March 31st two members of the staff of the Meteorological Office retired. Miss R. E. Smith joined the Office in 1891 and worked first in the Marine Division and later in the Library, where she was well known as the custodian of the lantern slides. Mr. A. E. Pycock joined the Office in 1887 and worked mainly in the Climatological Division, especially on the preparation of the *Weekly Weather Report.* Previous to 1887 he had spent 7 years with the Royal Meteorological Society and thus has completed 50 years' work in meteorology. A large gathering of past and present members of the staff met in the library at 5.30 p.m., when presentations were made by the Director on their behalf to Miss Smith and Mr. Pycock in recognition of their long and valued services.

The Weather of March, 1931

Pressure was below normal over the eastern United States, most of the North Atlantic, southern Europe and Russia, the greatest deficits being 16·6mb. at Horta and 6·8mb. at Moscow. Pressure was above normal over the western United States, Canada, Greenland, Spitsbergen, north-west Europe and Germany, the greatest excesses being 11·6mb. at 60°N., 60°W. and 11·1mb. at Thorshavn. On the Baltic and Bothnia Seas pressure was normal. Temperature was mainly above normal in south-west Europe, northern Scandinavia and Spitsbergen, but below normal in southern Scandinavia and central Europe. Rainfall was generally in excess in central Europe and northern Norway and deficient in Spitsbergen and Sweden, one of the greatest deficits being 24 per cent. of the normal at Bohuslaen, Sweden. Easterly winds and, except in Ireland and south-west England, dry and sunny conditions were the salient features of the weather of March over the British Isles. The first fortnight was cold in the east and north, with an exceptionally cold spell in the south-east from the 6th to 10th, while in the south-west it was warm and unsettled until the 6th and cold from then to the 10th. During this first warm spell in the south-west rainfall was heavy; 2·13in. occurred at Kilmacthomas (Co. Waterford) and 2·06in. at Glanmire (Co. Cork) on the 5th, and 1·34in. at Bodmin (Cornwall) on the 3rd. In the east and north snow fell heavily on the 1st and 2nd in Scotland and north-east England and slightly in south-east England. By the 4th cold south-easterly winds had set in. These gradually backed to east and spread over the whole country, and then on the 9th and 10th to north-east, when the coldest weather was experienced in south-east England. Snow fell heavily at times during this period,* but there were many long sunny intervals. The 12th and 14th were both sunny days, Clacton having as much as 10·4hrs. bright sunshine on the 12th. By the 11th, the snow had melted from the south but continued in the north until the 15th. From the 13th there was a gradual rise of temperature which extended to Scotland after the 16th as the winds came from a more southerly source. Temperature was highest on the 20th, when 69°F. was reached at Greenwich and Cardington, 67°F. at Tottenham and Cardiff, and 66°F. at Southport, Manchester and Morecambe, and the sunniest days of this period were the 15th, 17th and 18th. Aspatria had 10·6hrs. on the 18th. On the 22nd an anticyclone moved south-east over the British Isles and a period of quiet, mainly dry, weather followed, with fairly warm days and cold nights. Except in the extreme south-west pressure continued high and the weather dry but colder until the end of the month, with much sun on the 25th to 27th; 11·7hrs. were reported from Aberystwyth on the 27th. The extreme south-west, however, came under the influence of a large depression over the Atlantic about the 27th, and unsettled conditions prevailed there with much rain at times. 1·65in. fell at Dunmanway (Co. Cork) and 1·00in. at St. Austell (Cornwall) on the 31st. The distribution of bright sunshine for the month was as follows :—

* See page 53.

	Total (hrs.)	Diff. from normal (hrs.)		Total (hrs.)	Diff. from normal (hrs.)
Stornoway	147	+ 42	Liverpool	133	+25
Aberdeen	107	— 10	Ross-on-Wye	135	+19
Dublin	109	— 14	Falmouth	89	—49
Birr Castle	98	— 12	Gorleston	164	+29
Valentia	91	— 32	Kew	123	+18

The special message from Brazil states that the rainfall in all regions was scarce being 0·31in., 0·28in. and 1·02in. below normal in the northern, central and southern regions respectively. Five anticyclones passed across the country and the continental depression was active. Crops were generally in good condition and the weather favourable for the harvest. At Rio de Janeiro pressure was 0·6mb. below normal and temperature 0·2°F. below normal.

Miscellaneous notes on weather abroad culled from various sources. Unusually cold weather set in on the 1st in the Naples districts, and the surrounding mountains were covered with snow. Floods were experienced on the Seine from near the beginning of the month until about the 16th. On the 9th a severe snowstorm was experienced over most of Switzerland, and was followed by a thaw on the 13th which caused widespread avalanches and landslips. (*The Times*, March 3rd-25th.)

A hurricane was raging in the neighbourhood of Mauritius from the 4th to 6th and much damage was done to the sugar-cane crop. (*The Times*, March 6th-10th, 21st.)

Another hurricane passed over the Fiji Islands on the 2nd, accompanied by torrential rains which caused further floods. (*The Times*, March 3rd.)

Severe storms were experienced on the Atlantic early in the month. Storms and exceptionally high tides occurred along the Atlantic coast of the United States on the 4th. Heavy snowstorms were experienced in Canada and the Middle West on the 7th and 8th, while heavy gales and torrential rain swept New York and New Jersey on the 8th. (*The Times*, March 6th and 10th.) In the United States temperature was slightly below normal in the eastern districts, but above normal in the western, where it was as much as 15°F. above normal at Miles City and Havre for the week ending the 24th. In the Argentine the weather was abnormally warm for the time of year at the beginning of the month. (Washington, U.S. Dept. Agric., Weekly Weather and Crop Bulletin.)

Rainfall, March, 1931—General Distribution

England and Wales ...	36	per cent of the average 1881-1915.
Scotland	42	
Ireland	101	
British Isles	51	

Rainfall: March, 1931: England and Wales

Co.	Station	In.	Per-cent. of Av.	Co.	Station	In.	Per-cent. of Av.
Lond .	Camden Square.........	·23	13	*Rut* .	Ridlington...............	·17	10
Sur .	Reigate, Alvington.....	·34	15	*Linc* .	Boston, Skirbeck........	·35	22
Kent .	Tenterden, Ashenden...	·34	16	,, .	Cranwell Aerodrome...	·30	21
,, .	Folkestone, Boro. San..	·57	...	,, .	Skegness, Marine Gdns	·27	16
,, .	Margate, Cliftonville...	·15	9	,, .	Louth, Westgate........	·54	25
,, .	Sevenoaks, Speldhurst	·50	...	,, .	Brigg, Wrawby St.....	·43	...
Sus .	Patching Farm.........	·87	40	*Notts* .	Worksop, Hodsock.....	·32	19
,, .	Brighton, Old Steyne..	·41	20	*Derby* .	Derby, L. M. & S. Rly.	·10	6
,, .	Heathfield, Barklye....	·56	22	,, .	Buxton, Devon Hos....	·24	6
Hants .	Ventnor, Roy. Nat. Hos.	1·25	61	*Ches* .	Runcorn, Weston Pt...	·26	13
,, .	Fordingbridge, Oaklnds	·92	39	,, .	Nantwich, Dorfold Hall	·47	...
,, .	Ovington Rectory.......	·40	15	*Lancs* .	Manchester, Whit. Pk.	·31	14
,, .	Sherborne St. John.....	·18	8	,, .	Stonyhurst College.....	·53	14
Berks .	Wellington College.....	·12	6	,, .	Southport, Hesketh Pk	·37	17
,, .	Newbury, Greenham...	·16	7	,, .	Lancaster, Strathspey	·52	...
Herts .	Welwyn Garden City...	·24	...	*Yorks* .	Wath-upon-Dearne.....	·23	13
Bucks .	H. Wycombe, Flackwell	·14	...	,, .	Bradford, Lister Pk....	·43	18
Oxf . .	Oxford, Mag. College..	·10	7	,, .	Oughtershaw Hall......	1·31	...
Nor .	Pitsford, Sedgebrook...	·07	4	,, .	Wetherby, Ribston H.	·85	44
,, .	Oundle..................	·31	...	,, .	Hull, Pearson Park.....	·54	30
Beds .	Woburn, Crawley Mill	·07	4	,, .	Holme-on-Spalding.....	·96	...
Cam .	Cambridge, Bot. Gdns.	·19	13	,, .	West Witton, Ivy Ho.	·95	31
Essex .	Chelmsford, County Lab	·25	14	,, .	Felixkirk, Mt. St. John	1·80	91
,, .	Lexden Hill House....	·24	...	,, .	Pickering, Hungate....	1·18	59
Suff .	Hawkedon Rectory.....	·24	13	,, .	Scarborough............	·73	40
,, .	Haughley House........	·13	...	,, .	Middlesbrough..........	1·25	80
Norf .	Norwich, Eaton.........	...	...	,, .	Baldersdale, Hury Res.	·79	...
,, .	Wells, Holkham Hall	...	..	*Durh* .	Ushaw College..........	2·97	135
,, .	Little Dunham..........	·85	44	*Nor* .	Newcastle, Town Moor	1·03	49
Wilts .	Devizes, Highclere......	·45	21	,, .	Bellingham, Highgreen	1·70	58
,, .	Bishops Cannings.......	·52	23	,, .	Lilburn Tower Gdns....	1·23	46
Dor .	Evershot, Melbury Ho.	1·10	37	*Cumb* .	Geltsdale................	1·30	...
,, .	Creech Grange..........	1·36	48	,, .	Carlisle, Scaleby Hall	1·20	49
,, .	Shaftesbury, Abbey Ho.	·92	39	,, .	Borrowdale, Seathwaite	1·60	14
Devon .	Plymouth, The Hoe....	2·07	71	,, .	Borrowdale, Rosthwaite	1·70	...
,, .	Polapit Tamar..........	2·72	91	,, .	Keswick, High Hill.....	·99	...
,, .	Ashburton, Druid Ho.	..	...	*West* .	Appleby, Castle Bank..	·90	34
,, .	Cullompton..............	1·68	61	*Glam* .	Cardiff, Ely P. Stn.....	·93	29
,, .	Sidmouth, Sidmount...	1·48	61	,, .	Treherbert, Tynywaun	1·20	...
,, .	Filleigh, Castle Hill....	1·57	...	*Carm* .	Carmarthen Friary.....	1·22	32
,, .	Barnstable. N. Dev. Ath.	2·09	80	,, .	Llanwrda................	1·34	29
Corn .	Redruth, Trewirgie.....	5·28	147	*Pemb* .	Haverfordwest, School	2·20	64
,, .	Penzance, Morrab Gdn.	4·37	137	*Card* .	Aberystwyth............	1·49	...
,, .	St. Austell, Trevarna...	5·06	147	,, .	Cardigan, County Sch.	1·17	...
Soms .	Chewton Mendip........	1·09	31	*Brec* .	Crickhowell, Talymaes	·80	...
,, .	Long Ashton............	·86	34	*Rad* .	Birm W. W. Tyrmynydd	2·18	41
,, .	Street, Millfield........	·93	45	*Mont* .	Lake Vyrnwy...........	1·17	27
Glos. .	Cirencester, Gwynfa....	·26	11	*Denb* .	Llangynhafal............	·54	23
Here .	Ross, Birchlea...........	·47	23	*Mer* .	Dolgelly, Bryntirion...	1·38	28
,, .	Ledbury, Underdown..	·30	16	*Carn* .	Llandudno...............	·81	37
Salop .	Church Stretton........	·40	17	,, .	Snowdon, L. Llydaw 9	3·15	...
,, .	Shifnal, Hatton Grange	·28	15	*Ang* .	Holyhead, Salt Island	1·28	49
Worc .	Ombersley, Holt Lock	·13	8	,, .	Lligwy..................	1·02	38
,, .	Blockley.................	·11	...	*Isle of Man*			
War .	Birminghm, Edgbaston	·18	9		Douglas, Boro' Cem....	1·01	34
Leics .	Thornton Reservoir....	·09	5	*Guernsey*			
,, .	Belvoir Castle...........	·31	17		St. Peter P't. Grange Rd.	2·86	116

Erratum for February, Cambridge, Bot. Gdns. for 1·63 \| 127 read 2·11 \| 165.

Rainfall: March, 1931: Scotland and Ireland

Co.	Station	In.	Per-cent. of Av.	Co.	Station	In.	Per cent. of Av.
Wigt .	Pt. William, Monreith	1·01	35	*Suth* .	Loch More, Achfary ...	1·69	26
,, .	New Luce School......	1·40	40	*Caith* .	Wick.....................	1·17	52
Kirk .	Carsphairn, Shiel	1·82	30	*Ork* .	Pomona, Deerness......	1·99	71
Dumf.	Dumfries, Crichton, R.I	·83	...	*Shet* .	Lerwick	·77	25
,, .	Eskdalemuir Obs........	1·12	23	*Cork* .	Caheragh Rectory......	6·54	...
Roxb .	Branxholm	1·00	34	,, .	Dunmanway Rectory...	7·67	156
Selk .	Ettrick Manse	·91	18	,, .	Ballinacurra..............	7·10	250
Peeb .	West Linton	1·16	...	,, .	Glanmire, Lota Lo......	8·16	263
Berk .	Marchmont House......	1·43	54	*Kerry*.	Valentia Obsy...........	4·79	105
Hadd.	North Berwick Res....	1·29	68	,, .	Gearahameen............	5·40	...
Midl .	Edinburgh, Roy. Obs.	1·30	73	,, .	Killarney Asylum........	3·13	66
Lan .	Auchtyfardle	·90	...	,, .	Darrynane Abbey	4·43	109
Ayr .	Kilmarnock, Agric. C.	1·12	40	*Wat* .	Waterford, Brook Lo...	5·05	184
,, .	Girvan, Pinmore	1·26	33	*Tip* .	Nenagh, Cas. Lough ...	2·54	81
Renf .	Glasgow, Queen's Pk. .	1·22	47	,, .	Roscrea, Timoney Park	2·84	...
,, .	Greenock, Prospect H.	1·76	36	,, .	Cashel, Ballinamona ...	3·52	128
Bute .	Rothesay, Ardencraig.	1·82	51	*Lim* .	Foynes, Coolnanes	1·91	65
,, .	Dougarie Lodge.........	1·39	...	,, .	Castleconnel Rec........	2·37	...
Arg .	Ardgour House	1·73	...	*Clare* .	Inagh, Mount Callan...	4·36	...
,, .	Manse of Glenorchy...	1·40	...	,, .	Broadford, Hurdlest'n.	1·97	...
,, .	Oban......................	1·19	28	*Wexf*.	Gorey, Courtown Ho...	4·21	182
,, .	Poltalloch	1·29	34	*Kilk* .	Kilkenny Castle	2·65	116
,, .	Inveraray Castle........	1·65	26	*Wic* .	Rathnew, Clonmannon	3·81	...
,, .	Islay, Eallabus	1·70	45	*Carl* .	Hacketstown Rectory..	3·24	116
,, .	Mull, Benmore	...	...	*Leix* .	Blandsfort House.......	2·74	105
,, .	Tiree......................	...	...	,, .	Mountmellick...........	2·04	...
Kinr .	Loch Leven Sluice......	1·17	39	*Off'ly* .	Birr Castle	2·11	88
Perth .	Loch Dhu.................	1·95	30	*Kild'r*.	Monasterevin	...	...
,, .	Balquhidder, Stronvar	2·10	...	*Dubl* .	Dublin, FitzWm. Sq....	1·35	70
,, .	Crieff, Strathearn Hyd.	1·22	38	,, .	Balbriggan, Ardgillan.	2·19	109
,, .	Blair Castle Gardens...	·89	34	*Me'th* .	Beauparc, St. Cloud...	2·96	...
Angus.	Kettins School..........	1·02	46	,, .	Kells, Headfort.........	2·89	105
,, .	Dundee, E. Necropolis	·95	46	*W.M.* .	Moate, Coolatore......	2·43	...
,, .	Pearsie House...........	1·36	...	,, .	Mullingar, Belvedere...	2·99	111
,, .	Montrose, Sunnyside...	1·21	58	*Long* .	Castle Forbes Gdns......	2·53	86
Aber .	Braemar, Bank.........	1·59	53	*Gal* .	Ballynahinch Castle...	4·76	93
,, .	Logie Coldstone Sch....	1·15	44	,, .	Galway, Grammar Sch.	2·52	...
,, .	Aberdeen, King's Coll.	1·14	47	*Mayo* .	Mallaranny........... ...	3·64	...
,, .	Fyvie Castle	1·37	50	,, .	Westport House........	2·78	71
Moray.	Gordon Castle...........	1·05	45	,, .	Delphi Lodge...........	6·45	76
,, .	Grantown-on-Spey......	...	...	*Sligo* .	Markree Obsy...........	1·81	52
Nairn.	Nairn, Delnies	1·37	73	*Cav'n*.	Belturbet, Cloverhill...	1·68	61
Inv .	Kingussie, The Birches	·90	...	*Ferm* .	Enniskillen, Portora...	1·54	...
,, .	Loch Quoich, Loan......	·45	...	*Arm* .	Armagh Obsy	1·44	61
,, .	Glenquoich	1·14	12	*Down*.	Fofanny Reservoir	7·24	...
,, .	Inverness, Culduhtel R.	1·01	..	,, .	Seaforde	2·47	85
,, .	Arisaig, Faire-na-Squir	1·22	..	,, .	Donaghadee, C. Stn....	1·21	55
,, .	Fort William...........	·81	...	,, .	Banbridge, Milltown...	1·23	...
,, .	Skye, Dunvegan........	1·90	...	*Antr* .	Belfast, Cavehill Rd...	1·45	...
R & C.	Alness, Ardross Cas....	1·58	49	,, .	Glenarm Castle........	1·73	...
,, .	Ullapool	1·79	43	,, .	Ballymena, Harryville	1·93	61
,, .	Torridon, Bendamph...	·75	10	*Lon* .	Londonderry, Creggan	·97	30
,, .	Achnashellach	·49	...	*Tyr* .	Donaghmore	...	...
,, .	Stornoway	1·53	...	,, .	Omagh, Edenfel........	1·48	47
Suth .	Lairg......................	1·78	57	*D'n* .	Malin Head..............	1·20	...
,, .	Tongue	2·10	62	,, .	Dunfanaghy.............	1·29	...
,, .	Melvich	1·41	..	,, .	Killybegs, Rockmount	1·59	81

Climatological Table for the British Empire, October, 1930.

STATIONS	PRESSURE: Mean of Day M.S.L. mb.	PRESSURE: Diff. from Normal mb.	TEMPERATURE Absolute: Max. °F.	TEMPERATURE Absolute: Min. °F.	TEMPERATURE Mean Values: Max. °F.	TEMPERATURE Mean Values: Min. °F.	TEMPERATURE Mean Values: ½ max. and min. °F.	TEMPERATURE Mean Values: Diff. from Normal °F.	TEMPERATURE Mean: Wet Bulb °F.	Relative Humidity. %	Mean Cloud Am'nt 0—10	PRECIPITATION: Am'nt in.	PRECIPITATION: Diff. from Normal in.	PRECIPITATION: Days	BRIGHT SUNSHINE: Hours per day	BRIGHT SUNSHINE: Percentage of possible
London, Kew Obsy.	1011·5	−2·5	68	31	58·5	45·9	52·2	+2·3	47·3	90	6·5	1·07	−1·63	12	3·7	35
Gibraltar	1018·5	+1·3	89	54	78·2	62·1	70·1	+4·0	61·9	83	5·0	2·04	−1·27	5	..	..
Malta	1016·7	+0·1	80	53	72·6	63·0	67·8	−3·1	62·5	75	5·3	2·91	+0·04	11	7·8	69
St. Helena	1015·7	+1·1	72	52	62·2	54·5	58·3	−0·5	55·5	94	8·6	1·46	−0·45	13	..	..
Sierra Leone	1013·3	+1·7	89	68	84·8	71·0	77·9	−2·2	75·5	83	6·8	9·22	−3·40	21	..	..
Lagos, Nigeria	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..
Kaduna, Nigeria	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..
Zomba, Nyasaland	1011·1	+0·2	94	54	84·9	61·3	73·1	−1·0	..	55	3·2	0·01	−1·51	1	..	..
Salisbury, Rhodesia	1009·9	+0·3	91	49	84·1	56·7	70·4	−0·3	54·9	27	1·2	0·02	−1·12	1	10·2	82
Cape Town	1018·0	+0·6	87	45	71·8	54·6	63·2	+2·0	57·6	75	4·6	0·58	−1·07	5	..	..
Johannesburg	1014·1	+1·0	86	38	75·1	52·7	63·9	+1·2	50·0	40	3·4	0·54	−2·02	7	9·3	73
Mauritius	1018·1	−0·1	83	58	79·5	64·0	71·8	−0·9	67·3	64	5·7	2·99	+1·61	8	8·3	66
Bloemfontein	..	..	..	..	..	..	..	..	..	..	..	0·38	−1·30	..	..	..
Calcutta, Alipore Obsy.	1011·1	+1·7	93	73	89·8	76·4	83·1	+2·4	77·1	87	4·2	1·08	−3·11	3*	..	..
Bombay	1009·4	−0·4	96	72	91·0	77·5	84·3	+2·0	77·0	82	4·9	2·50	+0·83	5*	..	..
Madras	1009·3	+0·4	91	72	86·3	74·9	80·6	−1·7	77·2	89	8·3	28·84	+17·12	23*	..	..
Colombo, Ceylon	1010·6	+0·3	86	72	84·4	73·9	79·1	−1·2	76·6	83	8·1	33·38	+20·26	26	5·1	43
Hongkong	1014·3	+0·7	87	66	81·7	73·1	77·4	+0·5	70·5	68	4·5	0·41	−4·44	1	8·8	76
Sandakan	..	..	92	74	89·9	75·6	82·7	+1·2	78·2	77	..	2·30	−7·70	7	..	..
Sydney, N.S.W.	1017·9	+3·0	86	51	70·9	58·0	64·5	+1·0	60·5	68	6·7	2·09	−1·12	12	6·5	50
Melbourne	1017·4	+2·7	85	43	70·3	51·4	60·9	+3·3	55·2	63	7·5	2·12	−0·47	10	5·7	43
Adelaide	1017·3	+1·3	95	42	75·5	55·2	65·3	+3·4	56·3	47	7·1	2·80	+1·06	11	7·1	55
Perth, W. Australia	1017·0	+0·2	82	46	70·6	52·3	61·5	+0·5	55·7	57	4·8	1·97	−0·21	9	9·2	72
Coolgardie	1015·6	+0·4	97	39	77·2	50·2	63·7	+0·1	53·6	44	3·3	0·37	−0·37	3	..	..
Brisbane	1019·4	+3·2	89	57	78·6	61·5	70·1	+0·3	63·8	60	6·3	1·97	−0·60	12	8·1	63
Hobart, Tasmania	1014·6	+4·0	83	40	65·2	48·6	56·9	+2·9	50·9	62	6·3	1·64	−0·62	11	6·3	48
Wellington, N.Z.	1010·5	−2·6	65	38	56·7	44·2	50·5	−3·8	47·7	73	7·5	1·35	−2·73	14	6·0	45
Suva, Fiji	1015·3	+2·1	86	62	80·3	69·3	74·8	−1·2	69·3	70	6·9	0·83	−6·97	13	5·5	44
Apia, Samoa	1011·2	−0·3	87	72	84·5	75·6	80·1	+1·7	77·2	77	6·2	3·85	−2·21	11	6·8	55
Kingston, Jamaica	1011·8	+0·3	91	70	86·5	72·7	79·6	−0·9	71·9	88	4·9	3·44	−4·02	11	..	..
Grenada, W.I.	1013·3	+2·7	89	72	86·9	73·8	80·3	+0·2	73·8	77	4·8	6·17	−1·48	20	..	..
Toronto	1019·0	+1·0	75	27	56·3	41·7	49·0	+2·1	43·5	84	4·7	1·87	−0·59	10	4·6	41
Winnipeg	1015·9	+0·6	60	16	45·9	31·9	38·9	−1·9	..	..	7·7	3·01	+1·58	11	2·9	27
St. John, N.B.	1012·2	−4·3	84	30	56·8	42·8	49·8	+4·5	44·9	77	7·0	3·72	−0·82	11	4·7	43
Victoria, B.C.	1017·8	+0·2	61	36	53·9	44·6	49·3	−1·1	47·4	89	7·9	4·79	+2·24	15	4·1	38

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

M.O. 339.

The Meteorological Magazine

Air Ministry :: Meteorological Office

Vol. 66

May, 1931

No. 784

LONDON: PUBLISHED BY HIS MAJESTY'S STATIONERY OFFICE

To be purchased directly from H.M. STATIONERY OFFICE at the following addresses: ADASTRAL HOUSE, KINGSWAY, LONDON, W.C.2; 120, GEORGE STREET, EDINBURGH; YORK STREET, MANCHESTER; 1, ST. ANDREW'S CRESCENT, CARDIFF; 15, DONEGALL SQUARE WEST, BELFAST; or through any Bookseller.

The influence of weather changes on the numbers of animals

By C. E. P. BROOKS, D.Sc.

The past few years have seen the publication of several zoological papers dealing with fluctuations in the numbers of animals, which are of great interest to meteorologists, and appear to open up a new field in the application of meteorological data to economic life. Unfortunately some of them are published in technical or natural history journals outside our usual range of reading, and it seems worth while to summarise a few of them here.

Although "plagues" of mice or voles have been recorded from time to time in different parts of the world for some centuries at least, the systematic study of their causes was begun only in the present century. An excellent account of the problems involved was given by C. S. Elton in 1924[1] and a shorter summary more recently in 1929.[2] These problems may best be illustrated by a concrete example, that of the lemmings of southern Norway. These small rodents habitually live in the mountains, but periodically they migrate in swarms into the lowland in autumn, crossing crowded streets and even marching with great speed and determination into the sea. All these migrants die, mostly of an epidemic disease. Elton remarks that "lemming-years in Norway have the status of great floods or terrible winters." They have occurred with great regularity every three or four years since at least 1860, the average interval from 1862 to 1909 being 3.6 years. The direct cause of the

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migration is over-population, and as such might be assumed to represent a purely biological cycle of reproduction. The difficulty is that either migrations or maxima of population occur in widely separated localities, not only in Scandinavia, but even in Greenland and Canada, either in the same year or in the following year. Exactly the same cycle, even to the years of maxima, was found by A. D. Middleton in British voles.[3] It would seem impossible for purely biological cycles to keep in step in such widely distant regions without some governing control, and Elton regards this control as climatic.

The data for Canada are not direct, but are inferred from the numbers of skins of Arctic fox taken by the Hudson Bay Company. The lemming is the principal food of the Arctic fox, and a large number of the latter implies a large number of lemmings in the preceding year. An analysis of figures for 65 years read off from one of the diagrams shows a periodicity in the number of skins of almost exactly 3·6 years, with an amplitude almost equal to the annual mean. The periodicity is obviously real. The Arctic fox skins show also a less definite periodicity of between ten and eleven years, which is much more clearly brought out in the returns of the Canadian rabbit or varying hare (*Lepus americanus*) and the lynx which feeds on this animal. The periodicity in the numbers of skins of these two animals taken by the Hudson Bay Company is extraordinarily well marked, the curve rising steeply from zero to a maximum and falling again to zero in a manner closely resembling the sunspot curve. The rabbit shows another peculiarity; the number of young in a brood and of broods in a season also varies very definitely according to the year of the cycle. This he thinks cannot be due to physiological causes but must represent a corresponding cyclic variation of the environment. There are probably corresponding variations in the broods of other animals.

Most other animals about which for any reason (usually economic), data are available show similar periodic fluctuations, but the beaver forms a marked exception. This Elton regards as confirming his belief that the cause of the cycles in the other animals is climatic, as the beaver is independent of minor climatic fluctuations, for it lives on the bark of trees, and regulates its water-supply by building dams. Moreover fluctuations in the numbers of insects rarely—the cockchafer is an exception—show such regular periodicity, probably because, as shown by B. P. Uvarov,[4] they are more susceptible to meteorological "accidents" over a short period (a day or night to a few weeks) than to average conditions over a longer period. An excellent example of the effects of a single outstanding—and presumably not periodic— meteorological event, namely, the drought of 1921, on the numbers of fresh-water mollusca in eastern England has recently been published by Dr. A. E. Boycott.[5]

Now Elton remarks that the area over which mouse and lemming cycles tend to come in the same years—northern Labrador, Baffin Land, north-west Hudson's Bay, Scandinavia as far east as Finmark, the British Isles and probably Greenland—is precisely the area which is influenced by the Icelandic minimum, and he suggests that some climatic cycle acts on this low pressure area as a whole, possibly affecting rainfall or snowfall. That such a cycle cannot be clearly seen in the actual records of precipitation he does not regard as an insuperable objection, for the effects on mammals are cumulative and small irregularities or temporary fluctuations are smoothed out. As an illustration he cites lake-levels, which show periodicities much more clearly than do rainfall records, because they integrate the latter over time and space. The greater the degree of integration, the more clearly does the periodicity show up; thus the lynx, which feeds on the rabbit, shows a more regular periodicity of numbers. Moreover prolific animals, such as lemmings, mice or rabbits, have a natural biological cycle, increasing in numbers for a few years until over-population ensues and the great majority of the animals are killed off by some cause such as epidemic disease. If this biological cycle nearly coincides with a climatic cycle, it will be accentuated by a sort of resonance effect.

This is plausible enough, but there are difficulties. There is a weather periodicity of 3½ years in the Atlantic district, though one would not regard it as having either sufficient regularity or sufficient amplitude to be very potent biologically. Moreover the catches of fish in British seas, which B. Storrow[6] regards as directly connected with large scale movements of Atlantic waters and hence with the long-period or integrated barometric situation in the Atlantic, show no definite indications of a 3.6 year periodicity. The periodicity of the lynx is even less satisfactory. It is natural to look to the sunspot cycle as the cause, but the length of the lynx cycle, barely ten years, differs too much from the sunspot cycle. The dates of maxima in the former, and their place in the sunspot cycle (reckoned as number of years before or after a sunspot maximum) are as follows:—

Lynx maxima ...	1831	1839	1848-9	1859	1868	1878	1907
Sunspot maxima	1830	1837	1848	1860	1870	1883-4	1905
Years + or — ...	+ 1	+ 2	0	− 1	− 2	− 5	+ 2

There is no trace of regulation; the two cycles go their own ways quite independently, whereas if Elton's argument from the broods of the rabbit is correct, one would expect a very close parallelism indeed. It seems more likely that such a deep-seated physiological cycle is of ancient origin, and has become engrained in the Canadian rabbit in the course of ages, than that it is an *ad hoc* adjustment to contemporary environment. On the other hand the agreement between the lengths of the cycles of lemmings and mice suggests some common influence, and there is a possibility that the cycles were built up gradually in response to the average lengths of weather periodicities, at a time perhaps when these were more marked than at present.

There still remains the agreement of phase between north-eastern North America and north-western Europe, and for this it is difficult to see any alternative to Elton's theory of climatic control. It does not seem certain however that this control is necessarily periodic. It is the highly abnormal seasons that are by far the most effective (cf. ref. 5), and it is in these also that the abnormalities extend over the widest area. The mechanism is possibly somewhat as follows: the cycle may get a year out of step, so that when Norway is fully populated with lemmings Canada could still carry another year's increase with normal climatic conditions. If the next season is bad, in effect both countries are over-populated, and in both the numbers are drastically reduced, so that the cycle recommences at the same phase in both. The same result would follow an abnormally good season, which would enable Norway to carry its surplus lemming population for another year, giving it so to speak an overdraft on the bank of nature; again with the return to normal conditions the population would be reduced in both countries simultaneously. This is only a suggestion, but the problems merit further conjoint research by zoologists and meteorologists, for their intrinsic interest as well as for their economic importance.

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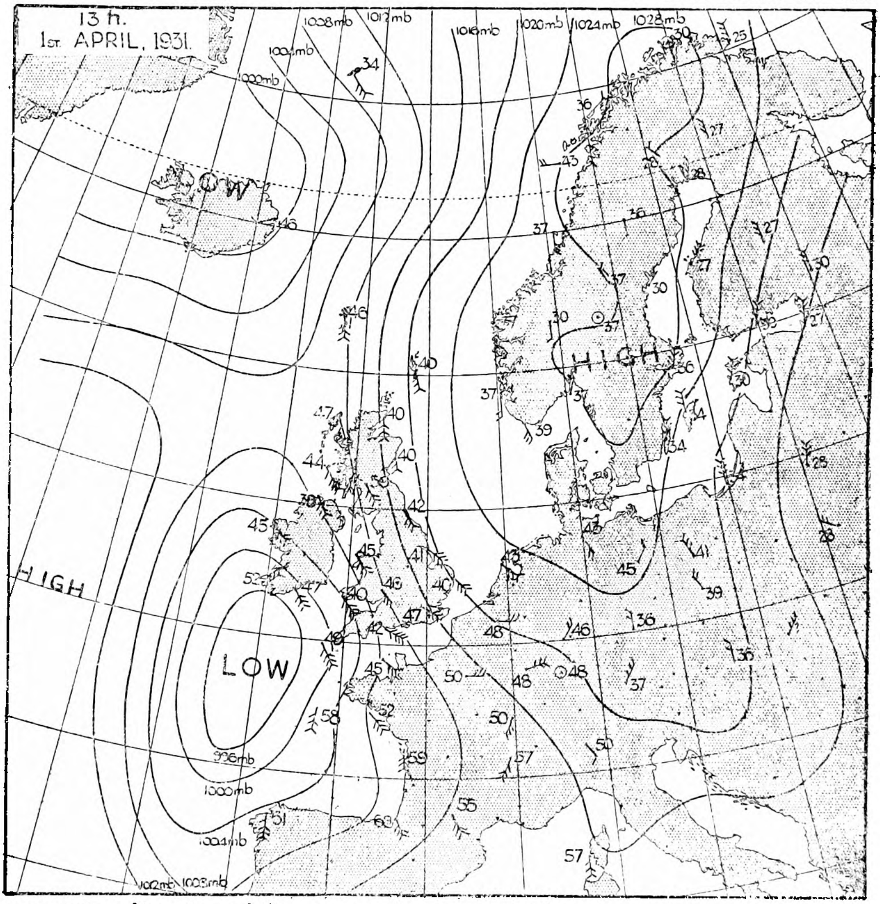
A noteworthy spell of dry air over England

The period March 29th to April 1st, 1931 (inclusive), deserves notice, meteorologically, by reason of the exceptional dryness of the air over a considerable part of England.

The first signs of this dryness made their appearance in the 13h. reports on March 29th, when Kew and Farnborough reported relative humidities of 35 per cent. approximately. March 30th indicated an intensification of the dryness and a slow spreading of the very dry air northward and westward: at 13h. on that day the relative humidity was approximately 25 per cent. at Kew, Croydon, Cardington and Farnborough and approximately 35 per cent. at Upper Heyford and Leafield. March 31st involved a further spreading northward and westward with Cranwell and Birmingham giving at 13h. relative humidities of approximately 35 per cent., a figure that was roughly the prevailing one over the whole of the inland parts of south-eastern England. The culminating dryness was, however, reached on April 1st, when some quite abnormally low readings of relative humidity were recorded, coupled with a further spreading of the dryness north and west. Selected figures that speak for themselves are a relative humidity of 15 per cent. (approximately) at Cardington at 12h. 30m., of 19·5 per cent. at South Kensington at noon, of 24 per cent. at Ross-on-Wye at 13h., of 25 per cent. (approximately) at Harrogate, Kew, Croydon, Farnborough, Leafield and Upper Heyford at the same hour, and of 25.8 per cent. at Grayshott at 12h. 45m. But following this maximum peak of the dryness there came very quickly the break-down, and by late evening on April 1st the spell of dry air was broken and relative humidities were back to the normal eighties and nineties, there to continue.

The synoptic conditions producing the dryness merit attention. On March 29th, a large anticyclone covered the whole of the North Sea. On the 30th this high pressure system became centred over Scandinavia with a connecting tongue going on to a less intense "high" off south-west Spain. On the 31st the main system remained over Scandinavia, but both the tongue and the "high" off south-west Spain moved eastward before the advance of a large depression off Ireland. On the 1st the retreat eastward of the tongue and the Spanish "high" continued as did the advance eastward of the Irish "low," while the Scandinavia "high" remained unchanged. By 7h. on the 2nd, however, this Scandinavia "high" had also began to move eastward whilst the "low" was centred over the Bay of Biscay and had the whole of the British Isles within the ambit of its isobars.

During, therefore, the four days, March 29th to April 1st, the air stream over eastern and south-eastern England and the Midlands had come from the far northern regions near Spitsbergen and had travelled southward over Scandinavia or western Russia and over Germany as a north wind before it turned west to cross the southern North Sea, France, and the eastern English Channel as a south-east one. That long track from the north meant that the air was originally cold but became warmed in its movement to more southerly latitudes, and that the long track was also a long land track meant that it had had little or no



opportunity to pick up moisture on the way. In these two factors, then, working together, lies the reason for the extremely low relative humidities experienced over much of England in the period under review.

The attached diagram shows the synoptic chart for 13h. on April 1st—the day of greatest intensity of the dryness—and a consideration of it will illustrate the nature of the air track to which reference has already been made.

William H. Pick.

Royal Meteorological Society

The monthly meeting of this Society was held on Wednesday, April 15th, at 49, Cromwell Road, South Kensington. Mr. R. G. K. Lempfert, M.A., F.Inst.P., President, in the Chair.

W. D. Flower, B.Sc.—An analysis of the cold front over Egypt on March 7th, 1929.

The cold front associated with a depression which passed across Egypt on March 7th, 1929, was analysed, using the usual autographic record of wind, temperature, humidity and pressure at Heliopolis and Ismailia, together with records of the vertical temperature gradient at the latter station. The cold air was shown to have advanced in the form of a wedge with its nose above the surface at Ismailia, but as a flat wedge on the surface at Heliopolis.

W. H. Pick, B.Sc.—A note on the relationship between fog and relative humidity.

The fogs occurring at synoptic hours at Cardington during the years 1929 and 1930 were examined, and it was shown that the majority of them were accompanied by unsaturated air as determined by readings of the dry and wet bulb thermometers. This concurrent occurrence of unsaturated air was independent of the intensity of the fog, even the majority of the very thick fogs being so accompanied. Interesting speculations are thus raised. An appendix gives details of fogs occurring at sea with distinctly unsaturated air, thus confirming the ideas of Dr. J. S. Owens.

H. Jameson, B.Sc.—Temperature observations on Adam's Peak, Ceylon.

Observations of temperature made at the summit of Adam's Peak, Ceylon, altitude 7,360 feet, on 23 days in January and February, 1930, were discussed and compared with simultaneous observations at Nuwara Eliya, a valley station at 6,170 feet. The night temperatures showed the normal differences between a valley and a peak site. During the day, however, there was a sharp rise of temperature in the morning, lasting till about 11 a.m., and giving much higher temperatures than might be expected at that altitude. This was followed by a steady fall, till the constant night temperature was reached about 6 p.m. It was suggested that these day temperatures were due to mountain winds converging up the Peak in the morning, and forming cloud over it before midday.

S. P. Wiltshire.—The correlation of weather conditions with outbreaks of potato blight.

Correspondence

To the Editor, *The Meteorological Magazine.*

An early Scottish Meteorologist

Thomson's Biographical Dictionary of Eminent Scotsmen (last edition 1875) has the following interesting details of the first person in Scotland to possess a barometer.

This was a Mr. David Gregory who lived near Aberdeen in the early part of the seventeenth century. He was the father of David Gregory, the able commentator on Newton's *Principia* and Savilian Professor of Astronomy at the University of Oxford. The elder Gregory, it appears, was originally a merchant but soon renounced all commercial pursuits, devoting himself entirely to the cultivation of science, studying chiefly mathematics and experimental philosophy.

In the account concerning him we read that, "Mr. Gregory's pursuits caused him to be noted throughout the whole country, and as he was the first person in Scotland who possessed a barometer, from which he derived an extensive knowledge of the weather, it was believed that he held intercourse with the beings of another world." So widely had this belief concerning him been circulated, that a deputation from the presbytery waited on him, and it was only by a fortunate chance that he escaped from undergoing a trial for witchcraft. He had acquired an extensive knowledge of medicine, and was in the habit of practising in the district without fee in all cases. It was this circumstance alone which prevented the reverend members of the presbytery from "calling him to account for his superior intelligence."

J. HARROWER.

95, *St. John's Road, Corstorphine, Edinburgh.* *April* 11*th*, 1931.

Exceptional Rain at Tungchwan, West China

In connexion with the article on Tungchwan in the March number of the magazine, the following meteorological items in a letter from Dr. Lucy E. Harris, Friends Mission, Tungchwan, Sze, W. China, dated July 7 *et seq.*, 1930, are of interest.

"Last Sunday night (*i.e.*, July 5-6th) we had a most phenomenal rainfall and thunderstorm, the like of which have not been seen in Tungchwan before (*i.e.*, about 25 years, possibly more). It began about 8.30 p.m. and kept on till morning with thunder and lightning almost the whole time and the rain coming down in torrents. It was almost impossible to sleep, the noise was so great. Unfortunately I could not measure the total amount as my rain-gauge only takes between 4 and 5 inches. It was quite full, but I do not know how much was lost. In the morning this house compound was like a lake, and the men's compound, which is lower, was still worse. The water was over a foot deep in the men's waiting room."

J. EDMUND CLARK

Street, Somerset. *March* 24*th*, 1931.

Limits of Visibility

The great distances at which objects can be seen under favourable meteorological conditions and in an atmosphere free from atmospheric pollution are well illustrated by the following extracts from notes recently received from Mr. Seton Gordon of Duntulm Lodge, Isle of Skye. The distances in miles have been inserted in brackets. Speaking of Saturday, November 29th, 1930, a "most beautiful day," he says, "a friend and I were on the summit of Beinn Edra. The thing which most impressed me was that I could (through the glass) see the swell breaking beneath the Rudha Stoer lighthouse, which seems about 56 miles from where I stood. I could see Handa (67 miles) quite plainly. West I could actually see the sun shining on the edge of the great precipice of Conachair on Hirta (87 miles), and on the neighbouring isle of Boreray I could see the two Stacks—Stac an Armuinn and Stac Lii. South I could see the northwest hill of Tiree (77 miles) and Hyskeir Light. Over North Uist I could see the Monach Lighthouse quite plainly (55 miles). . . . . . St. Kilda (87 miles) is always visible from that hill when visibility is really good." In the second note Mr. Seton Gordon remarks, "St. Kilda is always visible from the Cuillin Hills (95 miles) in very clear weather. . . . . . The longest views I have had are (1) the Paps of Jura (92 miles) from Sgurr na Banachdich (Cuillin), (2) the Paps of Jura (107 miles) and Ben Nevis (92 miles) from Hecla of South Uist."

Several of the examples enumerated above approach the limit of visibility as determined by the curvature of the earth and the heights of the objects and points of observation. They therefore suggest that if objects of suitable height were available in these districts they could be seen at even greater distances. Clouds may indeed occasionally be seen at greater distances. The present writer, on the afternoon of July 16th, 1930, on board s.s. *St. Magnus*, between Lerwick and Aberdeen, saw very clearly the tops of cumulus clouds which almost certainly were lying over the Norwegian coast, some 200 miles distant. The tops emerged above a line of haze just appreciably above the sea horizon. Allowing for an average amount of atmospheric refraction the cloud tops on that afternoon were apparently about 20,000ft. above sea level.

A. H. R. Goldie.

6, Drumsheugh Gardens, Edinburgh. December 10th, 1930.

The following letter, written by Mr. G. D. Simpson, Master Mariner, to the *Daily Mail*, is of interest in this connexion :—

At daybreak, 5.30 a.m. on November 23rd, in latitude 29° 54′ N., longitude 18° 49′ W., Teneriffe Peak, Canary Islands, was visible to the naked eye at a distance of 150 miles, bearing 130°. This, I believe, is the farthest distance on record at which the peak has been sighted. The altitude of its summit above the horizon was in accordance with that of an object 12,000ft. high (approximately the height of Teneriffe Peak) viewed from a distance of 150 miles by an observer 50ft. above sea level. This proves that the unusual visibility of the peak was not due to mirage.

Aurora Borealis—Aldergrove

The evening of Saturday, December 20th, 1930, was marked by a display of the aurora borealis, the brightest seen from this or any other district within the memories and experiences of its observers—Messrs. D. H. Clarke, W. L. Baxter and myself. The description given below is a combination of our three independent observations from various points and at different times.

Stratus, strato-cumulus (1,500ft.) and high strato-cumulus clouds, which had almost completely covered the sky during the afternoon, cleared rapidly from 17h. 40m., G.M.T., onwards until, at 18h. 30m. there was but a trace of the lower clouds remaining.

The aurora was first seen about 18h. 14m., it was a well defined arch of misty glow with sharp upper and lower edges from the horizon to its crest, brilliant enough to light up the country side and make the northern stars appear dim. Distant trees and other objects could be seen clearly, and a small cap of cloud over hills to west-north-west palely reflected its light. Figure 5, facing page 26, of the "Meteorological Glossary" (2nd Ed., 1930) gives an idea of the arch seen, but without the upward streamers shown in this sketch.

While riding towards Antrim town, it was noticed that the crest of the arch was well to westward of true north: any rapid movement in the bow could not be detected owing to one's own motion and the aurora's nebulous texture, but occasional pendants or downward streamers were seen in both the eastern and western halves. Gradually the western portion lost its marked upper and lower boundaries and became more curtain-like and of greater vertical depth. About 18h. 30m. there were three distinct horizontal breaks in the extreme western section, while the eastern end kept its sharp definition—not unlike a searchlight beam, only, of course, curved. A rough measure of the aurora's brilliance was given by comparison with the cloud reflected light of Belfast some 13 miles in a direct line to south-eastwards, to which it was quite equal.

Throughout the whole of the display there was in the western half a gently curved depression in the upper edge and it seemed to be moving slowly towards north. The phenomenon faded about 18h. 55m., no colours were seen, only a whitish glow: the positions in this description were checked against *Ursa Major* and *Stella Polaris*.

C. VAUGHAN STARR.

R.A.F. Station, Aldergrove. January 3rd, 1931.

NOTES AND QUERIES

Salinity of Rainwater

The question recently arose in connexion with the rusting of iron pipes of anemometers as to the salinity of the rainwater at different places in the British Isles. Through the courtesy of Sir John Russell, F.R.S., Director of the Rothamsted Experimental Station, monthly values of the salinity of the rain collected at Valentia Observatory from November, 1912, to November, 1916, have been received. The values were determined by the late Mr. N. H. J. Miller.

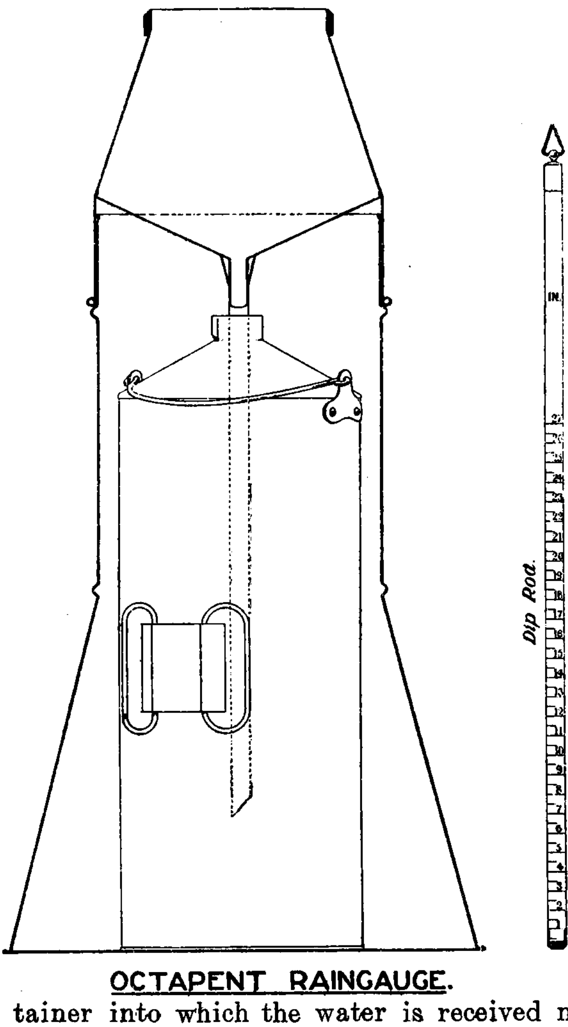
The monthly values have been compared with different quantities, viz., the total amount of rain, the percentage frequency of winds from land and from sea directions and the percentage frequency of winds of force 6 and over, irrespective of direction. The examination shows that there is little connexion between the percentage of salt and the quantities examined, with the exception of the last, viz., percentage frequency of winds of force 6 or more. With this quantity, however, there is a very close connexion.

The correlation coefficient between the percentage of strong winds and the percentage of salt (chlorine) in rainwater based on the values for the whole period is $+0{\cdot}72 \pm 0{\cdot}046$.

It is hoped to publish shortly a fuller discussion of the results.

New "Octapent" mountain rain-gauge

There are many parts of the country, particularly in mountainous regions, where an accurate knowledge of the rainfall is of the utmost importance in connexion with water supply schemes and hydraulic engineering, in which, owing to the absence of human habitation, the daily reading of a rain-gauge is impossible. It is frequently possible in these circumstances to arrange for the placing of gauges in suitable sites which can be visited monthly by an observer, the gauges being designed to hold the largest quantity of rain which is likely to fall in any individual month. Gauges employed for this purpose in the past have been of the "Bradford" and "Seathwaite" types, the former being in most common use. The Bradford gauge in its original form resembles the ordinary 5-in. Snowdon in shape, but it has a deep container capable of holding 15in. of rain. This capacity is insufficient for a monthly gauge even in only moderately wet situations. The "Seathwaite" gauge has a capacity of over 40in. and this is unnecessarily large, except in very wet situations. To meet the need for average moorland exposures Bradford gauges with a capacity of 27in. have been used. Satisfactory results are given by these gauges, but there are difficulties in their use, in that a hole of considerable depth is needed to bury the lower part of the gauge. In mountainous country the "soil" frequently consists of rock and there may be difficulty in providing a hole for the gauge in a spot where it is otherwise desirable that it should be placed. Further difficulty occurs in measuring the amount of water collected. The can is about 3ft. long and weighs, when full, some 23lb. It is not easy to handle this and to pour the water into a glass measure without considerable risk of spilling it. It recently occurred to Mr. E. G. Bilham that this difficulty could be overcome and a very effective mountain rain-gauge made by combining a 5-in. rim with an 8-in. container, thus providing in a compact space a large volume for the water received through a 5-in. rim. A gauge which has been made up for the Meteorological Office by Mr. W. Rollason in accordance with this proposal, is illustrated in the attached drawing. The outside dimensions of the gauge are little larger than in the splayed base Meteorological Office pattern 8-in. gauge and the container into which the water is received measures 18in. by 7in. It holds 27in. of rain without overflowing. When full of water it necessarily weighs as much as the container in the 27-in. "Bradford" gauge, but its shape renders it much easier to handle. Except for the brass rim and the can fittings, the gauge is made entirely of copper. There are no external seams in the funnel and a fruitful source of trouble in rain-gauges is, therefore, eliminated. The gauge is provided with



OCTAPENT RAINGAUGE.

a dip rod for rough preliminary check readings, a glass measure of 2-in. capacity being used for the actual measurements. It is proposed to call this gauge the "Octapent" rain-gauge, the name suggesting that the new gauge combines some of the features both of the 8-in. and the 5-in. gauges. It appears probable that it will meet the need for a mountain gauge suitable for average conditions in a more satisfactory manner than has previously been possible, and although not yet on the market, its design has already created considerable interest.

The Deepening of Depressions by Day and Night

The difficulty expressed by Major Goldie* "in seeing why the normal pressure variation should be associated so markedly with the variations of rainfall . . . . ." does not appear to exist for the Norwegian meteorologists, if one may judge from a recent paper.† On p. 69 of that publication it is stated that the simplest and most probable explanation of the semi-diurnal pressure wave is that it is determined by the "moist-labile" rainfall reinforced by the resonance of the atmosphere. Refsdal, it may be noted, also quotes views of A. Schmauss‡ that near the turning points of the daily pressure curve are critical periods in regard to the setting-in of depressions.

S. T. A. Mirrlees.

Alto-cumulus formed by an aeroplane

At about 15h. 10m., G.M.T., on January 14th, 1931, at South Farnborough, Hants., my attention was called to a trail of white cloud that was apparently being emitted by an aeroplane flying at about 12,000 feet. After watching the evolutions of the machine for a few minutes I came to the conclusion, as did most other observers, that it was a usual "sky writing" experiment. I was thus considerably surprised about an hour later to hear that the trail had been formed unintentionally, and further, that another pilot had had the same experience. The second pilot whilst climbing noticed that a white cloud which was apparently being emitted from another aeroplane above him, suddenly ceased as the latter continued its climb. On arriving at the height of this white cloud, 13,000 feet (uncorrected), a similar trail which had begun to form behind his machine ceased abruptly as he gained height. So he descended to 13,000 feet again, the phenomenon reappeared, and he found that it was possible to form quite a dense cloud layer provided that he kept within a layer of about 400 feet vertical thickness. On looking to the left the cloud

* *London, Meteorological Magazine*, 66, 1931, p. 66.

† Der Feuchtlabile Niederschlag. By A. Refsdal. *Oslo. Geofys. Publ. V. No. 12. 1930.*

‡ Die Lebensdaten der Mitteleuropäischen Depressionen I. *München Meteor. Jahrb. 1923.*

appeared to form a few feet behind the trailing edge of the wings in a line with the propeller tip, but unfortunately he omitted to notice whether a similar formation was present on his right. No details are available from the first pilot. From the ground two distinct streams, which appeared to originate from the sides of the aeroplane, could be detected. These appeared to unite into a single billowy stream at a distance behind the machine equal to twice its length and after a very short interval the whole cloud simulated a band of alto-cumulus. The only way it could be detected from other banks of alto-cumulus was in its apparent greater brightness. The difference may be likened to that between old and new paintwork. Once formed the cloud moved southward in the general northerly current prevailing at that height and was still visible about an hour afterwards.

The temperature as given by a strut thermometer was – 2°F., but unfortunately no humidity readings are available. Up to 15h., G.M.T., the sky had been entirely clear, but at the time of these ascents banks of alto-cumulus clouds were forming and spreading over the sky from the north at the precise height (13,000 feet). The synoptic chart for 13h., G.M.T., on January 14th, 1931, indicated that a milder north-westerly surface current associated with a depression near Iceland was spreading south-eastwards across the country, but there were no indications from the upper air temperature data that a warmer moist layer existed above 13,000 feet. A nephoscope reading shows the alto-cumulus drifting from 360° at about 45 m.p.h., while the wind at 11,000 feet as determined at Cardington at 12h., G.M.T., was from 15° at a speed of 61 m.p.h.

Possible reasons for the formation are (1) the sudden cooling of saturated air due to reduction of pressure (*a*) immediately behind the leading edge of the aeroplane, (*b*) in front of the propeller, (2) mechanical disturbance and precipitation of a supercooled layer, and (3) emission of nuclei and water vapour from the two exhausts (located on each side of the machine and terminating in front of the wings). In the first case, four streams or series of vortices, appearing to originate at the wing tips, would be expected. In the second and third cases there seems no apparent reason why the cloud should be confined to a stream on each side of the aeroplane unless the formation is dependent upon the addition of nuclei and water-vapour. This appears to be the most likely explanation.

W. H. Bigg.

Reviews

The Areas Covered by Intense and Widespread Falls of Rain. By J. Glasspoole. Proc. Inst. Civil Engineers. 229, 1929-30, pp. 137-194.

For engineering purposes two distinct types of information about rainfall are needed. The water engineer entrusted with the responsibility of a town's water supply needs to know how much water he can expect to obtain from his gathering ground. His main concern is the average rainfall, and his needs are therefore met if he has access to records showing the actual annual fall at a sufficient number of points in the gathering ground over a period of years. The engineer who has to deal with a drainage system, however, needs information of a different type. To him, heavy falls occurring in short periods are of chief importance since it is they which may cause the damage by flooding which it is his business to minimise. The term "short period" may mean anything from a few minutes to several days according to the scale of the drainage system under consideration. Thus a street drain may be inadequate to deal with a fall of one-fifth of an inch occurring in five minutes, because the "time of concentration" of the water running off the area served by the drain is very small. On the other hand the time of concentration of the run-off to the main out-fall of the complete drainage system of a large town may be several hours and in a river basin it may be several days. It is clear therefore that information as to the maximum probable falls in periods varying from a few minutes to several days must be available if a drainage system is to be properly designed at all points. Since falls of great intensity are often highly localised it is equally important that information as to the area over which they extend should also be available.

The annual volumes of *British Rainfall* contain sections giving particulars of "heavy falls in short periods" and "heavy falls on rain days." In recent years it has been customary, also, to give measurements of the areas enclosed by successive isohyetal lines in the case of the most noteworthy falls. In addition, a number of rainstorms of outstanding interest have been discussed in detail in separate papers printed either in *British Rainfall*, the *Meteorological Magazine* or the *Quarterly Journal of the Royal Meteorological Society*. A good deal of information bearing on drainage problems has thus become available, but it has not hitherto been collected together in a form suitable for ready consultation by an engineer. Dr. Glasspoole's paper thus meets a very real need, and it may be added that the information given in it is of considerable interest to meteorologists as well as to engineers.

In the first part of the paper particulars are given of the areas covered by heavy falls of specified magnitude during two or more rainfall days. As an example of the information given we may quote the data relating to the Norwich floods of August 25th and 26th, 1912. During the two rainfall days we learn that the fall exceeded 8in. over 18 sq. miles, 7in. over 259 sq. miles, 6in. over 705 sq. miles, 5in. over 1,039 sq. miles, 4in. over 1,939 sq. miles, 3in. over 3,463 sq. miles, and 2in. over 7,462 sq. miles. In the next section similar information is given for a number of remarkable falls on single rainfall days. Falls in shorter periods down to about two hours are then considered and in the descriptive matter relating to particular falls details are given of some of the more remarkable intensities over periods down to two minutes. The paper concludes with a discussion of types of intense and widespread rains. Like other rains these unusual falls may be classified under "orographic," "cyclonic" and "convectional." Heavy orographic rains are confined to the mountainous districts of the west and north; convectional rains reach their maximum development in the central and eastern districts, but any part of the British Isles may be visited by a heavy cyclonic fall and the most heavy and widespread falls are of this type. Nevertheless, Dr. Glasspoole finds that over a considerable area of the British Isles a fall exceeding 4in. in a day has never been recorded. The counties concerned fall into two well-defined groups; the first includes most of Ireland, the south-west of Wales and Cornwall; the second includes the Midlands of England, Gloucester, Hereford, Worcester, Warwick, Rutland and Derby. The author is of opinion that this immunity represents a definite climatic factor. Having regard to the fact that cyclonic systems have in the past given falls exceeding 7in. in a rainfall day in counties as far apart as Somerset and Norfolk, however, it seems possible that some revision of this conclusion may eventually be called for.

E. G. Bilham.

Climate, A treatise on the principles of weather and climate. By W. G. Kendrew, M.A. Size 8½ × 5½in., pp. ix+329, *Illus.* Published by Mr. Milford, at the Clarendon Press, Oxford, 15s. net.

Mr. Kendrew, who is well known as one of the few authors to produce a work on climatology in the English language, in his latest book views the subject of climate from a different angle. This book is described in the preface as written primarily for the general reader who wishes to know something of the principles of weather and climate and for those workers who find a knowledge of climatology desirable for the furtherance of their main subject of study. After a short introductory chapter, parts II to VI deal with the following subjects: insolation and temperature; pressure and winds; humidity, rainfall, evaporation, clouds, thunderstorms; sunshine and cloud; fog; the 36 chapters giving explanations of the principles involved and also interesting practical applications. The numerous clear maps, diagrams and reproductions of autographic records are a praiseworthy feature. Parts VII to X deal with mountain and plateau climate; the weather of temperate regions; local winds; some climatic types. The reproductions of synoptic charts are extremely interesting, and the reader who studies these carefully will gain a considerable insight into some of the peculiarities of the weather of this country. These charts deal with events recent enough to be well within the memory of the reader, for example gales in November, 1929, or heavy snow in south of England, December, 1927. Of the photographs, those of the Matterhorn and of a tornado cloud may be mentioned. The printing is done in the usual excellent style of the Clarendon Press, so that one is the more surprised to see a few misprints (" Saragossa Sea," perhaps, but " rain guages " at least should not occur in a meteorological book). The book is written in a clear and interesting style and is in most respects abreast of recent developments. The case for and against the polar front theory is stated, ultra-violet radiation, atmospheric pollution, humidity and temperature in relation to the human body are dealt with. On the whole, the book may be cordially recommended to the general reader. To the other class for whom the author writes, the plan may make it less suitable for quick reference, information about " Mediterranean climate," or " westerlies," for example, having to be sought under the separate headings of pressure and winds, rainfall, sunshine and so on. There are two chapters, " The Wind Systems of the Globe " and " The Major Regions of Pressure and Winds," in which opportunities have been missed. Modern authorities tell us that a zonal distribution of winds such as is shown in Fig. 31 implies pressure decreasing continuously one way round the circles of latitude. The Ferrel diagram leads to a *reductio ad absurdum*, a point which so far seems to be ignored by most writers of text-books. However useful " ideal " continents and oceans may be in fixing certain principles in the mind, they are not independent theoretically predicted schemes and the agreement between " theory " and observation is small matter for wonder.

Another ancient generalisation which has in recent years been proved wrong is the " rule " that the western equatorial sectors of the oceans are the homes of tropical revolving storms. Since the opening of the Panama canal brought about the frequenting of new trade routes, it has been found that the eastern north Pacific is also a region subject to such storms. As Mr. Kendrew has given us what is in most respects an excellent book, one may take it that in due course a second edition will be reached, when opportunity might be taken to bring in more recent views on the general circulation of the atmosphere.

In a work containing so many facts it is easy for occasional slips to occur. Some minor points to which attention should be given are the following: the west African type of tornado is characteristic of west Africa, not of the whole equatorial belt (p. 87); all dust is not hygroscopic nuclei, ions act as condensation nuclei only in exceptional circumstances (p. 126); glazed frost may also occur when a warm moist air current sets in suddenly after severe frost (p. 169 and p. 213); the statement that strato-cumulus is a combination of stratus and cumulus should be amplified (p. 175); " Millikan rays " is no longer used as a term for the penetrating radiation as Millikan was not the discoverer (p. 191); dust devils differ from tornadoes not only in intensity but in having an indifferent sense of rotation, the tornado of the eastern United States has always counter-clockwise rotation (p. 275). An interesting point about the Berg winds of the South African coast (p. 301) is that they often bring it about that the maximum temperature of what is nominally a winter day is 15° to 25° higher than that of summer. One mentions such minor points because Mr. Kendrew's previous work leads us to expect the highest standard from him, and their mention must not be taken as detracting from the general excellence of a book which can be strongly recommended as an introduction to the principles of weather and climate.

S. T. A. MIRRLEES.

The Gulf Stream and its problems. By H. A. Marmer. Reprinted from Smiths. Ann. Rep. for 1929, Washington, D.C., pp. 285-307.

This is a useful summary of existing knowledge of the oceanography of the Gulf Stream and its influence on the weather of the surrounding coasts. In the latter connexion, however, no reference is made to the English studies of the relations between the fluctuations of the Gulf Stream and European weather, described in several publications of the Meteorological Office.

Books Received

Average annual rainfall in New Zealand for the period 1891-1925. By E. Kidson, D.Sc., F.Inst.P. Giving maps showing average number of rain days per annum and mean annual rainfall for the period 1891-1925 for North Island and South Island separately.

Anales del Observatorio Nacional de San Bartolemé en los Andes Colombianos. Observaciones meteorologicas de 1928. Bogotá, 1930.

Royal Alfred Observatory, Mauritius. Annual report, 1929, and Results of magnetical and meteorological observations for January to December, 1928, January to December, 1929, and January to August, 1930; Port Louis, 1928, 1929 and 1930.

Beitrag zur Erklärung des "Barometereffektes" der Ultrastrahlung. By C. Dorno. Reprinted from Gerlands Beiträge zur Geophysik 26, 1930, pp. 395-402.

Obituary

M. Raoul Gautier.—The death has occurred of M. Raoul Gautier at Geneva on April 19th, 1931, in his 78th year. M. Gautier was born on April 15th, 1854, and devoted most of his life to the study of the climatology of Geneva and the neighbourhood, including the Great St. Bernard and St. Maurice. He was an honorary Professor, and at one time Rector of the University of Geneva and had been honorary Director of the Observatory at Geneva since 1889. He was Vice-President of the Geodesy section of the International Union of Geodesy and Geophysics and President of the Swiss Committee of Geodesy and Geophysics and of the Swiss Geodetic and Meteorological Commissions.

News in Brief

On the morning of March 4th a peculiar type of precipitation continuing for some hours was observed by Mr. R. T. Andrews at Larkhill, Salisbury Plain. The precipitation consisted of small irregularly shaped fragments of perfectly clear ice and did not resemble hailstones in any way. The sky was covered with nimbus and alto-stratus.

The General Board of the University of Cambridge has appointed Dr. H. Jeffreys, at St. John's College, reader in geophysics.

The Weather of April, 1931

Pressure was above normal over Spitsbergen, northern Scandinavia, Russia, Poland, the western Mediterranean and adjacent coasts, most of the North Atlantic, and the eastern and south-western United States, the greatest excesses being 6·9mb. at Waigatsch and 3·6mb. at Lat. 40° N., Long. 40° W. Pressure was below normal over Iceland, most of western Europe, Madeira, Florida, north-western United States and Canada, the greatest deficits being 5·7mb. at Seydisfjord and 4·6mb. at Juneau (Alaska). Temperature was above normal at Spitsbergen and northern Scandinavia, being as much as 16·1°F. above normal at Spitsbergen, and below normal over most of the rest of western and central Europe. Rainfall was deficient generally over western Europe with the exception of the British Isles and most of Sweden, where in Dalecarlia and Ostrogothia rainfall was twice the normal.

Over the British Isles the weather of April was mainly dull and unsettled with low day temperatures except between the 9th and 13th. In eastern England the rainfall was more than twice the normal in many places. A depression centred off the south-west coasts on the 1st moved slowly eastwards, causing heavy rain with local flooding in parts of Ireland and south-west England on the 1st, 2·00in. fell at Kilmacthomas, Co. Waterford, and rain in England and southern Scotland on the 2nd and in south-east England on the 3rd (Good Friday). Snow fell in parts of Ireland on the 1st and in Scotland on the 2nd. This was followed by an anticyclone giving fine sunny weather in Scotland on Good Friday and in southern England on the 4th, but this improvement was only temporary in the south and in Ireland, cool unsettled conditions prevailing there until about the 7th, while in Scotland and northern and eastern England the weather was fine and often sunny but cool; 12 hrs. bright sunshine were recorded at Durham and Kilmarnock on the 5th. On the 7th a depression stretching from Greenland to the Azores was approaching, the winds became southerly and there was a welcome change to warm conditions, a fine hot spell being recorded from the 9th to 13th. Temperature on the 11th rose to 68°F. at Cambridge and to 66°F. locally even as far north as Nottingham and Hull. The 11th and 13th were the sunniest days of the month with over 11 hrs. and 12 hrs. respectively at many places mainly in southern England; 13·0 hrs. were registered at Rhayader on the 13th. By the evening of the 13th the anticyclone over the southern British Isles was moving away westwards, and there was a decided drop in temperature accompanied by much cloud. From the 15th-19th a low-pressure system passed south-eastwards across the country and cold inclement weather prevailed. Maximum temperatures did not exceed 40°F. at Durham and Harrogate on the 18th. Snow, sleet or hail occurred at most places on the 17th, 18th and 19th, sleet and hail being reported even as far south as Guernsey on the 18th. Thunderstorms also were experienced locally in the eastern half of England on the 17th, 19th, 22nd and at Durham on the 24th. Precipitation though frequent during this period was usually slight in amount except in the south-east on the 19th, when 1·00in. was measured at Campsea Ashe (Suffolk). By the 18th the western part of the kingdom was coming under the influence of the anticyclone over the Atlantic, and sunny conditions prevailed in Ireland and west Scotland on the 18th, 19th and 20th. From then until the 30th depressions moved eastwards or south-eastwards across the country, and the weather became slightly milder but continued unsettled though with bright periods. Heavy rain occurred in England and Wales on the 24th and 25th, 2·06in. at Roe Wen (Carnarvon) on the 25th, and 1·91in. at Lincomb Lock (Worcester) on the 24th and sleet in Scotland on the 27th. Good sunshine records were obtained in Wales, north-west England and south Scotland on the 29th and over the country generally on the 30th; 13·6 hrs. were measured at Morecambe on the 29th. The distribution of bright sunshine for the month was as follow :—

	Total (hrs.)	Diff. from normal (hrs.)		Total (hrs.)	Diff. from normal (hrs.)
Stornoway	133	— 21	Liverpool	113	—45
Aberdeen	107	— 51	Ross-on-Wye	97	—53
Dublin	127	— 38	Falmouth	112	—72
Birr Castle	117	— 37	Gorleston	122	—62
Valentia	134	— 26	Kew	113	—44

The special message from Brazil states that the rainfall in the northern and central districts was scarce, with 0·47in. and 1·10in. below normal respectively, and abundant in the south with 1·34in. above normal. Five anticyclones passed across the country and there were frequent depressions in the south. The weather was generally fair and the crops in good condition. At Rio de Janeiro pressure was 0·2mb. below normal and temperature 0·5°F. above normal.

Miscellaneous notes on weather abroad culled from various sources. A spell of cold weather accompanied by snow occurred in northern France about the 20th, and heavy snowstorms were experienced in the neighbourhood of Grenoble about the same time. The late thaw in Russia delayed spring sowing for two or three weeks; by the 25th Vilna was seriously affected by floods as the river Vilia had risen 17ft. above its normal level, and several lives were lost in the floods in the Dvina Basin between the 25th and 30th. Navigation re-opened at Helsingsfors on the 3rd and at Hernosänd on the 29th. (*The Times*, April 6th-May 2nd.)

In a severe storm about the 10th, 125 fishermen were drowned off the south-west coast of Korea. Eleven people were killed at Taipo, near Hong Kong on the 20th in a railway accident due to the line being undermined by heavy rain; 13in. of rain fell in two days. (*The Times*, April 11th and 23rd.)

Abundant beneficial rains were experienced in South Australia at the beginning of the month. (*The Times*, April 4th.)

While Montreal lay under a heat wave on the 13th, an inch of snow fell in other parts of the Province of Quebec, followed later in the day by heavy rain. (*The Times*, April 16th.) Temperature was above normal over most of the United States during the middle of the month and rainfall generally below normal. Precipitation was below normal in the Argentine during the first part of the month. (*Washington, D.C., U.S. Dept. Agric., Weekly Weather and Crop Bulletin.*)

Rainfall, April, 1931—General Distribution

England and Wales ...	173	per cent of the average 1881-1915.
Scotland	106	
Ireland	111	
British Isles	143	

Rainfall: April, 1931: England and Wales

Co.	Station	In.	Per-cent. of Av.	Co.	Station	In.	Per-cent. of Av.
Lond .	Camden Square	3·71	241	*Rut* .	Ridlington	3·74	238
Sur .	Reigate, Alvington	5·02	300	*Linc* .	Boston, Skirbeck	2·57	190
Kent .	Tenterden, Ashenden	3·00	185	,, .	Cranwell Aerodrome	2·93	222
,, .	Folkestone, Boro. San.	3·14	...	,, .	Skegness, Marine Gdns	2·23	166
,, .	Margate, Cliftonville	2·30	170	,, .	Louth, Westgate	2·92	175
,, .	Sevenoaks, Speldhurst	4·41	...	,, .	Brigg, Wrawby St.	3·17	...
Sus .	Patching Farm	3·21	183	*Notts* .	Worksop, Hodsock	3·35	228
,, .	Brighton, Old Steyne	2·55	157	*Derby* .	Derby, L. M. & S. Rly.	3·62	222
,, .	Heathfield, Barklye	3·84	208	,, .	Buxton, Devon Hos.	5·50	187
Hants .	Ventnor, Roy. Nat. Hos.	3·24	193	*Ches* .	Runcorn, Weston Pt.	2·41	139
,, .	Fordingbridge, Oaklnds	2·45	134	,, .	Nantwich, Dorfold Hall	3·12	...
,, .	Ovington Rectory	4·14	219	*Lancs* .	Manchester, Whit. Pk.	3·29	171
,, .	Sherborne St. John	3·05	172	,, .	Stonyhurst College	3·38	125
Berks .	Wellington College	3·24	201	,, .	Southport, Hesketh Pk	2·47	134
,, .	Newbury, Greenham	2·63	144	,, .	Lancaster, Strathspey	1·96	...
Herts .	Welwyn Garden City	3·73	...	*Yorks* .	Wath-upon-Dearne	2·89	183
Bucks .	H. Wycombe, Flackwell	3·12	...	,, .	Bradford, Lister Pk.	3·60	179
Oxf .	Oxford, Mag. College	2·93	190	,, .	Oughtershaw Hall	4·62	...
Nor .	Pitsford, Sedgebrook	3·85	252	,, .	Wetherby, Ribston H.	3·19	181
,, .	Oundle	2·34	...	,, .	Hull, Pearson Park	3·11	199
Beds .	Woburn, Crawley Mill	3·55	237	,, .	Holme-on-Spalding	3·34	...
Cam .	Cambridge, Bot. Gdns.	...	...	,, .	West Witton, Ivy Ho.	3·54	165
Essex .	Chelmsford, CountyLab	3·26	255	,, .	Felixkirk, Mt. St. John	4·25	254
,, .	Lexden Hill House	2·80	...	,, .	Pickering, Hungate	3·98	238
Suff .	Hawkedon Rectory	4·46	290	,, .	Scarborough	3·12	200
,, .	Haughley House	2·62	...	,, .	Middlesbrough	2·87	209
Norf .	Norwich, Eaton	3·47	203	,, .	Baldersdale, Hury Res.	...	...
,, .	Wells, Holkham Hall	2·86	...	*Durh* .	Ushaw College	3·21	170
,, .	Little Dunham	4·28	264	*Nor* .	Newcastle, Town Moor	2·62	161
Wilts .	Devizes, Highclere	2·82	148	,, .	Bellingham, Highgreen	3·79	175
,, .	Bishops Cannings	2·97	147	,, .	Lilburn Tower Gdns.	3·17	160
Dor .	Evershot, Melbury Ho.	2·84	120	*Cumb* .	Geltsdale	2·56	...
,, .	Creech Grange	1·92	89	,, .	Carlisle, Scaleby Hall	2·21	113
,, .	Shaftesbury, Abbey Ho.	2·83	133	,, .	Borrowdale, Seathwaite	5·90	80
Devon .	Plymouth, The Hoe	2·84	125	,, .	Borrowdale, Rosthwaite	4·56	...
,, .	Polapit Tamar	2·80	120	,, .	Keswick, High Hill	2·57	...
,, .	Ashburton, Druid Ho.	..	...	*West* .	Appleby, Castle Bank	2·67	137
,, .	Cullompton	3·30	145	*Glam* .	Cardiff, Ely P. Stn.	2·97	117
,, .	Sidmouth, Sidmount	3·38	159	,, .	Treherbert, Tynywaun	6·27	...
,, .	Filleigh, Castle Hill	4·36	...	*Carm* .	Carmarthen Friary	3·73	136
,, .	Barnstable. N. Dev. Ath.	3·27	154	,, .	Llanwrda	3·82	116
Corn .	Redruth, Trewirgie	2·37	82	*Pemb* .	Haverfordwest, School	2·55	96
,, .	Penzance, Morrab Gdn.	1·67	69	*Card* .	Aberystwyth	3·74	...
,, .	St. Austell, Trevarna	3·30	117	,, .	Cardigan, County Sch.	3·19	...
Soms .	Chewton Mendip	2·66	90	*Brec* .	Crickhowell, Talymaes	...	...
,, .	Long Ashton	2·72	125	*Rad* .	BirmW. W. Tyrmynydd	5·09	138
,, .	Street, Millfield	2·25	113	*Mont* .	Lake Vyrnwy	5·54	184
Glos. .	Cirencester, Gwynfa	2·69	144	*Denb* .	Llangynhafal	3·84	202
Here .	Ross, Birchlea	2·91	153	*Mer* .	Dolgelly, Bryntirion	7·38	202
,, .	Ledbury, Underdown	3·28	180	*Carn* .	Llandudno	2·88	159
Salop .	Church Stretton	3·50	162	,, .	Snowdon, L. Llydaw 9	13·65	...
,, .	Shifnal, Hatton Grange	4·52	269	*Ang* .	Holyhead, Salt Island	1·85	89
Worc .	Ombersley, Holt Lock	3·37	222	,, .	Lligwy	3·10	154
,, .	Blockley	4·11	...	*Isle of Man*			
War .	Birminghm, Edgbaston	4·02	231		Douglas, Boro' Cem.	1·85	76
Leics .	Thornton Reservoir	4·60	271	*Guernsey*			
,, .	Belvoir Castle	3·31	216		St. PeterP't. GrangeRd.	2·07	103

Rainfall: April, 1931: Scotland and Ireland

Co.	Station	In.	Per-cent. of Av.	Co.	Station	In.	Per cent. of Av.
Wigt	Pt. William, Monreith	1·92	87	*Suth*	Loch More, Achfary	7·07	146
,,	New Luce School	2·56	96	*Caith*	Wick	1·82	91
Kirk	Carsphairn, Shiel	3·53	85	*Ork*	Pomona, Deerness	2·38	115
Dumf	Dumfries, Crichton, R.I	1·73	...	*Shet*	Lerwick	3·09	136
,,	Eskdalemuir Obs.	3·14	92	*Cork*	Caheragh Rectory	1·90	...
Roxb	Branxholm	2·63	139	,,	Dunmanway Rectory	2·31	56
Selk	Ettrick Manse	4·49	128	,,	Ballinacurra	2·18	84
Peeb	West Linton	2·71	...	,,	Glanmire, Lota Lo.	2·73	97
Berk	Marchmont House	3·19	158	*Kerry*	Valentia Obsy.	2·63	72
Hadd	North Berwick Res.	1·62	116	,,	Gearahameen	3·80	...
Midl	Edinburgh, Roy. Obs.	2·02	146	,,	Killarney Asylum	...	...
Lan	Auchtyfardle	1·94	...	,,	Darrynane Abbey	1·81	53
Ayr	Kilmarnock, Agric. C.	1·87	91	*Wat*	Waterford, Brook Lo.	2·36	93
,,	Girvan, Pinmore	2·22	75	*Tip*	Nenagh, Cas. Lough	2·76	110
Renf	Glasgow, Queen's Pk.	1·36	69	,,	Roscrea, Timoney Park	2·75	...
,,	Greenock, Prospect H.	2·32	64	,,	Cashel, Ballinamona	...	...
Bute	Rothesay, Ardencraig.	2·81	94	*Lim*	Foynes, Coolnanes	2·88	118
,,	Dougarie Lodge	2·14	...	,,	Castleconnel Rec.	2·70	...
Arg	Ardgour House	5·08	...	*Clare*	Inagh, Mount Callan	3·00	...
,,	Manse of Glenorchy	3·93	...	,,	Broadford, Hurdlest'n.	2·72	...
,,	Oban	2·19	70	*Wexf*	Gorey, Courtown Ho.	2·80	128
,,	Poltalloch	2·45	81	*Kilk*	Kilkenny Castle	1·73	79
,,	Inveraray Castle	4·11	89	*Wic*	Rathnew, Clonmannon	3·36	...
,,	Islay, Eallabus	2·80	97	*Carl*	Hacketstown Rectory	4·50	170
,,	Mull, Benmore	4·80	...	*Leix*	Blandsfort House	2·75	105
,,	Tiree	2·28	...	,,	Mountmellick	...	...
Kinr	Loch Leven Sluice	2·33	121	*Off'ly*	Birr Castle	3·03	141
Perth	Loch Dhu	4·10	86	*Kild'r*	Monasterevin	2·32	...
,,	Balquhidder, Stronvar	2·68	...	*Dubl*	Dublin, FitzWm. Sq.	2·72	143
,,	Crieff, Strathearn Hyd.	2·39	109	,,	Balbriggan, Ardgillan.	1·97	99
,,	Blair Castle Gardens	1·54	73	*Me'th*	Beauparc, St. Cloud	2·99	...
Angus	Kettins School	2·16	130	,,	Kells, Headfort	3·71	148
,,	Dundee, E. Necropolis	2·13	125	*W.M*	Moate, Coolatore	2·85	...
,,	Pearsie House	...	...	,,	Mullingar, Belvedere	3·64	154
,,	Montrose, Sunnyside	2·22	122	*Long*	Castle Forbes Gdns.	3·20	134
Aber	Braemar, Bank	2·96	125	*Gal*	Ballynahinch Castle	3·67	104
,,	Logie Coldstone Sch.	2·58	128	,,	Galway, Grammar Sch.	1·83	...
,,	Aberdeen, King's Coll.	1·54	82	*Mayo*	Mallaranny	4·24	...
,,	Fyvie Castle	2·06	96	,,	Westport House	3·66	135
Moray	Gordon Castle	1·92	110	,,	Delphi Lodge	5·83	101
,,	Grantown-on-Spey	2·27	115	*Sligo*	Markree Obsy	2·98	112
Nairn	Nairn, Delnies	1·56	104	*Cav'n*	Belturbet, Cloverhill	2·46	107
Inv	Kingussie, The Birches	1·73	...	*Ferm*	Enniskillen, Portora	2·15	...
,,	Loch Quoich, Loan	5·61	...	*Arm*	Armagh Obsy	3·35	159
,,	Glenquoich	4·75	73	*Down*	Fofanny Reservoir	7·52	...
,,	Inverness, Culduthel R.	1·98	...	,,	Seaforde	3·03	116
,,	Arisaig, Faire-na-Squir	2·00	...	,,	Donaghadee, C. Stn.	1·88	93
,,	Fort William	3·11	...	,,	Banbridge, Milltown	2·94	...
,,	Skye, Dunvegan	3·68	..	*Antr*	Belfast, Cavehill Rd.	3·10	...
R & C	Alness, Ardross Cas.	3·32	137	,,	Glenarm Castle	3·35	...
,,	Ullapool	3·42	111	,,	Ballymena, Harryville	2·99	113
,,	Torridon, Bendamph	...	...	*Lon*	Londonderry, Creggan	2·64	103
,,	Achnashellach	4·49	...	*Tyr*	Donaghmore	...	...
,,	Stornoway	3·35	...	,,	Omagh, Edenfel	3·19	121
Suth	Lairg	2·89	123	*D.n*	Malin Head	2·24	...
,,	Tongue	2·51	96	,,	Dunfanaghy	2·43	...
,,	Melvich	2·49	...	,,	Killybegs, Rockmount	3·41	95

Climatological Table for the British Empire, November, 1930.

STATIONS	PRESSURE: Mean of Day M.S.L. (mb.)	PRESSURE: Diff. from Normal (mb.)	TEMPERATURE: Absolute Max. (° F.)	Absolute Min. (° F.)	Mean Values Max. (° F.)	Mean Values Min. (° F.)	Mean Values ½ max. and min. (° F.)	Mean Values Diff. from Normal (° F.)	Mean Wet Bulb (° F.)	Relative Humidity (%)	Mean Cloud Am'nt (0—10)	PRECIPITATION: Am'nt (in.)	Diff. from Normal (in.)	Days	BRIGHT SUNSHINE: Hours per day	Percentage of possible
London, Kew Obsy.	1011·6	— 3·0	57	25	50·4	39·2	44·8	+ 0.8	41·4	88	6·6	3·85	+ 1·63	15	2·0	23
Gibraltar	1020·3	+ 2·3	78	48	69·7	55·5	62·6	+ 2·1	55·1	84	5·4	7·26	+ 0·87	7	..	..
Malta	1020·2	+ 3·7	74	49	67·9	58·2	63·1	— 0·8	58·2	79	3·7	1·53	— 2·04	7	8·2	80
St. Helena	1014·9	+ 1·0	66	55	62·6	56·4	59·5	— 0·6	57·2	96	10·0	1·16	— 0·52	12	..	..
Sierra Leone	1013·2	+ 2·3	88	69	86·8	73·1	79·9	— 1·3	76·8	80	5·1	2·68	— 2·44	10	..	..
Lagos, Nigeria	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..
Kaduna, Nigeria	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..
Zomba, Nyasaland	1009·0	+ 0·1	94	62	86·6	67·3	76·9	+ 1·3	..	63	5·8	1·53	— 3·55	5	..	..
Salisbury, Rhodesia	1009·0	+ 0·7	91	57	82·3	61·3	71·8	+ 1·1	64·0	63	5·0	2·23	— 1·47	8	..	..
Cape Town	1016·8	+ 1·0	92	48	76·5	56·6	66·5	+ 2·1	59·9	71	4·0	1·03	— 0·06	4	..	..
Johannesburg	1011·4	+ 0·8	86	49	78·1	56·2	67·1	+ 3·6	58·9	65	4·0	3·00	— 1·96	12	8·8	66
Mauritius	1017·2	+ 1·1	89	62	81·9	68·4	75·1	— 0·4	70·3	65	6·9	2·11	+ 0·53	18	7·8	60
Bloemfontein	..	..	..	..	..	..	..	..	..	..	..	0·40	— 1·87	..	..	..
Calcutta, Alipore Obsy.	1014·1	+ 0·8	90	60	82·0	66·0	74·0	+ 0·9	66·1	83	4·9	2·43	+ 1·77	3*	..	..
Bombay	1012·4	+ 0·4	93	69	89·1	72·8	80·9	+ 0·4	70·7	74	2·2	0·00	— 0·45	0*	..	..
Madras	1011·0	— 0·3	89	65	82·5	71·8	77·1	— 1·8	73·7	85	7·1	21·45	+ 7·20	15*	..	..
Colombo, Ceylon	1011·6	+ 1·5	90	72	85·5	74·4	79·9	+ 0·2	76·2	79	7·7	9·73	— 2·06	21	6·8	58
Hongkong	1019·4	+ 1·8	86	61	75·7	66·7	71·2	+ 1·6	64·1	65	5·0	0.03	— 1·64	1	6·8	62
Sandakan	..	..	90	71	87·4	74·6	81·0	+ 0·2	77·7	83	..	16·77	+ 2·11	21	..	..
Sydney, N.S.W.	1014·3	+ 0·6	91	53	75·8	60·8	68·3	+ 1·2	62·3	58	5·9	0·68	— 2·13	9	8·1	58
Melbourne	1014·3	+ 0·1	89	44	73·0	51·5	62·3	+ 1·0	54·6	57	6·7	2·35	+ 0·13	13	6·5	46
Adelaide	1016·2	+ 1·1	97	44	77·8	56·5	67·1	+ 0·2	56·7	43	5·4	0·92	— 0·24	11	8·9	64
Perth, W. Australia	1017·3	+ 2·0	97	47	76·6	57·6	67·1	+ 1·1	59·1	52	4·8	0·97	+ 0·18	9	9·5	69
Coolgardie	1015·2	+ 2·1	99	46	86·7	55·3	71·0	+ 0·2	56·2	33	2·8	0·03	— 0·65	1	..	..
Brisbane	1016·3	+ 1·8	97	59	83·7	65·2	74·5	+ 0·9	66·5	55	3·1	0·95	— 2·71	8	9·1	68
Hobart, Tasmania	1008·7	— 0·7	80	39	65·1	47·5	56·3	— 0·9	49·5	54	7·1	2·52	0·00	17	7·4	51
Wellington, N.Z.	1008·8	— 3·3	65	39	59·0	46·7	52·9	— 4·0	49·9	71	7·4	4·02	+ 0·50	11	6·6	46
Suva, Fiji	1012·1	+ 1·0	87	66	81·7	72·1	76·9	— 0·3	72·0	75	8·4	8·13	— 1·38	19	3·7	29
Apia, Samoa	1010·0	+ 0·5	89	74	85·2	76·5	80·9	+ 2·2	78·5	81	5·6	11·75	+ 2·46	20	5·9	46
Kingston, Jamaica	1012·9	+ 0·5	91	67	87·3	71·6	79·5	+ 0·2	70·5	87	5·3	3·55	+ 0·52	8	..	..
Grenada, W.I.	1013·9	+ 2·9	90	71	87·5	74·0	80·7	+ 1·4	74·1	77	4·6	5·08	— 3·31	17	..	..
Toronto	1019·7	+ 2·9	61	13	46·7	34·9	40·8	+ 4·5	35·7	81	7·1	0·68	— 2·27	10	3·0	31
Winnipeg	1016·1	— 0·6	58	14	33·1	17·9	25·5	+ 4·7	..	..	5·7	1·55	+ 0·59	9	3·8	42
St. John, N.B.	1020·0	+ 6·1	54	10	45·7	30·9	38·3	+ 1·6	33·8	79	6·0	2·17	— 2·24	6	4·1	43
Victoria, B.C.	1019·8	+ 4·3	56	31	47·6	40·5	44·1	— 0·3	42·0	91	8·3	1·31	— 5·15	13	2·5	27

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

M.O. 340.

The Meteorological Magazine

Air Ministry :: Meteorological Office

Vol. 66

June, 1931

No. 785

LONDON: PUBLISHED BY HIS MAJESTY'S STATIONERY OFFICE

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Halo Phenomena

THE following communications give eye-witnesses' accounts of recent solar halos and associated phenomena. The coincidence that all three observed the upper tangent arc adds an unusual feature of interest:—

Mrs. A. E. Moule, of Home Cottage, Bradfield, near Reading, sends us particulars of a solar halo, upper tangent arc and sun pillar observed at Bradfield, near Reading, on the early morning of May 3rd, 1931. The phenomena were first observed at 6.10 a.m. (B.S.T.) when the sun was partially obscured by misty clouds and the sun pillar was very bright. By 6.27 the light of the sun was much stronger and the sun pillar was fainter, especially towards the top. A very faint halo of 22° was visible with an exceedingly bright tangent arc showing prismatic colours. At 6.40 the sun pillar had vanished, the halo was faint and the tangent arc very bright but less coloured. The arc was still visible at 8.30 as a bright light but without its characteristic curved shape.

The altitude of the sun on May 3rd was 4° at 6.10 a.m., 7° at 6.27 and 26° at 8.30. Mrs. Moule's sketch is reproduced as the upper part of Fig. 1.

Mr. A. Moon, of 39, Clive Avenue, Clive Vale, Hastings, writes as follows:—

"On Saturday, the 18th of April, I observed a very intense

(94402) 107/27 1,080 6/31 M. & S. *Gp.303*

arc of contact at 13h. 10m. (G.M.T.) together with a very faint halo of about 22°. At the same time a white arc curved towards the sun was seen to the north-east, which, if it had been complete would have passed through the sun. This fact was confirmed later (at about 13h. 25m.) by the appearance of a whitish arc passing through the sun towards the north and north-west, and was undoubtedly a portion of the parhelic circle. The arc of contact at the zenith of the halo of 22° was very intense, showing plainly the colouring from red to violet. The ends were curved downwards in a similar manner to the phenomenon observed here on October 19th, 1930, though in a less striking manner.

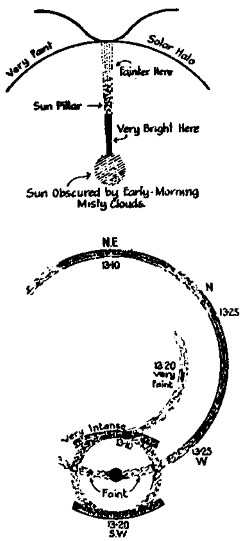

Fig. 1.

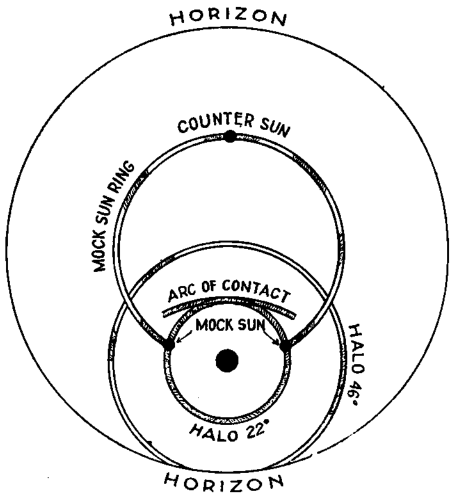

Fig. 2.

At 13h. 20m. another very faint part of a white circle appeared inside the large parhelic circle as shown in the accompanying rough diagram. This was of short duration. A bright arc similar to that at the zenith of the halo of 22° but in a reversed position made its appearance about 13h. 20m., at the " base " of the halo. These bright arcs remained visible some time after the white circle had vanished; the latter was only visible in one large patch of high cirriform cloud which moved from the east-north-east round towards the north-west and west.

Between 13h. 35m. and 13h. 40m. only the two bright arcs were visible with no trace of the halo, and no cloud was visible to the naked eye in the vicinity of the upper contact arc. The clouds were " false cirrus " and patches of cirro-nebula. Weather conditions were showery with large cumulo-nimbus and masses of " false cirrus." A considerable fall of snow and sleet occurred during the morning.

The lower diagram of Fig. 1 represents the complete phenomenon together with the times at which each portion made its appearance."

The altitude of the sun during Mr. Moon's observation was about 50°.

Mr. W. J. Fowler and Mr. R. T. Andrews, of the Meteorological Office, Larkhill, Salisbury Plain, write that "On March 20th at 2 p.m. the rather unusual halo phenomena, of which a drawing is enclosed (Fig. 2), were seen at Larkhill, Salisbury Plain.

The sky was almost covered with a thin veil of cirro-stratus and some cirrus and alto-cumulus. Round the sun was a 22° halo with an upper arc of contact, the ends of which turned down, and at the point of contact the colouring was very vivid. Mock suns were very brilliant at the junction of the mock sun ring with the 22° halo and a counter-sun 180° from the sun was visible for some time; large portions of a 46° halo were also seen. When the mock sun ring disappeared a band of cirrus cloud seemed to take the place of the ring itself.

The above conditions continued for about 15 minutes and towards the end the halos disappeared and gave place to a solar corona, but the mock suns were still visible for a short time."

During this observation the altitude of the sun was 34.°

Some Phenomena related to Halos

By F. J. W. Whipple, Sc.D.

There are several interesting features in the groups of phenomena described in the three communications printed above. To use a word which I coined some time ago, all the phenomena are no doubt chionisms, being due to the reflection or refraction of light by ice crystals. In general from the occurrence of any particular chionism we can deduce the presence of ice crystals of particular types. Thus, on May 3rd when Mrs. Moule made her observations near Reading there were flat crystals, probably star-shaped, falling with their planes nearly horizontal and producing the sun pillar, whilst needle-like hexagonal prisms falling with their axes horizontal were revealed by the arc of contact. There were also prisms falling at random and causing the faint halo of 22°.

On March 20th and again on April 18th no sun pillars were seen. We may not deduce that the flat crystals were not present; the sun was in each case too high for the production of a sun pillar. Hexagonal prisms with axes horizontal account for the arcs of contact. The upper arcs were turned down like portions of an elliptic halo whereas on May 3rd the corresponding arc was turned upwards, this is accounted for by the different altitudes of the sun. The change of type occurs when the altitude is about 40°. The lower arc of contact seen on April 18th was cured upwards, the altitude of the sun being about 50°.

The mock sun ring seen on the two occasions indicates that light was being reflected from vertical planes, probably the faces of hexagonal prisms with vertical axes. The presence of prisms floating in that position was shown by the mock suns of March 20th. On April 18th the sun was too high for mock suns to be noticed. The halo of 46° is evidence for the existence of crystals with faces at right angles, probably composite crystals, hexagonal prisms attached to flat caps.

There are two more chionisms to mention. The counter-sun of Fig. 3 and the arc marked " very faint " in Fig. 2. A counter-sun, a luminous, colourless patch at the same elevation as the sun and on the opposite side of the sky indicates reflection of light from pairs of vertical surfaces at right angles. If crystals can grow together, four prisms with pointed ends making a rectangular cross, and if the side faces of the individual prisms are all perpendicular to the plane containing the crystal axes then these aggregates will fall with the crosses horizontal and the conditions for the formation of a counter-sun will be satisfied. This is Besson's theory of the phenomenon. The difficulty in accepting it is that composite crystals of the cross pattern have hardly ever been found; as far as I know the orientation of the facets of such crystals has not been investigated.

The explanation given by Humphreys for the formation of the counter-sun (or anthelion, as it is generally named) is that some of the hexagonal prisms with flat caps float with the axes of the prisms horizontal and that there is a tendency for two of the six facets of a prism to be vertical. This explanation is hard to accept, for the nicety of balance would surely be upset by the attachment of a flat end to the prism. (Cf. Humphreys, Physics of the Air, 1920, p. 520, Fig. 178.)

The observation of March 20th is perhaps favourable to Humphreys's explanation, for evidence for the flat-capped prisms and for prisms with horizontal axes has been mentioned.

The " very faint " arc of Fig. 2 may have been a part of an " oblique arc through the anthelion." No explanation of the oblique arcs is generally accepted.

There is a tendency for observers to suggest in their descriptions of chionisms that the phenomena are produced in the clouds. We are not in the habit of assuming that rainbows are produced in clouds, though it is rare to see a complete rainbow without a cloud background. The crystals which produce halos may occur in swarms, but it is misleading to refer to the swarms as if they were identical with clouds. There is an instructive account in Glaisher's " Travels through the Air " of a crystal-swarm encountered in a stratum of dry air with rain falling into the stratum from above and with ordinary cloud below. The ascent in which these observations were made started from

Wolverton on June 26th, 1863, and terminated, after 2½ hours, near Ely. It was on the downward journey that the swarm of ice crystals was encountered. Between 18,000 ft. and 16,000 ft. the aeronauts were in cloud and at the lower level heavy rain fell pattering on the balloon. Of the next stage of descent Glaisher writes: " On passing below 14,000 ft. and for a space of nearly 5,600 ft. we passed through a beautiful snowy scene. There were no flakes in the air—the snow was entirely composed of spiculæ of ice, of cross spiculæ at angles of 60°, and an innumerable number of snow crystals, small in size, but distinct and of well-known forms easily recognisable as they fell and remained on the coat. This unexpected meeting with snow on a summer afternoon was all that was needed on this occasion to complete the experience of the characteristics of extreme heat of summer with the cold of winter within the range of a few hours. On passing below the snow, which we did when about 10,000 ft. from the earth, we entered a murky atmosphere which continued until we reached the ground; indeed, so thick and misty was the lower atmosphere that although we passed over Ely Cathedral and not far from it, we were unable to see it."

Every meteorologist knows that large snow flakes are aggregates of small crystals, but not many have seen the process of aggregation. There is a good description by Tissandier in Glaisher's book. On November 8th, 1868, three aeronauts made an ascent in a snowstorm. By sacrificing much ballast they attained an altitude of 5,900 ft. to find themselves " present at the admirable spectacle of the formation of snow. Just now large flakes danced around the car in a thousand irregular curves and sported in the wind, now we have brilliant almost iridescent, crystalline plates, which are mutually attracted and increase in volume whilst we watch them, growing considerably larger before they are many hundred yards below the car." The balloon rose to 6,500 ft. when the particles were very fine—an endless number of microscopic crystalline needles. In descending Tissandier found the flakes of snow rather more numerous than before, though according to the psychrometer the air appeared nearly dry. We can but echo his questions: " How do these mysterious crystals form in air so mild? By what marvellous mechanism does Nature shape these angular forms that are constantly created before our eyes? Are the invisible atoms of vapour drawn together by the same force which causes planetary worlds to gravitate in space? Are we not witnessing the formation of an endless number of corpuscular worlds modelled by Divine art? "

By way of postcript to this article I should like to mention another lesson which I have learned from the same volume, namely, that the hypothesis which was put forward a few years ago by certain meteorologists that all considerable raindrops are melted snowflakes or hail, is not valid. On July 21st, 1863, when it was raining steadily on the ground the drops being " as large as a fourpenny piece," Glaisher passed through clouds with a minimum temperature of 59° F. into clear air above. On the same occasion he came down to the bottom of the cloud layer and heard the rain pattering on the trees of Epping Forest, rain which seems to have been produced between the clouds and the ground " that which we saw had its origin within 800 ft. of the ground."

Glaisher's observations during the 28 ascents which he made in the years 1862 to 1866 are printed in the Reports of the British Association. Only the descriptive matter is reproduced in " Travels in the Air." The original observations and especially those made in the clouds would repay careful study now that the question how clouds form in non-saturated air is receiving so much attention.

Alto-cumulus Castellatus Clouds and Thunderstorms

THIS note is based on a fairly complete series of observations of alto-cumulus castellatus cloud in the London area during the years 1923 to 1930. For many years past Mr. Spencer Russell has kept continuous cloud records, and during the period under review the writer has also noted examples of castellatus cloud. In general the same cases were noted by both observers, but Mr. Russell's list is more complete, and the observations used were really his examples supplemented by a few others. The criteria used by both observers in identifying the type were not only the turreted tops but also the existence of a layer of alto-cumulus structure. Various forms of cloud, including cirrus and alto-stratus, occasionally develop cumuliform tops, and the new detailed International Cloud Classification denotes these by the adjective " cumuliformis." Sometimes large towering cumulus or cumulo-nimbus clouds with anvils develop with their base at alto-cumulus levels, and in my private records I have found it necessary to use the terms " high-level cumulus " and " high-level cumulo-nimbus." One of the examples of alto-cumulus castellatus in the large International Cloud Atlas* shows a large heap of cloud. On days when the large type develops, the small type with real alto-cumulus structure can usually be seen sometime during the day. Sometimes the large masses develop upwards from an alto-cumulus layer, and if the layer is low (say 6,000 feet) it may eventually form the base of a thunderstorm. In such cases the layer is often rather thick

* A brief additional note on this subject will be given after the publication of the large atlas.

at an early stage, and might more accurately be described as "strato-cumulus castellatus"; this is a very thundery cloud form.

A more typical sequence of developments, when the life history of the clouds can be followed, is somewhat as follows. A delicate layer of small-grained alto-cumulus first appears, becoming thicker with larger cloudlets, some of which develop turreted tops. Subsequently the cloudlets assume an appearance resembling fracto-cumulus and then dissolve. (This sequence was first described to me in detail by M. A. Giblett and J. Bjerknes, who observed it while on the Thames in the late summer of 1926.)

The total number of examples observed in the eight years was 107. Every month from February to October was represented, the maximum frequency being 26 in July and 25 in August; 95 of the cases occurred in the period May to September, and the subsequent discussion will be entirely limited to these. On 66 out of the 95 occasions, or 69 per cent., there was thunder within 100 miles either on the day of observation or on the following day.

The observations fall into two groups. A small group of 11 cases occurred in polar air, and the upper air temperature, when observed, was low. When there is much large cumulus or cumulo-nimbus cloud, there is often alto-cumulus cloud formed as a sort of residue, perhaps persisting for long afterwards, at levels lower than that of the tops of the cumulo-nimbus. In a few cases the castellatus form appears, though good examples are rare in cool weather. Observers are likely to differ in their treatment of the less well-defined types.

The larger group comprises 84 observations in warm weather, and includes all the really good displays. Observations of upper air temperatures up to about 15,000 feet or more were obtained at Duxford or Farnborough on 52 of these occasions, and a comparison with the monthly means shows that on the average there was an excess of 10°F. at 5,000 feet and of 5°F. at 15,000 feet. The average lapse rate was thus above the normal, with warm air below and less warm air above, giving a condition favourable for thunderstorm development. The other condition required for thunder is an adequate moisture supply at lower levels. In some cases in the rear of anticyclones, alto-cumulus castellatus clouds appear when the air lower down is dry, so that there is no immediate prospect of thunder. Although the thundery conditions often follow in about 24 hours or less, the clouds are not an infallible sign of thunder.

In every instance there was some information as regards the upper wind, either from nephoscope observations of the alto-cumulus clouds, or from pilot balloon ascents up to fully 10,000 feet. Among the 84 examples in the warm weather group, the upper wind at about 10,000 to 15,000 feet (or at the cloud level) was in 74 cases from a direction between south and west, inclusive, the velocity being often considerable; in seven of the remaining cases it was from a point in the south-east quadrant. Observations of changes of upper air temperature up to about 15,000 feet in a period of about 24 hours preceding an observation of castellatus clouds were available on 38 occasions in the warm weather group. At the height of 5,000 feet, temperature rose on 25 occasions, fell on 10, and remained steady on three. On the average of all cases there was a rise of 4°F., and there were seven cases of a rise of 10°F. or more, the largest rise being 21°F. At the height of 15,000 feet, temperature rose on nine occasions, fell on 22, and remained steady on seven. On the average of all cases the fall was barely 1°F., the largest fall being 7°F.

Thus the main feature of the change was a rise of temperature at about 5,000 feet, and the same is true if we consider only those cases definitely associated with thunder. This rise of temperature is normally accompanied by a wind which veers with height, as theoretically it should if the wind is geostrophic and the rise of temperature is due to the horizontal motion. The slight fall of temperature which often takes place high up cannot be easily interpreted in terms of purely geostrophic motion. These falls are usually associated with an approaching cold front, but seem to have no very definite relation to the front. The falls are small and probably gradual rather than sudden; larger falls often occur behind the front. A strong west component in the upper wind does not in itself imply a fall of temperature, and over-running cold air should not be put forward in explanation of a thunderstorm unless this can be proved by means of a suitable series of observations of upper air temperature.

Many of the thunderstorms associated with castellatus cloud occur at night. It has been suggested by R. W. Green* that all nocturnal summer thunderstorms are of turret cloud type, except for a few which develop in polar air. I think this is justified, especially if the term "turret cloud" is given a liberal interpretation. Certainly nearly all the night storms in the London area have been of this type. An important point in connexion with such storms is the trigger action required to start off the disturbance. As a rule this is supplied by a front, most frequently a cold front but sometimes a warm front. In some cases, however, there is no front at the earth's surface and no definite indication of a front up above. One obvious way of starting the disturbance would be a super-adiabatic lapse rate of temperature, but this is somewhat rare and should not be put forward as an explanation without definite evidence. Accord-

* *London, Meteorological Magazine* 64, 1929, *p.* 186.

ing to L. F. Richardson,* stability in the atmosphere depends not only on the lapse rate but also on wind shearing, *i.e.*, on the rate of change of wind with height. This rate is usually high when castellatus clouds are present. Indeed if the lapse rate is increased by the horizontal motion, a change of wind with height is automatically involved. The problem of small disturbances of the dimensions of turret clouds is rather different from that of the larger disturbances giving thunderstorms.

The detailed investigation of castellatus clouds could be carried out from aeroplanes, preferably with the aid of autographic instruments. As a rule a layer of alto-cumulus cloud has a high lapse-rate below and in it, but an inversion or stable layer above it. In the case of alto-cumulus castellatus it is clear that when there is such a stable layer it must be a very thin one, easily broken through. The fact that usually only some of the cloudlets develop turrets suggests that the thin stable layer is often present. A small inversion was noted above a layer containing clouds of this type at Berck on July 16th, 1918, in thundery weather.

C. K. M. Douglas.

Royal Meteorological Society

The monthly meeting of this Society was held on Wednesday, May 20th, in the Society's Rooms, at 49, Cromwell Road, South Kensington, Mr. R. G. K. Lempfert, M.A., F.Inst.P., President, in the Chair.

Sir Gilbert Walker, C.S.I., F.R.S.—Recent work by S. Mal on the forms of stratified clouds.

The paper contains an account of work done partly at the Imperial College of Science and partly at Berlin and Lindenberg where Professor Hergesell had been generous in the provision of facilities. Two years ago it had been suggested that the breaking up of a stratum of cloud into polygons or long strips was often due to instability accompanied in the latter case by shear parallel to the strips. But there was no direct evidence regarding the conditions prevailing in the sky and the production of rectangular arrays of cloudlets had still to be effected experimentally. Mal showed that a rectangular pattern was caused when the unstable stratum was subjected to a less rapid shear than is needed for strips; and verified the measurements made in the sky that cloud strata break up or persist according as their temperature gradient is unstable or stable; and that when they break up the pattern assumed is polygonal, rectangular or in strips according as the shear is zero, moderate or large. The author describes some new types of cloud and

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* The Supply of Energy from and to Atmospheric Eddies. *London, Proc. R. Soc. A.*, 97, 1920, *pp.* 354-73.

suggests an application to the conditions prevailing in the sun.

C. K. M. Douglas, B.A.—A problem of the general circulation. It is shown that, so far as can be judged from present data, there is no appreciable net flow of polar air in the lower troposphere (*i.e.*, between about 1 and 4km.) towards the subtropical anticyclone. This supports the view of Dr. Jeffreys, namely, that the exchange of air between different latitudes, required to maintain the angular momentum of the zone of west winds against friction, is carried out entirely by currents lying side by side, and not one above the other. It is shown that if this exchange of air could be treated by the methods developed in the classical theory of turbulence, cyclones and anticyclones being regarded as eddies in the general circulation, then the supply of angular momentum into the westerly zone would be enormously greater than what is required. It is thought the angular momentum does not diffuse in this way, owing to the large size of cyclones and anticyclones (this is probably to some extent true also of the diffusion of heat and moisture). The fundamental problem is the relation of the individual cyclone to the general circulation, and this has not yet been solved. Some empirical facts are mentioned which may prove useful to future investigators of the subject.

G. S. P. Heywood, B.Sc.—Wind structure near the ground, and its relation to temperature gradient.
The wind velocities in this paper were obtained by two anemometers at heights of 12.7m. and 94.5m. above the ground. Though the diurnal variation of wind velocity at different heights has been worked out by numerous observers, there are not many results from anemometers as high as 95m.; for this reason the ordinary diurnal variation at this height in summer and winter is shown together with that at 13m. for comparison. The vertical gradient of temperature up to 87m. is also recorded. Wind gradient must depend largely on temperature gradient, and in the paper the relation between the difference in wind velocity and the difference in temperature over approximately the same height interval, is worked out for various wind strengths. The various factors controlling the wind gradient are investigated, and the results are found to agree with Taylor's theory of turbulence. The gustiness of the wind is also studied in its relation to vertical temperature gradient and to wind direction.

Correspondence

To the Editor, *The Meteorological Magazine.*

Mammato-cumulus Clouds and Thunderstorms

W. J. Humphreys, in his " Physics of the Air " (Second Edition, p. 294. New York, 1929), says, categorically, that " mammato-cumulus, sometimes called pocky-cloud, festoon cloud, 'rain balls,' sack-cloud, or other similar name . . . occurs . . . seldom except in connection with a severe thunderstorm."

Humphreys is an American and his statement can therefore be taken as being based on American observations. There is a danger, however, that the English reader may take it is being applicable to the British Isles as well and it is the aim of this note to show that, so far as the British Isles are concerned, mammato-cumulus cloud occurs frequently without any thunderstorm, severe or otherwise, occurring at or near the place of observation of the cloud either at, or within four or five hours on either side of, the time of observation.

This I have already shown in conjunction with Mr. G. A. Wright in a note* dealing with observations at one station only. But in this present contribution I have examined the matter over a far more extended range of stations in the British Isles. That more extended survey was made possible by the courtesy of the members of the Meteorological Office Staff at the various stations set out in the table below, who supplied me with details of the observations of mammato-cumulus made at their stations over the years 1926-9, both inclusive. Examination of the *Daily Weather Reports* (issued by the Meteorological Office, London) then enabled it to be determined whether or no thunderstorms had occurred at or about the time of observation of the mammato-cumulus or within the four or five hours preceding or following that time of observation. In this connexion it needs to be noted that either thunder alone, or lightning alone, or thunder and lightning together without precipitation, was taken to mean a thunderstorm in addition to what may be termed the complete thunderstorm, thunder, lightning and precipitation together. The results of the survey are set out in the table below :—

Station	No. of occurrences of mammato-cumulus	No. of such occurrences with thunderstorms either at, or within 4 or 5 hours of, the observation
South Farnborough ...	21	3
Calshot	9	1
Holyhead	7	0
Croydon	6	0
Sealand	7	2
Cranwell	22	1
Felixstowe	23	1
Renfrew	4	0

In short, therefore, taking the aggregate, there were 99 occur-

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* Mammato-Cumulus Cloud at Cranwell, Lincolnshire. By W. H. Pick and G. A. Wright. *London : Q.J.R. Meteor. Soc.* 53, 1927, p. 185.

rences of mammato-cumulus cloud, and of these only 8 were connected with thunderstoms either at the time of observation or within four or five hours on either side of the time of observation. This is a striking result and one that shows that the statement of Humphreys that mammato-cumulus occurs " seldom except in connexion with a severe thunderstorm " is not justified for conditions in the British Isles.

It remains to add that, being personally responsible for many of the Cranwell observations, I can testify that they were examples of mammillated low cloud (below 4,000 feet) and not examples of mammillated alto-stratus.

WILLIAM H. PICK.

December 4th, 1930.

NOTES AND QUERIES

Winds up to 1,500 ft. at Mount Batten, Plymouth

A NOTE giving comparisons of winds at the surface and at 1,500ft. at Mount Batten, Plymouth, was sent recently to the Meteorological Office, and it included diagrams showing for each month of the year mean wind speeds and percentage frequency of direction at the two heights. These diagrams revealed several points of interest. Two points are of particular interest; one, south-west winds occur most often in July and August and least so in December; two, east winds are most frequent in October and rarest in January.

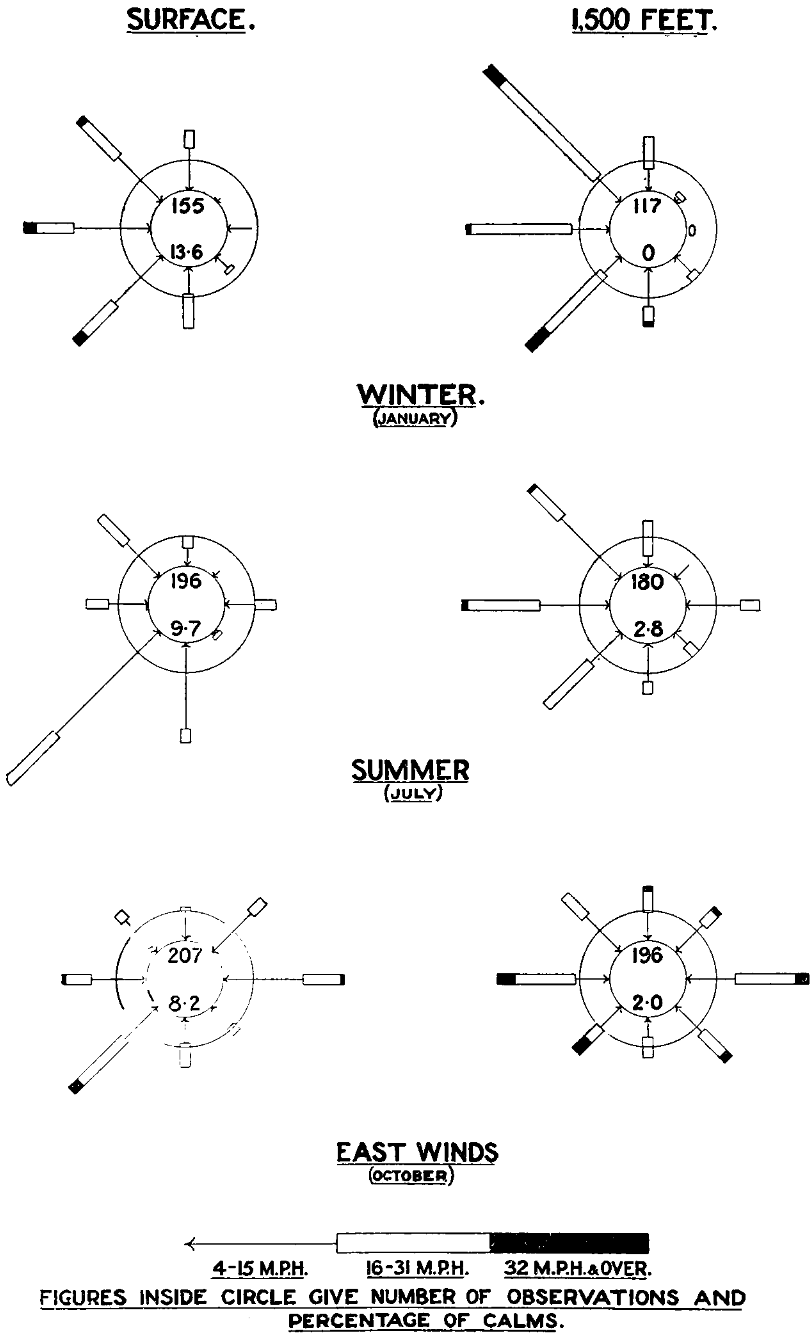
The following tables show the prevailing wind directions and the strongest mean wind for each month of the year :—

	Prevailing Wind		Strongest Wind	
Month	Surface	1,500 feet	Surface	1,500 feet
January ...	W—NW	W—NW	SW	SW
February ...	SW	SW—NW	SW*	†
March	E	NW	NW*	S
April	SW, NW, N	NW	†	NW and NE
May	SW	W and E	NW	S
June	SW and NW	NW	SW—NW	SW*
July	SW	W	SW	SW
August ...	SW	W	SW—W	SW
September ...	SW	W—NW	W—NW	†
October ...	E and SW	E	SW—W	SW
November ...	E	NW—N	SW—W	NW
December ...	NW	W	S—SW	W—NW

* Fairly constant in all directions. † Constant in all directions.

The accompanying diagrams show the distribution of wind force and direction in winter (January), summer (July), and during October when east winds predominate. It will be noted that an increase of force occurs at 1,500ft., and except in the case of east winds a veer takes place between the surface and the higher level.

H. Applegate.



PERCENTAGE FREQUENCY OF WINDS AT MOUNT BATTEN, PLYMOUTH.

Amazing Rainfall in the Bahamas

Capt. C. J. P. Cave has kindly sent us the following paragraph from "The West India Committee Circular" for May 14th, 1931 :—

"There was an amazing cloudburst at West End, Grand Bahama, on April 15th, when, according to the Collector of Revenue, no fewer than 24in. of rain (equivalent to London's annual rainfall) fell in less than 5 minutes. The downpour was accompanied by a mighty rushing wind of 70 to 80 miles an hour, which did much damage to small craft and wrecked an aeroplane."

The record is more than amazing, and before commenting upon it, we should like to have fuller details.

Reviews

The Cyclone Season 1928-1929 *at Mauritius.* By R. A. Watson, B.A. Misc. Publ. Royal Alfred Observatory, No. 10.

An interesting analysis of 8 cyclones which occurred in the south Indian Ocean. Daily synoptic charts are included for the periods during which the cyclones lasted. They enable the tracks of the storms to be followed readily. In addition, the tracks of these cyclones are shown together on a general chart.

Autographic records of pressure and wind are given to illustrate the passage of two of these cyclones at Rodrigues. The publication includes a table showing the number of cyclones that have occurred on any particular date during the last 78 years, and also a table of directions of movement of cyclones as they cross various parallels of latitude.

The analogy suggested between the effect of the land mass of Madagascar and that of the Alps and Norway is very interesting. Other similar examples might be quoted, namely, (*a*) India where several cyclones have passed across the country from the Bay of Bengal into the Arabian Sea, and (*b*) the Philippines where typhoons regularly cross from mid-Pacific into the China Sea. One of these latter has actually continued across the Malayan Peninsula into the Bay of Bengal. T. R. Beatty.

Atlas Pluviomètric de Catalunya. By Joaquim Febrer. Memòries Patzot. Volume 1. Size 11 x 8½ in., pp. 523, *Illus.*, Barcelona. Institució Patxot. 1930.

This publication gives details of the monthly rainfall and number of rain-days of all available records in Catalonia from their commencement until 1925. The longest record is that maintained at the Observatory of the University at Barcelona since 1861. Records for 306 stations have been collected from various sources. The monthly means have been evaluated for 17 stations with more than 30 years' records, and the means of shorter records adjusted by reference to the nearest long-period station. Computed monthly means are also given for each station, together with a note of the long-period station used in the computation. The positions of the 306 stations are shown on a map of Catalonia (the north-east of Spain, extending for about 100 miles round Barcelona), on the scale of 22 miles to 1 inch. A series of maps show the mean monthly and annual rainfall, the rainfall of the driest and wettest year, the proportion of the annual rainfall in each month and the mean number of days with rain.

The general practice adopted in Catalonian climatological statistics, of using the seasonal year December to November, is adhered to. Thus, in the tables and maps December is taken as the initial month. Another departure from the routine adopted in the British Isles is that the rainfall maps are drawn without reference to the configuration.

This work on the rainfall of Catalonia by the head of the Climatological Section of the Meteorological Service of Catalonia, was awarded first prize in the Patxot competition of 1925. This competition was instituted some four years previously by Mr. Raphaël Patxot i Jubert in order to stimulate research in the physical sciences and in mathematics, especially in Catalonia. In this connexion it may be mentioned that the subject of the ninth competition is "The Meteorology of the Western Mediterranean, especially of the coast of Catalonia and preferably from the dynamical aspect of the problem." Entries should be submitted before December 31st, 1931, and the prize is 5,000 pesetas (about £25). J. GLASSPOOLE.

Barometers (*List* 565) *and Meteorological Thermometers* (*List* 567), pp. 34 and pp. 24, *Illus.* C. F. Casella & Co. Ltd. London.

No apology, it is felt, is needed, in bringing these two excellently illustrated catalogues of this well-known firm to the notice of our readers. Where it is felt that an explanation of the mode of operation of an instrument is needed, it is given in a short but clear descriptive article.

In the barometer catalogue are listed aneroids and barographs as well as mercury barometers. Examples of the Kew (Station and Marine), Fortin and Newman type of mercury barometer for observatory work are given, while barometers for ornament as well are not forgotten. Graduations to meet the needs of purchasers whether in inches, millimetres or millibars, can be engraved as desired. Of aneroids, there is a large selection ranging from instruments designed to be carried in the pocket to those $4\frac{1}{2}$ inches in diameter. These aneroids can be graduated to read heights or pressure or both. There are also listed, an aneroid for the dashboard of a car, altimeters for use on aeroplanes, and a small altimeter which can be strapped on to the arm. Pendant aneroids for the home in the ornamental mounts of various designs are also included.

The thermometer catalogue is almost entirely devoted to thermometers for general meteorological use, and so includes such theromemeters as maximum, minimum, grass and earth, though right-angled soil thermometers are not shown. Also listed are such allied instruments as a bimetallic thermograph, hair hygrograph and a combination of these two, a Mason hygrometer, an Assmann psychrometer with a clock or motor-driven fan and a whirling psychrometer. A standard Stevenson screen is also included. It is interesting to notice that such thermometers as the black bulb *in vacuo*, solar radiation, and Six's maximum and minimum are still listed. Mention should also be made of a variety of evaporimeters and recorder drums for various speeds of rotation which are given in the catalogue.

Many of the more important instruments can be supplied with a certificate from the National Physical Laboratory.

J. E. BELASCO.

Books Received

Bulletin de l'Observatoire de Talence (Gironde). 2nd Series, Nos. 10-14. Talence, 1930 and 1931.

Royal Botanic Society of London. Quarterly summary and meteorological readings, Nos. 43, 44, 45.

Deutsches Meteorologisches Jahrbuch für 1921-1922. Freistaat Sachsen. Edited by Prof. Dr. E. Alt. Jahrgang xxxix to xl. Dresden, 1930.

Gulf Stream daily thermograms across the Straits of Florida. By Charles F. Brooks. Reprinted from Washington, Monthly Weather Rev. 58, 1930, pp. 148-54.

Summary of meteorological observations made at the meteorological stations in the Netherlands West Indies during the years 1919-1928. Compiled by the Royal Dutch Meteor. Inst. The Hague, 1930.

Obituary

Professor Alfred Wegener.—We learn with deep regret of the death of Professor Alfred Wegener, leader of the German expedition to Greenland. This expedition, the fourth in which he has taken part, set out on April 1st, 1930, for Kamarujuk in latitude 71°N. on the west coast, and in spite of difficulties caused by an unusually severe season, succeeded on July 31st in establishing a station on the central part of the inland ice, about 250 miles from both east and west coasts, where observations were to be maintained throughout the year. On September 22nd last year Professor Wegener set out with Dr. Loewe and a party of thirteen Greenlanders for the purpose of taking supplies and instruments to Dr. J. Georgi and Dr. E. Sorge, who were observing at the central station. He sent back twelve of the Greenlanders in October, and continued with Dr. Loewe and the remaining Greenlander, Rasmus, to the central station. Here Loewe remained, while Wegener and Rasmus commenced the return journey on November 1st. They failed to arrive at Kamarujuk, but their comrades, supposing that they had remained at the ice camp, did not send out a relief party until April 23rd. Wegener's body was found buried in the snow, but there is no trace of Rasmus, nor of Wegener's diaries and other notes, and the search is being continued.

Alfred Wegener was born on November 1st, 1880, and studied at Berlin, Heidelberg and Innsbruck, obtaining the degree of Doctor at Berlin with an astronomical thesis. From 1906 to 1908 he took part in a Danish expedition to Greenland under Mylius-Ericksen, having charge of the meteorological work, including upper air observations with kites and captive balloons; on his return he summarised the observations for publication. He returned to Greenland in 1911 to 1913, in association with Colonel Koch, one of his companions in 1906-1908. In 1916 he was appointed to the meteorological service of the German army, and took part as meteorological adviser on a number of Zeppelin flights. After the war he joined the Deutsche Seewarte at Hamburg, remaining until 1925, when he was appointed Professor of Geophysics and Meteorology at the University of Graz. His third expedition to Greenland in 1929 was by way of preparation for the fourth, which was his most ambitious attempt, but which has ended so sadly. He leaves a wife and two daughters.

Besides his explorations, Wegener's work has ranged over a very wide field. In 1911 he published his well-known book, "Thermodynamik der Atmosphäre," which reached its third edition in 1928, and is a standard meteorological text-book. Other papers deal with the investigation of the outermost layers of the atmosphere, atmospheric optics and the theory of halos, the resistance of the air to the passage of meteors, abnormal audibility of explosions, and the problems of dynamical meteorology. He is most generally known however for his theory of "continental drift," as set out in his book "The Origin of Continents and Oceans." The first German edition of this work appeared in 1915, the second in 1920, the third in 1922 and the fourth in 1929. An English translation of the third edition was issued in 1924, and the book has also appeared in French, Russian, Swedish and Spanish. It marshals with great skill all the arguments which go to show that the continents are rafts of granitic rock floating in a heavier basaltic magma, and have repeatedly changed their positions during geological time, both relative to each other as the great primeval continent broke up into smaller masses, and relative to the poles. The theory is important to meteorologists because the author adduced the movements of the poles to explain the great apparent variations of geological climates, and especially the glaciation of regions now within the tropics. The climatological part of the theory was set out in greater detail in "Die Klimate der Geologischen Vorzeit," by W. Köppen and A. Wegener. In the last decade the question of continental drift has been a subject of great argument in scientific circles; no general agreement has yet been reached, but the theory has already resulted in several advances of geophysical knowledge, and it is given to few men to inspire research as Wegener has done.

News in Brief

Mr. Seton Gordon reports that "at Duntulm, Skye, on April 29th, from about 1½ hours before sunset onward, there was an unusually brilliant ring round the sun, and a shadow or faint second ring outside it. This brought a change of weather as usual. I do not ever remember having seen two rings before."

Major Goldie who sends this report, remarks that the rings observed by Mr. Seton Gordon are no doubt the common 22° and the less frequent 46°.

Dr. H. R. Mill has been appointed President of the Geographical Association for 1932.

We regret to learn that in February Dr. Joaquim de Sampaio Ferraz resigned for reasons of health from his post as Director of the Brazilian Meteorological Institute, which he initiated in 1921. He has been succeeded by M. Paul Pires Xavier.

The Weather of ~~April~~ May, 1931

PRESSURE was below normal in a belt extending from south-west Scandinavia, Germany and Austria across the Atlantic to eastern Canada and the eastern United States, over the western coasts of the United States and of Canada and Alaska and also over the Caspian and Black Seas, the greatest deficit being 8·1mb. at Valentia (Ireland). Pressure was above normal in a wedge over the middle western districts of Canada and of the United States, over the Atlantic to the south of Bermuda and the Azores, from Iceland to Spitsbergen and over most of Scandinavia, Russia, southern Europe, and north Africa, the greatest excesses being 5·6mb. at lat. 50°, long. 100° and 5·4mb. at Jan Mayen. Temperature was above normal over Spitsbergen and western Europe except the Iberian Peninsula, and rainfall was in excess over most of western Europe though deficient in northern Scandinavia and at Spitsbergen. In eastern Gothaland (Sweden) the rainfall was between twice and three times the normal.

The weather of May over the British Isles was generally unsettled with some long bright periods and heavy rain. Pressure continued high to the north-west and north of the British Isles during the greater part of the month, causing depressions to move across the country instead of skirting the north-west coasts. For the first few days a complex low pressure system extended from the Faroes to the western Mediterranean. Slight rain fell at most places on the 1st and 2nd, except in north-east England and south Scotland, where sunshine was abundant; 13.4hrs. were measured at Scarboro' on the 1st. This fine weather spread over the rest of the north and west during the next day or two. Aberdeen had 14.7hrs. bright sunshine on the 3rd, but in the south the 3rd was dull, wet and cold. On the 4th and 5th there was a general rise of temperature over the country as the winds backed to SW., and the weather became brighter though thunderstorms occurred locally on the 5th, 7th and 8th. A belt of high pressure moved across the British Isles on the 8th and 9th accompanied by bright warm sunny weather. From then to the 16th, however, a depression was situated off the north-western coasts, temperature was about normal with slight rain at times, but some bright periods. The 11th was a sunny day in Ireland. From the 16th-20th depressions again moved across the country and the weather was dull and cold with rain at times in the east but sunny in the west. After an extension of the high-pressure system over Greenland and Scandinavia had passed across the country on the 20th and 21st, during which the weather was cold and sunny, temperature rose generally above normal and continued warm until the end of the month. The 27th was the warmest day, when 70°F. was exceeded even as far north as Morecambe and Ilkley and 76°F. was reached at Cambridge and Southampton. Rain occurred in almost all districts on the Saturday and Sunday of the Whitsun holidays, but on Whit Monday there was brilliant sunshine at most places, 14.7hrs. at Norwich and 14.5hrs. at Margate. After this conditions continued unsettled with thunderstorms locally from the 26th-29th and heavy rain alternating with bright intervals, 4.18in. fell at Cardiff and 2.90in. at Wheddon Cross, Somerset, on the 27th. On this day severe thunderstorms were also recorded in the Isle of Wight (Shanklin 1·72in.) and Hereford-

(*Continued on p.* 124)

Rainfall: May, 1931: England and Wales

Co.	Station	In.	Per-cent of Av.	Co.	Station	In.	Per-cent of Av.
Lond .	Camden Square.........	2·67	152	*Rut* .	Ridlington..............	2·58	128
Sur .	Reigate, Alvington....	3·12	172	*Linc* .	Boston, Skirbeck.......	2·61	148
Kent .	Tenterden, Ashenden...	1·90	121	,, .	Cranwell Aerodrome...	2·70	149
,, .	Folkestone, Boro. San..	1·87	...	,, .	Skegness, Marine Gdns	2·02	119
,, .	Margate, Cliftonville...	1·98	125	,, .	Louth, Westgate........	2·15	106
,, .	Sevenoaks, Speldhurst	2·84	...	,, .	Brigg, Wrawby St.....	2·51	...
Sus .	Patching Farm.........	3·65	197	*Notts* .	Worksop, Hodsock.....	2·26	114
,, .	Brighton, Old Steyne..	2·19	135	*Derby* .	Derby, L. M. & S. Rly.	2·65	139
,, .	Heathfield, Barklye....	2·34	130	,, .	Buxton, Devon Hos....	3·02	97
Hants .	Ventnor, Roy. Nat. Hos.	3·69	217	*Ches* .	Runcorn, Weston Pt...	2·43	105
,, .	Fordingbridge, Oaklnds	2·48	119	,, .	Nantwich, Dorfold Hall	3·96	...
,, .	Ovington Rectory.......	3·17	146	*Lancs* .	Manchester, Whit. Pk.	2·68	126
,, .	Sherborne St. John.....	3·26	168	,, .	Stonyhurst College.....	2·06	72
Berks .	Wellington College.....	3·24	174	,, .	Southport, Hesketh Pk	2·06	98
,, .	Newbury, Greenham...	2·61	139	,, .	Lancaster, Strathspey	2·05	...
Herts .	Welwyn Garden City...	2·52	...	*Yorks* .	Wath-upon-Dearne.....	2·76	136
Bucks .	H. Wycombe, Flackwell	2·65	...	,, .	Bradford, Lister Pk....	2·32	111
Oxf . .	Oxford, Mag. College..	2·75	157	,, .	Oughtershaw Hall......	3·84	...
Nor .	Pitsford, Sedgebrook...	2·53	132	,, .	Wetherby, Ribston H.	2·96	143
,, .	Oundle..................	1·98	...	,, .	Hull, Pearson Park.....	3·00	155
Beds .	Woburn, Crawley Mill	2·81	145	,, .	Holme-on-Spalding.....	2·44	...
Cam .	Cambridge, Bot. Gdns.	2·85	162	,, .	West Witton, Ivy Ho.	3·06	136
Essex .	Chelmsford, CountyLab	2·67	185	,, .	Felixkirk, Mt. St. John	2·93	156
,, .	Lexden Hill House....	2·09	...	,, .	Pickering, Hungate....	2·73	139
Suff .	Hawkedon Rectory.....	2·77	150	,, .	Scarborough............	2·02	106
,, .	Haughley House........	2·20	...	,, .	Middlesbrough..........	2·30	120
Norf .	Norwich, Eaton...... ...	3·57	185	,, .	Baldersdale, Hury Res.	3·31	...
,, .	Wells, Holkham Hall	3·18	198	*Durh* .	Ushaw College..........	2·93	136
,, .	Little Dunham..........	3·68	190	*Nor* .	Newcastle, Town Moor	2·45	121
Wilts .	Devizes, Highclere......	2·73	151	,, .	Bellingham, Highgreen	2·94	122
,, .	Bishops Cannings.......	3·36	172	,, .	Lilburn Tower Gdns....	2·42	105
Dor .	Evershot, Melbury Ho.	3·42	168	*Cumb* .	Geltsdale..............	2·10	...
,, .	Creech Grange..........	3·70	181	,, .	Carlisle, Scaleby Hall	2·60	109
,, .	Shaftesbury, Abbey Ho.	2·60	126	,, .	Borrowdale, Seathwaite	6·95	94
Devon .	Plymouth, The Hoe....	3·84	185	,, .	Borrowdale, Rosthwaite	7·63	...
,, .	Polapit Tamar..........	...	...	,, .	Keswick, High Hill.....	3·95	...
,, .	Ashburton, Druid Ho.	..	...	*West* .	Appleby, Castle Bank..	3·02	137
,, .	Cullompton.......	3·25	150	*Glam* .	Cardiff, Ely P. Stn.....	7·29	291
,, .	Sidmouth, Sidmount...	2·95	151	,, .	Treherbert, Tynywaun	6·28	...
,, .	Filleigh, Castle Hill....	3·21	...	*Carm* .	Carmarthen Friary.....	3·84	139
,, .	Barnstable. N. Dev. Ath	3·40	164	,, .	Llanwrda..........	...	...
Corn .	Redruth, Trewirgie.....	4·01	174	*Pemb* .	Haverfordwest, School	4·16	166
,, .	Penzance, Morrab Gdn.	3·26	147	*Card* .	Aberystwyth...........	3·64	...
,, .	St. Austell, Trevarna...	3·44	142	,, .	Cardigan, County Sch.	2·69	...
Soms .	Chewton Mendip........	4·12	149	*Brec* .	Crickhowell, Talymaes	...	...
,, .	Long Ashton............	3·47	164	*Rad* .	BirmW.W.Tyrmynydd	6·17	180
,, .	Street, Millfield	3·21	168	*Mont* .	Lake Vyrnwy...........	6·48	205
Glos. .	Cirencester, Gwynfa....	4·21	205	*Denb* .	Llangynhafal............	3·63	164
Here .	Ross, Birchlea..........	3·43	161	*Mer* .	Dolgelly, Bryntirion...	4·05	122
,, .	Ledbury, Underdown..	3·80	186	*Carn* .	Llandudno.............	2·15	113
Salop .	Church Stretton........	5·46	212	,, .	Snowdon, L. Llydaw 9	11·35	...
,, .	Shifnal, Hatton Grange	4·36	212	*Ang* .	Holyhead, Salt Island	3·39	173
Worc .	Ombersley, Holt Lock	4·35	212	,, .	Lligwy..................	2·23	104
,, .	Blockley..............	4·38	...	*Isle of Man*			
War .	Birminghm, Edgbaston	3·94	184		Douglas, Boro' Cem....	3·75	150
Leics .	Thornton Reservoir....	2·92	145	*Guernsey*			
,, .	Belvoir Castle..........	3·07	145		St. PeterP't. GrangeRd.	2·51	148

Rainfall: May, 1931: Scotland and Ireland

Co.	Station	In.	Per-cent. of Av.	Co.	Station	In.	Per cent. of Av.
Wigt	Pt. William, Monreith	2·24	95	*Suth*	Loch More, Achfary	5·51	125
,,	New Luce School	2·88	101	*Caith*	Wick	4·91	237
Kirk	Carsphairn, Shiel	5·33	126	*Ork*	Pomona, Deerness	4·74	238
Dumf	Dumfries, Crichton, R.I	3·41	...	*Shet*	Lerwick	2·75	131
,,	Eskdalemuir Obs.	4·59	139	*Cork*	Caheragh Rectory	3·43	...
Roxb	Branxholm	3·43	152	,,	Dunmanway Rectory	4·80	141
Selk	Ettrick Manse	4·91	134	,,	Ballinacurra	4·27	180
Peeb	West Linton	3·64	...	,,	Glanmire, Lota Lo.	4·35	177
Berk	Marchmont House	2·68	108	*Kerry*	Valentia Obsy	4·69	148
Hadd	North Berwick Res.	3·00	151	,,	Gearahameen	8·10	...
Midl	Edinburgh, Roy. Obs.	2·77	148	,,	Killarney Asylum	4·33	142
Lan	Auchtyfardle	3·11	..	,,	Darrynane Abbey	4·01	135
Ayr	Kilmarnock, Agric. C.	2·63	114	*Wat*	Waterford, Brook Lo.	4·81	207
,,	Girvan, Pinmore	2·17	73	*Tip*	Nenagh, Cas. Lough	4·23	171
Renf	Glasgow, Queen's Pk.	4·08	167	,,	Roscrea, Timoney Park	4·63	...
,,	Greenock, Prospect H.	5·83	169	,,	Cashel, Ballinamona	6·10	254
Bute	Rothesay, Ardencraig.	4·97	164	*Lim*	Foynes, Coolnanes	2·79	120
,,	Dougarie Lodge	3·28	...	,,	Castleconnel Rec.	4·24	...
Arg	Ardgour House	7·58	...	*Clare*	Inagh, Mount Callan	4·41	...
,,	Manse of Glenorchy	3·88	...	,,	Broadford, Hurdlest'n.	4·16	...
,,	Oban	3·24	107	*Wexf*	Gorey, Courtown Ho.	4·89	220
,,	Poltalloch	...	...	*Kilk*	Kilkenny Castle	4·56	206
,,	Inveraray Castle	6·32	161	*Wic*	Rathnew, Clonmannon	5·27	...
,,	Islay, Eallabus	3·23	122	*Carl*	Hacketstown Rectory	5·35	206
,,	Mull, Benmore	11.40	...	*Leix*	Blandsfort House	4·36	179
,,	Tiree	3·44	..	,,	Mountmellick	3·42	...
Kinr	Loch Leven Sluice	3·63	149	*Off'ly*	Birr Castle	2·81	126
Perth	Loch Dhu	8·55	191	*Kild'r.*	Monasterevin	3·35	...
,,	Balquhidder, Stronvar	5·93	...	*Dubl*	Dublin, FitzWm. Sq.	3·60	175
,,	Crieff, Strathearn Hyd.	4·74	190	,,	Balbriggan, Ardgillan.	2·93	141
,,	Blair Castle Gardens	4·32	213	*Me'th*	Beauparc, St. Cloud	3·78	...
Angus	Kettins School	4·44	182	,,	Kells, Headfort	4·33	160
,,	Dundee, E. Necropolis	3·42	163	*W.M.*	Moate, Coolatore	3·46	...
,,	Pearsie House	3·96	...	,,	Mullingar, Belvedere	3·47	141
,,	Montrose, Sunnyside	2·86	140	*Long*	Castle Forbes Gdns.	4·41	171
Aber	Braemar, Bank	3·21	135	*Gal*	Ballynahinch Castle	5·67	158
,,	Logie Coldstone Sch.	3·12	125	,,	Galway, Grammar Sch.	4·51	...
,,	Aberdeen, King's Coll.	4·59	197	*Mayo*	Mallaranny	5·90	...
,,	Fyvie Castle	...	...	,,	Westport House	4·65	163
Moray	Gordon Castle	2·58	122	,,	Delphi Lodge	8·26	139
,,	Grantown-on-Spey	4·02	172	*Sligo*	Markree Obsy	4·73	187
Nairn	Nairn, Delnies	2·48	138	*Cav'n*	Belturbet, Cloverhill	3·98	160
Inv	Kingussie, The Birches	2·98	...	*Ferm*	Enniskillen, Portora	4·33	...
,,	Loch Quoich, Loan	10·89	...	*Arm*	Armagh Obsy	3·61	152
,,	Glenquoich	8·22	150	*Down*	Fofanny Reservoir	8·75	...
,,	Inverness, Culduthel R.	2·68	...	,,	Seaforde	3·85	146
,,	Arisaig, Faire-na-Squir	...	...	,,	Donaghadee, C. Stn.	3·58	158
,,	Fort William	6·27	...	,,	Banbridge, Milltown	2·67	...
,,	Skye, Dunvegan	4·31	...	*Antr*	Belfast, Cavehill Rd.	4·54	...
R&C	Alness, Ardross Cas.	2·99	115	,,	Glenarm Castle	5·05	...
,,	Ullapool	2·02	79	,,	Ballymena, Harryville	5·34	187
,,	Torridon, Bendamph	2·83	62	*Lon*	Londonderry, Creggan	3·12	119
,,	Achnashellach	5·94	...	*Tyr*	Donaghmore	...	...
,,	Stornoway	3·68	...	,,	Omagh, Edenfel	3·92	151
Suth	Lairg	2·95	118	*D.n*	Malin Head	2·36	...
,,	Tongue	3·71	156	,,	Dunfanaghy	2·71	...
,,	Melvich	4·38	...	,,	Killybegs, Rockmount	4·38	123

Climatological Table for the British Empire, December, 1930.

STATIONS	PRESSURE: Mean of Day M.S.L. mb.	PRESSURE: Diff. from Normal mb.	TEMPERATURE: Absolute Max. °F.	TEMPERATURE: Absolute Min. °F.	TEMPERATURE: Mean Values Max. °F.	TEMPERATURE: Mean Values Min. °F.	TEMPERATURE: Mean Values ½ max. and min. °F.	TEMPERATURE: Mean Values Diff. from Normal °F.	TEMPERATURE: Mean Wet Bulb °F.	Relative Humidity %	Mean Clou'd Am'nt 0—10	PRECIPITATION: Am'nt in.	PRECIPITATION: Diff. from Normal in.	PRECIPITATION: Days	BRIGHT SUNSHINE: Hours per day	BRIGHT SUNSHINE: Per-centage of possible
London, Kew Obsy.	1012·8	− 0·9	52	28	45·0	36·0	40·5	+ 0·2	38·1	91	8·1	1·82	− 0·47	14	0·7	9
Gibraltar	1019·5	− 0·6	67	43	62·6	50·8	56·7	+ 0·7	50·7	83	4·8	2·95	− 2·66	10	..	..
Malta	1014·0	− 2·6	70	48	62·5	54·3	58·4	+ 0·5	54·4	78	7·1	6·36	+ 2·65	16	4·9	51
St. Helena	1014·0	+ 0·5	69	55	66·5	57·5	62·0	− 0·2	58·7	92	8·8	0·74	− 1·22	9	..	..
Sierra Leone	1011·8	+ 0·9	89	69	87·3	73·4	80·3	− 1·1	76·8	82	3·8	0·10	− 1·32	2	..	..
Lagos, Nigeria	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..
Kaduna, Nigeria	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..
Zomba, Nyasaland	1007·9	− 0·4	94	63	84·9	68·0	76·5	+ 3·4	..	67	6·4	4·58	− 6·29	18	..	..
Salisbury, Rhodesia	1008·9	+ 0·1	85	58	77·8	61·6	69·7	+ 0·1	63·6	72	7·5	12·00	+ 6·22	25	5·2	39
Cape Town	1014·2	− 0·1	98	48	78·5	59·1	68·8	+ 0·9	62·6	72	4·6	0·44	− 0·37	6	..	..
Johannesburg	1010·2	+ 0·9	87	43	79·8	57·2	68·5	+ 3·4	58·6	62	4·5	4·32	− 1·11	13	8·7	64
Mauritius	1015·1	+ 1·1	88	67	85·6	70·9	78·3	0·0	72·5	61	5·8	2·56	− 2·17	21	9·6	72
Bloemfontein	..	..	..	..	..	..	..	..	..	..	..	1·19	− 1·26	..	..	..
Calcutta, Alipore Obsy.	1015·7	0·0	81	51	77·6	55·6	66·6	+ 0·1	56·6	82	1·4	0·00	− 0·20	0*	..	..
Bombay	1013·2	− 1·3	94	65	87·9	69·8	78·9	+ 1·4	67·0	69	0·7	0·00	− 0·05	0*	..	..
Madras	1013·5	0·0	85	64	83·0	70·6	76·8	+ 0·1	72·5	85	4·9	4·76	− 1·05	9*	..	..
Colombo, Ceylon	1012·0	+ 1·3	89	64	86·8	72·5	79·7	+ 0·7	74·3	72	5·3	0·27	− 5·10	3	8·3	71
Hongkong	1019·3	− 0·4	77	49	68·2	60·6	64·4	+ 1·4	59·4	74	7·5	0·89	− 0·24	8	3·9	36
Sandakan	..	..	89	73	86·8	74·5	80·7	+ 0·6	77·1	83	..	15·44	− 2·22	16	..	..
Sydney, N.S.W.	1012·8	+ 0·9	96	57	76·2	63·6	69·9	− 0·2	64·8	67	6·0	5·31	+ 2·40	14	8·1	56
Melbourne	1013·5	+ 1·0	93	50	74·9	56·5	65·7	+ 1·4	60·6	66	7·3	5·06	+ 2·72	17	5·8	39
Adelaide	1013·2	0·0	102	52	85·6	62·3	73·9	+ 2·8	60·7	37	5·8	0·91	− 0·09	7	9·0	63
Perth, W. Australia	1012·9	− 0·3	101	49	79·7	60·5	70·1	− 0·6	61·9	53	4·0	0·90	+ 0·32	5	10·8	76
Coolgardie	1011·2	0·0	100	50	89·2	60·6	74·9	− 0·9	61·3	42	3·2	3·50	+ 2·80	5	..	..
Brisbane	1014·1	+ 2·1	92	58	84·6	65·4	75·0	− 1·4	67·3	52	5·5	1·94	− 2·90	7	9·9	71
Hobart, Tasmania	1013·0	+ 3·3	87	45	68·8	52·1	60·5	+ 0·1	54·7	59	6·1	2·53	+ 0·57	12	7·5	49
Wellington, N.Z.	1015·9	+ 3·7	74	42	62·1	49·8	55·9	− 4·5	53·1	77	8·2	2·99	− 0·23	9	6·1	40
Suva, Fiji	1009·9	+ 1·3	87	70	83·8	73·5	78·7	− 0·2	73·7	75	7·2	7·01	− 5·10	24	6·6	50
Apia, Samoa	1006·8	− 1·6	87	71	84·4	76·2	80·3	+ 1·0	76·8	80	7·1	15·63	+ 2·01	16	5·1	40
Kingston, Jamaica	1013·6	− 0·4	90	67	87·0	70·2	78·6	+ 0·9	68·1	83	3·7	0·04	− 1·55	1	..	..
Grenada, W.I.	1012·8	+ 1·3	89	71	86·5	72·9	79·7	+ 1·6	73·6	77	6·6	4·55	− 2·72	18	..	..
Toronto	1017·5	+ 0·1	45	1	33·7	23·8	28·7	+ 2·5	26·1	82	8·3	1·16	− 1·67	11	1·8	20
Winnipeg	1017·5	− 0·4	38	−20	19·7	7·0	13·3	+ 7·6	..	..	5·9	0·59	− 0·39	9	3·1	38
St. John, N.B.	1015·0	+ 0·8	45	− 4	30·8	18·5	24·7	+ 0·3	20·2	70	7·0	3·42	− 0·75	12	3·0	34
Victoria, B.C.	1021·5	+ 4·7	52	33	46·7	39·6	43·1	+ 1·6	40·6	87	7·9	0·78	− 5·13	16	2·1	25

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

Climatological Table for the British Empire, Year 1930.

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.	1012·7	− 2·7	89	25	57·0	44·5	50·8	+ 1·0	45·9	86	7·2	25·34	+ 1·54	166	3.8	29
Gibraltar	1017·2	− 0·6	93	40	72·1	56·9	64·5	+ 0·2	56·6	83	4·8	36·30	+ 0·48	89	..	..
Malta	1015·6	− 0·3	93	45	70·3	60·3	65·3	− 0·8	60·0	76	4·6	26·27	+ 6·41	86	8·7	70
St. Helena	1015·3	+ 1·0	..	51	..	57·0	..	..	58·0	94	8·9	29·55	− 10·57	203	..	..
Sierra Leone	1013·4	+ 1·9	95	67	85·1	72·5	78·8	− 1·9	75·1	83	5·9	114·47	− 42·76	158	..	..
Lagos, Nigeria	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..
Kaduna, Nigeria	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..
Zomba, Nyasaland	1012·5	− 0·2	94	46	78·1	60·4	69·2	− 0·2	..	73	5·5	36·29	− 18·25	103	..	..
Salisbury, Rhodesia	1012·7	− 0·1	91	35	76·3	53·8	65·1	− 0·3	56·2	53	3·8	23·75	− 8·19	82	7·9	66
Cape Town	1018·1	+ 1·2	104	36	73·0	54·4	63·7	+ 1·4	55·9	79	4·3	16·47	− 8·57	91	..	..
Johannesburg	1016·9	+ 0·4	89	28	70·7	49·4	60·1	+ 0·4	49·4	54	3·0	22·49	− 10·73	86	9·0	75
Mauritius	1016·0	− 0·1	89	55	80·2	67·4	73·8	− 0·2	69·6	69	5·6	35·99	− 13·67	202	8·0	66
Bloemfontein	..	..	..	...	..	..	..	..	..	..	..	..	..	..	..	..
Calcutta, Alipore Obsy.	1008·0	+ 0·4	107	49	88·1	71·5	79·8	+ 1·1	71·8	84	5·0	59·88	− 2·66	84*	..	..
Bombay	1009·2	0·0	96	59	87·5	74·2	80·9	+ 0·4	72·9	76	3·8	89·98	+ 17·79	73*	..	..
Madras	1008·7	− 0·1	107	63	90·3	74·9	82·6	− 0·4	75·1	77	5·9	78·69	+ 27·95	78*	..	..
Colombo, Ceylon	1010·6	+ 0·7	93	64	86·2	74·8	80·5	− 0·3	76·4	77	6·7	116·51	+ 31·26	186	7·3	60
Hongkong	1012·8	+ 0·2	93	41	77·0	68·9	72·9	+ 0·7	68·1	77	7·1	96·10	+ 12·28	128	5·7	47
Sandakan	..	..	94	70	88·3	74·7	81·5	+ 0·2	77·1	81	..	103·14	− 16·58	131	..	..
Sydney, N.S.W.	1017·5	+ 1·6	106	41	70·5	56·8	63·7	+ 0·5	58·4	71	5·5	44·47	− 3·43	141	6·9	57
Melbourne	1018·1	+ 1·7	103	34	68·7	50·3	59·5	+ 1·1	53·4	64	6·0	25·41	− 0·14	145	5·8	47
Adelaide	1018·4	+ 1·3	112	37	74·9	54·7	64·8	+ 1·9	55·1	51	5·4	18·65	− 2·55	116	7·5	62
Perth, W. Australia	1016·1	− 0·3	108	41	74·3	56·6	65·4	+ 1·3	58·1	63	4·7	39·80	+ 5·77	129	7·9	64
Coolgardie	1016·1	+ 0·1	115	33	78·7	52·8	65·7	+ 1·2	55·4	52	3·6	13·87	+ 3·71	56	..	..
Brisbane	1017·6	+ 1·7	97	41	77·3	60·1	68·7	− 0·2	62·4	65	5·1	41·22	− 3·44	142	7·5	62
Hobart, Tasmania	1015·0	+ 2·5	93	32	62·7	47·2	55·0	+ 0·6	49·1	66	6·2	19·38	+ 4·36	152	6·1	50
Wellington, N.Z.	1014·9	+ 0·2	77	32	58·3	46·7	52·5	− 2·8	49·8	77	6·8	38·21	− 9·83	147	5·8	48
Suva, Fiji	1011·9	+ 0·5	92	58	81·7	71·2	76·4	− 0·6	71·9	76	6·9	102·92	− 9·46	235	5·3	43
Apia, Samoa	1009·6	− 0·7	89	69	84·8	75·0	79·9	+ 1·4	77·1	78	5·3	89·48	− 17·37	160	6·7	55
Kingston, Jamaica	1013·6	− 0·1	95	64	87·3	71·8	79·6	+ 0·2	70·1	82	3·9	15·48	− 18·11	72	..	..
Grenada, W.I.	1013·5	+ 1·2	90	70	86·9	73·4	80·2	+ 1·4	73·9	77	4·8	54·11	− 21·97	213	..	..
Toronto	1016·1	− 0·3	95	− 6	55·4	39·3	47·4	+ 3·0	41·2	72	5·8	25·74	− 7·73	139	5·6	44
Winnipeg	1015·5	− 0·8	94	−35	47·0	28·8	37·9	+ 3·6	..	..	5·3	22·63	+ 1·56	114	6·0	47
St. John, N.B.	1014·4	− 0·3	87	− 8	50·6	35·1	42·9	+ 1·7	38·5	75	6·2	40·29	− 7·79	149	5·5	44
Victoria, B.C.	1017·6	+ 1·1	87	15	55·1	43·7	49·4	− 0·1	46·0	80	5·9	18·80	− 13·69	119	6·3	49

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

(*Continued from p.* 119)

shire (Dorstone 1·75in.). The distribution of bright sunshine for the month was as follows:—

	Total (hrs.)	Diff. from normal (hrs.)		Total (hrs.)	Diff. from normal (hrs.)
Stornoway	171	— 20	Liverpool	166	—33
Aberdeen	187	0	Ross-on-Wye	152	—51
Dublin	177	— 28	Falmouth	171	—60
Birr Castle	172	— 10	Gorleston	176	—49
Valentia	189	— 14	Kew	160	—41

The special message from Brazil states that for May the rainfall was scarce in the northern regions with an average 1·38in. below normal, irregular in distribution in the central regions with 0·16in. above normal and in excess in the southern regions with 0·71in. above normal. Six anticyclones passed across the country and the continental depression was active during the later part of the month. The cereal crops and vegetables were in normally good condition. At Rio de Janeiro pressure was 0·7mb. above normal and temperature 0·2°F. above normal.

Miscellaneous notes on weather abroad culled from various sources.

Owing to heavy rain and an unusually rapid thaw this spring the rivers in various parts of the central and northern provinces of Sweden overflowed their banks early in the month. Serious floods were also reported later from the country to the north of Lake Vener, Sweden, where Klarälven had overflowed and submerged 200 farms. Torrential rains flooded large parts of south Germany early in the month. Navigation re-opened at Riga and Uleaborg between the 18th and 25th. Thunderstorms damaged vineyards and fruit trees in the Rhine Valley, particularly near Assmannshausen and Lorch, and in the Eifel hills about the 27th (*The Times*, May 8th-28th).

Owing to the rainfall for April and May in Manitoba, Saskatchewan and Alberta being less than half the normal the prospects of the wheat crop are becoming endangered (*The Times*, June 6th). Temperature was below normal generally in the eastern United States, and above normal along the Pacific coasts. In the Missouri and Upper Mississippi valleys and the Mountain Region it was variable. Rainfall was irregular in distribution. Temperature in the Argentine was mainly below normal, and especially so during the week ended the 19th, when it was as much as 9-10°F. below. Precipitation was also deficient (*Washington, D.C., U.S. Dept. Agric., Weekly Weather and Crop Bulletin*). The first heat wave of the year occurred in New York State on the 28th-30th when 94°F. was registered at Albany, N.Y., on the 29th.

Rainfall, May, 1931—General Distribution

England and Wales	150	per cent of the average 1881-1915.
Scotland	145	
Ireland	162	
British Isles	151	

M.O. 340.

The Meteorological Magazine

Air Ministry :: Meteorological Office

Vol. 66

July, 1931

No. 786

LONDON: PUBLISHED BY HIS MAJESTY'S STATIONERY OFFICE
To be purchased directly from H.M. STATIONERY OFFICE at the following addresses: ADASTRAL HOUSE, KINGSWAY, LONDON, W.C.2; 120, GEORGE STREET, EDINBURGH; YORK STREET, MANCHESTER; 1, ST. ANDREW'S CRESCENT, CARDIFF; 15, DONEGALL SQUARE WEST, BELFAST; or through any Bookseller.

Tornadoes in England and Germany, June 1931

By W. H. PICK, B.Sc.

BOTH England and Germany have experienced lately on different days examples of that rare phenomenon in our latitudes, a tornado. The English visitation caused devastation in Birmingham on Sunday, June 14th, and the German occurrence similar disturbance in the valley of the Else, in Westphalia, during the evening of June 17th. As the two visitations were similar meteorologically in some respects, as well as in the damage caused, it is thought that a treatment of them together may not lack in interest.

From information derived largely from Mr. A. T. Kelley of the Birmingham Meteorological Observatory and from the columns of the *Birmingham Post* for Monday, June 15th, the sequence of events in Birmingham in the afternoon of the previous day appears to be as set out below, all times mentioned being G.M.T. Moderate rain at about 12h. 30m. had ceased just before 13h. 30m., at which hour, however, there became audible the rumbling of distant thunder. At 14h. rain recommenced and thunder became closer and incessant. Forty minutes later the storm broke suddenly with torrential rain resembling that of a cloud-burst and accompanied by almost continuous thunder, lightning and hail. The tornado made its appearance at approximately the same time in the Sparkhill district of the city and travelled rapidly along a track varying

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from a width of nearly 800 yards to one of 200 yards, passing through Greet, Small Heath and Bordesley in a north-easterly direction to the Erdington boundary of the city. Altogether, a scar of some ten to twelve miles in length was left across Birmingham from the south to the north-east, a scar marked by a very great amount of material damage evidenced by broken houses, stripped roofs, windows blown inwards and uprooted trees, and unfortunately by the loss of one life. The storm ceased at about 15h. 15m., giving way to lulling winds and a burst of temporary sunshine. No precise measurements of wind force or other elements are available in the actual tornado during its passage, but it is worthy of mention that at the Birmingham Meteorological Observatory 0.8in. of rain fell in the 40 minutes from 14h. 35m. to 15h. 15m. It is also noteworthy that at Ross-on-Wye just previously between 13h. 48m. and 14h. no less than 0.5in. of rain had fallen, though violent tornado phenomena were not experienced there. The speed of advance of the tornado through Birmingham appeared to be of the order of 30 m.p.h., a figure of the same magnitude as in American tornadoes. Reports were received indicating that the duration of the tornado at any one spot was of the order of two minutes, and that the whirls in the tornado were clockwise in direction.

The synoptic chart for 13h., shown in Fig. 1, reveals the pressure distribution prevailing. A complex series of depressions covered the British Isles, with a well-marked "occlusion" running across the country from northern Ireland to south-east England. This "occlusion" moved rapidly north-eastward, and at 18h. stretched from the Hebrides to the Wash, and it was on it during its passage across Birmingham that the tornado occurred.

It is interesting to record that various other reports have come to hand indicating other exceptional weather happenings along the line of this occlusion. Of these one of the most noteworthy is that of 1.9in. of rain at Walsall measured at the Corporation rain gauge at the Sewage Disposal Works between 14h. G.M.T. and 14h. 45m. G.M.T. Another most interesting report comes from Bembridge, where, to quote the *Isle of Wight County Press*, "the tide rose and fell a distance of four feet, three times, accompanied by whirlwinds."

The German visitation of June 17th was similar in that it, too, was associated with the passing of a well-marked "occlusion." The details of this tornado, about to be given, are derived mainly from *The Times* of June 19th. After a thundery day, there came a sudden and striking darkening of the sky at about 6 o'clock in the evening, local time, and, on the horizon, appeared a funnel-shaped, grey-black cloud which advanced rapidly, accompanied by a noise "like the howl of dozens of sirens." The height of the cloud is given as about 300 feet until it dipped on the town of Plettenberg, which lay wrapped in the abnormal darkness already mentioned. Concurrent with the dipping of the cloud there came the uprooting of trees, and "heavy beams, scaffolding, roofs and fences flew through the air, some of them for a distance of several hundred feet." The

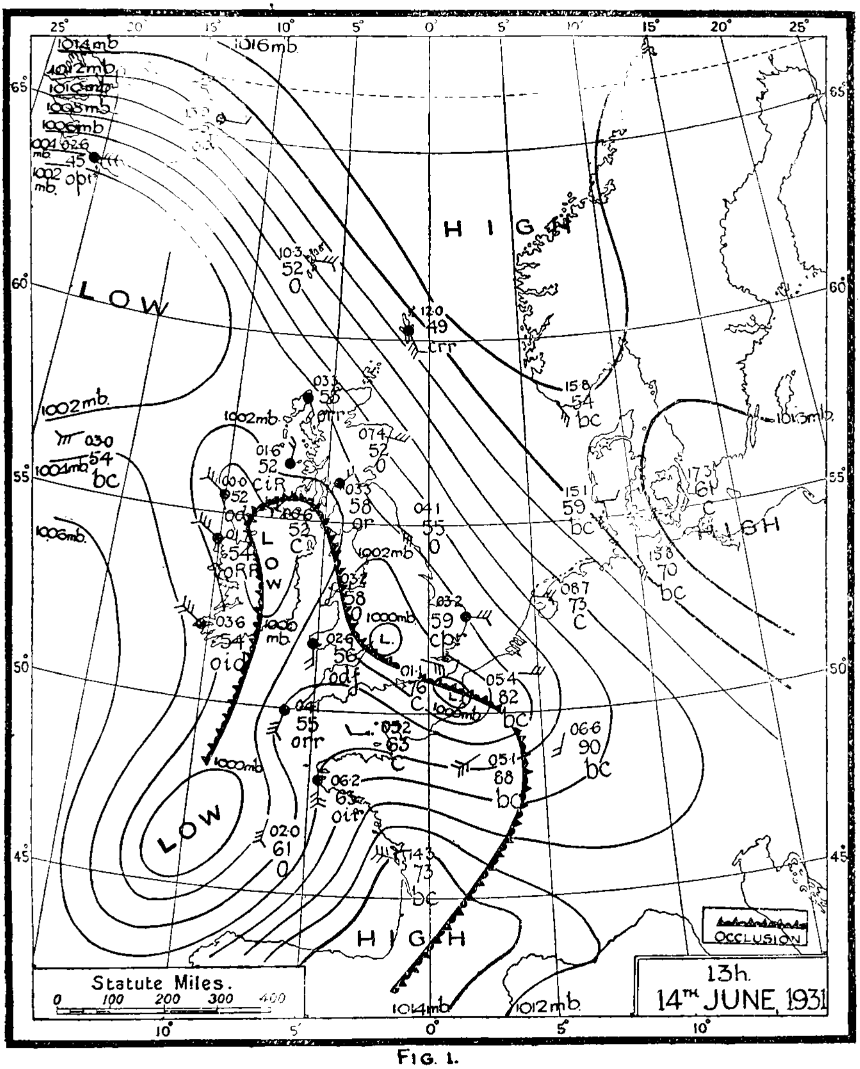


FIG. 1.

turmoil lasted only for a very short time. however, and very soon the whirlwind ceased and the darkness lifted, to be succeeded by torrential rain which added floods to the prevailing distress. Once again, as at Birmingham, loss of life has to be recorded, three persons being killed, two through walls collapsing and one by reason of a hurtling beam. In addition to Plettenberg, Holthausen and Herscheid (also in the valley of the Else) suffered very seriously.

The pressure distribution just preceding this calamity is shown in Fig. 2, which portrays the synoptic chart for 13h. G.M.T. on June 17th. Here again, as in the Birmingham disaster, the essential feature is the passage (in this case eastward) of a well-marked " occlusion." As a contributory cause the exceedingly high temperatures over Germany during the afternoon as shown on the chart reproduced doubtless played their part in adding to the intensity of the phenomena along the " occlusion."

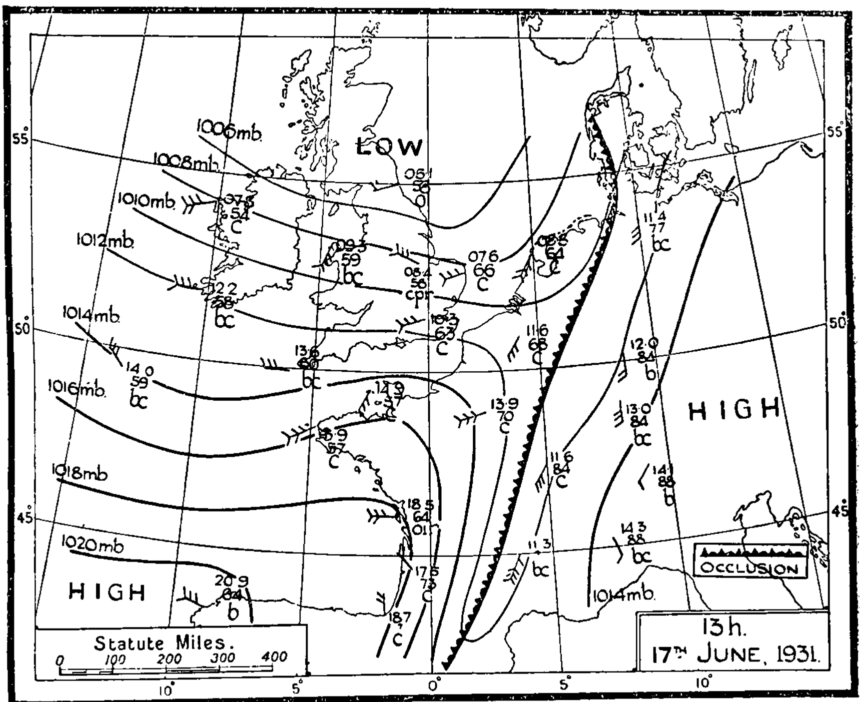


FIG 2.

It is almost inevitable that the Birmingham tornado should lead to comparison with what may be termed the " classical " tornado of the British Isles—that in south Wales and the west of England on Monday, October 27th, 1913, discussed by the late Mr. H. Billett in " Geophysical Memoirs, No. 11." The violence in that tornado was certainly at least equal to that experienced at Birmingham, while the number of deaths was greater, being five. The noise preceding the tornado was equally marked. The thunder, however, appeared to be less intense in the 1913 example as compared with the 1931 case, but the lightning was more marked, it being stated that " the blue lightning was appalling." The rate of advance of the 1913 tornado was 35 m.p.h., a figure comparable with the 1931 one. It is moreover interesting to record that analysis of the charts for the 1913 tornado in the light of the modern Norwegian views seems to show that, as in the recent visitation at Birmingham, the tornado occurred along a well-defined "occlusion" which, in this case, moved quickly northward.

WILLIAM H. PICK.

Extracts from letters describing the weather of Sunday, June 14th, 1931, in the Birmingham and Hereford areas

Neville Hall, Esq., 88, *Bromyard Road, Hall Green, Birmingham.*

"Here in Bromyard Road . . . . at about 3.50 p.m. (S.T.) the rain increased and at 4 o'clock was coming down in torrents . . . . about 3 minutes later we heard a howl as wind makes, and immediately the air was full of twigs, leaves and small branches. Four little girls coming home from Sunday School were blown flat and shot along the wet pavement like bits of paper. My motor cycle and side-car standing in the gutter was turned upside down . . . and a 2-seater coupé . . . was blown backwards . . . . the brakes being on. All our garden fences were flattened."

J. R. Sayers, Esq., 111, *Southam Road, Hall Green.*

"About 4 p.m. . . . . a curious lull in the great black thunderstorm then raging caused me instinctively to run to the window (facing north) and I was just in time to see some 20-ft. high trees shudder and then all bow to the ground, one immediately in front of me . . . . breaking off at the root. Instantly the air appeared full of objects, great and small, flying in a northern direction, broken vegetation, tiles, masonry, &c., my neighbour's garage roof included . . . . my front gate and gate-post was torn away . . . . I estimate that the duration of this great blast of air was 15 to 20 seconds."

Charles Duval, Esq., 67, *Waverly Road, Small Heath.*

"I happened to be looking at the sky at the moment of the tornado's arrival here and saw a small black cloud travelling from the south at a terrific speed. I called my wife to see it, and within a few seconds the wind arrived. Personally I think it had passed us in little over half a minute. The wind stopped my clock at 4.20 p.m., as with the first gust the front door was blown open and it took three of us to close it."

E. Dwyer, Esq., 198, *Monicu Road, Small Heath.*

"the whirlwind made its approach . . . . It was similar to the noise of about six aeroplanes in the air together and was like a great black cloud . . . . It did not appear to be travelling at a great rate but had a rolling and twisting appearance."

F. J. Parsons, Esq., The Observatory, Ross-on-Wye.

"The rainfall was terrific (at Ross) . . . . As near as I can calculate from the trace . . . . nearly 13mm. . . . . fell in about 0·2 hours, 13h. 48m. to 14h. 0m. G.M.T.

At Huntley—mid-way between Gloucester and Ross-on-Wye—huge hailstones fell and shattered the windows of a motor-bus."

Robert Gray, Esq., Oaklands, Dorstone, Herefordshire.

" The thunderstorm 12.45 to 4 p.m. S.T. was a very heavy one here . . . . The rainfall during the periods amounted to 0·87 inches; most of this fell between 1.15 and 1.45 (S.T.) and 3.15 to 3.45 (S.T.)."

J. Taylor, Esq., The Council House, Walsall.

" The storm . . . . struck Walsall between 3 p.m. and 4.30 p.m. (S.T.), the storm being at its maximum at approximately 3.45 p.m. (S.T.). During this time 1·9 inches of rain was recorded at the Corporation rain-gauge at the Sewage Disposal Works. A fair amount of damage was done to roads and footpaths by the scour of the water, but no damage of an exceptional nature was done. . . . In Walsall the rain was very intense, but the wind was not exceptionally high and did no damage that I know of."

F. Smith, Esq., 299, Reddings Lane, Sparkhill, Birmingham.

" The tornado appeared from a dense mass of grey clouds . . . . suddenly it appeared to congregate into one huge cloud, all outlying clouds rushing to one spot. This mass of cloud suddenly began to rush across the sky and formulated a funnel which hung suspended from the mass and reached the housetops. At the same time all sorts of missiles flew upwards towards it. It rushed across faster than I have ever seen clouds move before."

The Detailed Study of Geological Climates

For more than thirty years, Dr. F. Kerner-Marilaun has been a student of geological climates, and has published the results of his researches in a long series of important papers. He has now presented us with a considered survey of the subject, including much new matter, in a single volume.* Dr. Kerner-Marilaun is especially qualified for such a study, for though professionally a geologist (he is head of the Austrian geological service) and a palæobotanist, he is also a competent meteorologist with a unique knowledge of the geographical basis of climatology. He is well known as the greatest living exponent of the effect of the distribution of land and sea on climate, and his book naturally has a strong geographical bias, though other aspects are not neglected.

*Paläoklimatologie. By Dr. Fritz Kerner-Marilaun. pp. VIII + 512, *Illus.* Berlin. Gebrüder Borntraeger, 1930.

The basis of palæoclimatology is the collection of evidence as to past climates—a somewhat obvious truism which, however, many theorists have been in danger of forgetting. Hence the first part of the book is concerned with the geological material, consisting mainly of fossil plants and to a less extent animals, fossil soils and terrestrial deposits. The method is simple; such remains must be regarded as analogous to those forming at present, and the climatic conditions of the latter must be determined as closely as possible. The difficulties multiply, however, when this principle comes to be applied in practice. The identification of fragmentary remains of plants is often doubtful; the fossil species differ from the existing ones and may have required different climatic conditions for their development. Insufficient information is available on many subjects, for example, given a sufficiently high temperature, how would different plants withstand the long polar night? The inorganic deposits are in some ways more hopeful, for we may assume that the physical conditions required for the formation of some particular type do not change, but here we are faced by the difficulty that the character of the older deposits may have been obscured during subsequent geological periods. Thus, many of the identifications of glacial tillite from early geological periods are very doubtful. Some of the conclusions rest on negative evidence, for example, red deep-sea clays are rare in the older deposits, and this is regarded as evidence that the temperature of the bottom of the ocean was higher than at present. The study of soils is especially difficult; the climatic conditions necessary for particular types can only be expressed in complicated formulæ, which are of little help to the palæoclimatologist.

In spite of these difficulties, it is easy enough to obtain a superficial measure of success, to fill in the blank spaces of the ancient continents with primeval forests, grasslands, deserts and ice-sheets. But this is not enough; for a scientific study we require to know as nearly as possible the actual distribution of temperature and precipitation in winter and summer. And here we meet two further difficulties; first that our isolated finds may not be typical, or may reflect the climatic conditions of an earlier time, as do relict floras, and secondly, that they may be only approximately of the same age. The latter is an especial difficulty in dealing with fossils, for under the influence of a rapid climatic change a species or assemblage of species may migrate through many degrees of latitude, and as the fossils are often our only means of age determination, the impression may be given of a widespread flora and a uniform climate. By this time the reader is thoroughly despondent, feeling that all research into past climates is vanity. The author has perhaps overstated the case, for the following chapters contain many neat examples of a sufficiently precise determination of climatic conditions, especially in the later geological periods. As an example we may quote Heer's summary of the climatic conditions of central Europe during the upper Miocene. In March there were frequent storms and thunder rains, for the deposits contain associated flowers and leaves of trees on which these organs unfold in early spring, accompanied by broken off twigs. The frequent occurrence of fruits of willow, poplar and elm, which ripen in May, suggests windy weather in this month. Fine calm weather in summer is inferred from the finding of whole swarms of flying ants and gnats, which danced on the shore of the lake on mild summer evenings, until a land breeze carried them over the water where they perished. The autumn and winter also were calm, for the spherical fruits of the plane and amber-tree are found with the leaves and flowers, showing that they must have remained on the trees throughout these seasons.

The author next approaches the subject from a different angle, namely, the evaluation of the geographical and other factors which modify the local or general climate, and this part of the book will be of great interest to meteorologists. The discussion is remarkably thorough; beginning with the influence of height above sea level, he discusses the factors of land and sea distribution, now and formerly, the factor of latitude and the "solar climate," the effect of variations in the eccentricity of the orbit and other astronomical conditions, the possible effect of variations of solar radiation and the part played by the varying transmission of the sun's rays through the atmosphere, as modified by volcanic dust. The effect of high ground is especially important, and here we are seriously handicapped by the lack of information as to the height of the mountain ranges in the earlier geological periods. The Pleistocene topography can be inferred from the present, while it is believed that during the Mesozoic and early Tertiary there were no high mountains.

The study of palæogeography, or the reconstruction of the distribution of land and sea during former geological periods. has now become a highly specialised branch of geology, with an elaborate technique, and numerous charts representing all periods from the Cambrian onwards are available for study. For the earlier periods the results are necessarily rather speculative, in fact many of the charts express rather a chain of ideas than the results of observation, but nearer the present the broad outlines at least are known, and in places the details have been filled in. Especially important is the diagnosis of ocean currents, which are described as the real heat carriers, far outweighing currents of air. Generally speaking, the author estimates that the distribution of climate (including rainfall as well as temperature) is controlled as much by land and sea distribution as by latitude, for even the isotherms are at present so eccentric that thermal arguments for movements of the pole have little weight, while the isohyets show scarcely any relation to latitude, and there is no reason to suppose that the present is abnormal in either of these respects.

Since merely qualitative statements are of little use, however, a large part of the book is occupied in the development of definite quantitative methods of calculating this geographical effect. Briefly, it is divided into two parts, the "eurymorphogenous" or distant, and the "stenomorphogenous," or local. The "distant" effect envisages the conditions over the whole globe, the presence or absence of polar ice, the existence and direction of ocean currents, the heating or cooling effect of large continents to the south or north. Its calculation cannot be carried out mechanically, but the author is able to lay down some general principles, chief among which is that of "akryogeny" or the absence of ice. According to this theory, the low Arctic temperatures which exist at present are in a very large measure due to the existence of a large sheet of floating ice, and if in any way this ice could be swept away, the akryogenous winter temperature would be only about 3°C. below the freezing point of sea water. This, of course, would cause the ice to form again, so that the akryogenous temperature is merely an abstraction, but if owing to a more favourable land and sea distribution, such as would be brought about by the opening of a second broad channel between the equatorial and arctic oceans, a greater supply of heat than at present were carried to the Arctic ocean, the akryogenous temperature would rise above the freezing point. and the ocean would remain open throughout the year. Now the reconstructions do show such favourable conditions during many geological periods, especially the Jurassic and Eocene, and these are precisely the periods in which rich floras extended to high northern latitudes, and in which there is no trace of Arctic ice. The conclusion, which represents the combined work of Kerner-Marilaun and myself, appears inescapable, namely, that these periods, to which geologists have given the name "pliothermal," were really non-glacial.

Such a revolutionary change as the abolition of the Arctic ice, however, must have world-wide effects, and accordingly Kerner-Marilaun calculates the hypothetical non-glacial temperatures of a water hemisphere in all latitudes, figures which he requires as a basis for his studies of the "distant" effect of the land and sea distribution. Actually he obtains for the pole under average astronomical conditions a January temperature of −5°C., which is only 3°C. below the freezing point of sea water. Since almost the only geographical situation for a polar ocean which is definitely less favourable than a continuous water surface over a whole hemisphere is for it to occupy a basin entirely shut in by land, the predominance of mild polar climates in geological time is to be expected. The zonal temperatures on a water hemisphere give a measure of the heating or cooling effect produced by ocean currents which traverse the parallels of latitude. Thus it is calculated that the passage of a current from the Indian Ocean through the Mediterranean would raise the winter temperature of southern Europe by 5.5°C.

The "local" land and sea effect at any point is calculated from the percentage of land within a certain distance of the point, generally within circles of 5, 10 and 20 degrees radius. The formulæ are based on a long series of calculations employing data for Europe and the Mediterranean, and are therefore not of universal application, but as they are employed mainly for studies of conditions during the Tertiary in Europe, this is not a disadvantage. For more extended studies, however, formulæ would be required built on a broader basis.

The calculation of the distribution of rainfall from the land and sea distribution is even more difficult than that of temperature, but the author gives us the results of some experiments in this direction in which he calculates for the Mediterranean district the percentages of the year's rainfall occurring in the winter and summer quarters. It is interesting to note that while the winter percentage at any point can be calculated directly from the percentage of sea within 10 and 20 degree circles round the point, the summer percentage can only be derived indirectly through a calculation of the pressure distribution.

The effect of the astronomical co-ordinates (eccentricity, &c.) cannot be incorporated directly into the calculations, because of the impossibility of knowing in which part of the cycle any pre-glacial deposit was formed, but the limiting values of the astronomical effects calculated by Spitaler are employed to provide limits of the possible departure from the temperatures calculated from the land and sea distribution only. Possible variations of solar radiation are necessarily left out of account entirely in the first approximation, but a correction is made for the interception of the sun's rays by volcanic dust. When all this has been done, we have an estimation of what the climate ought to have been, which we can compare with the climate deduced from the fossils and nature of the rocks. We have, in fact, the two sides of an equation; if they agree, we may assume that our calculations are approximately correct, if they differ, either there is some mistake in our calculations or inferences, or there is some additional term which we have not taken into account.

As his first example Kerner-Marilaun gives a calculation of the January and July temperatures at Messel near Darmstadt in Germany during the Eocene. We may copy his tables, which are of exceptional interest :—

	January.	*July.*
Present temperature	0·5°C.	20·0°C.
Corrections for :—		
Decrease in surrounding land	+1·5	−1·0
Increased warmth of Gulf Drift ... ... (Akryogenous effect)	+4·0	−4·0
Drift from Indian Ocean	+5·5	—
Sea covering of Asia Minor	—	+0·5
Effect of Obic Sea	+2·0	—
Effect of elevation (200m.)...	−1·5	−1·5
Volcanic dust	−0·5	−0·5
Astronomical effects (Spitaler)	+1·0 to −2·5	+2·0 to +0·5

The net result is that according to the earth's astronomical situation at the time, the temperature lay between 13·5 and 10°C. in January and between 23·5 and 21°C. in July. From the plant remains and the nature of the deposit the temperature is calculated as 13·5°C. in January and 20°C. in July. The two sides of the equations agree within the limits of probable error, and it is not necessary to bring in unknown influences such as a change of latitude or of solar radiation.

Not all the examples given agree so well, and it is not yet possible to say whether the discrepancies are due to errors in the interpretation of the geological data, to errors in the calculated temperatures, or to some additional, unknown factor such as a change of solar radiation. Only by the comparison of a number of determinations from widely different latitudes can this uncertainty be determined, and these are not yet available. Nevertheless, the author foreshadows the time when, from a large number of such calculations in different geological periods, it may be possible to construct a history of solar radiation, and of its distribution over the earth's surface.

The great stumbling block of most theories of past climates is the late Palæozoic glaciation of the tropical continent of Gondwanaland. Kerner-Marilaun, basing his calculations on a reconstruction by Frech, cools the plateau by a cold current from the north, which gives a July temperature of less than 15°C. at sea level in latitude 25°N. This seems too high for extensive glaciation, though he points out that glaciers in New Zealand and Alaska extend into nearly the same summer temperature. Here questions of contemporaneity between the fossiliferous deposits of Eurasia and the tropical boulder clays are important, and until these have been settled, further progress will be difficult. In this connexion he makes the interesting remark that the *Glossopteris* flora which developed during the glaciation of the southern hemisphere is too rich to represent an impoverished glacial assemblage, but gives rather the impression of the evergreen flora of middle southern latitudes.

It is to be hoped that the book, difficult though it is, will be widely read by meteorologists, who may thus realise that the problems of palæoclimatology are as much meteorological as geological, and offer them many opportunities for research. The present is the key to the past, but we may venture to hope that in return the past will supply the key to some of the still unsolved riddles of the present.

C. E. P. BROOKS.

Royal Meteorological Society

The monthly meeting of this Society was held on Wednesday, June 17th, in the Society's Rooms at 49, Cromwell Road, South Kensington, Mr. R. G. K. Lempfert, M.A., F.Inst.P., President, in the Chair.

The following Memoirs were discussed :—

No. 26. S. Chapman, F.R.S.—A theory of upper-atmospheric ozone.

The main part of the paper consists of a discussion of the daily and annual variations of the ozone content of the atmosphere in any latitude up to about 50°. The ozone is treated as if it were uniformly spread through a layer of air 10Km. thick, having the same density as the air at the level of maximum ozone density. Convection and diffusion of ozone are neglected. The thermal decomposition of ozone ($2O_3 = 3O_2$) is discussed, and estimated to be negligible, except possibly in connexion with an eleven-year (sunspot) variation of ozone.

No. 29. C. K. M. Douglas, B.A.—On the relation between temperature and pressure in the troposphere.

It is shown that the high correlation co-efficients between pressure and temperature high up in the troposphere are closely related to the constancy of the lapse-rate of temperature. The correlation between the mean temperature of the column up to 9Km. and the temperatures at 3 and 6Km. are very high. Some factors tending to produce a constant lapse-rate are discussed. It is previously shown that the observed pressure-temperature correlations do not necessarily imply a "solid current" or "barotropic" motion, but are consistent with very large changes of wind direction with height, provided that these are spread through most of the troposphere and not concentrated at a surface of discontinuity.

Groups of extreme cases show that when the barometer at sea level is very low or very high the troposphere contributes about half the deviation from the mean. Both cyclones and anticyclones can be grouped into systems largely confined to the troposphere, and systems extending to the stratosphere. The argument in favour of an advectional theory is developed.

Correspondence

To the Editor, *The Meteorological Magazine.*

Thunderstorms on June 14th, 1931

On Sunday, June 14th, the day when the tornado swept across the Midlands,* thunderstorms and squalls were experienced generally over the rest of the British Isles.

Mr. B. P. Granger of Cloud House, Attenborough, Notts, writes that "On Sunday, June 14th, 1931, a series of thunderstorms passed over this station in rapid succession during the afternoon. Thunder was heard almost continuously from about 13h.-17h., while the lightning was frequent, one flash striking a tree about two hundred yards to the south of the station.

About 15h. large hailstones began to fall, being of a size almost unknown in this district. The average size measured an inch in diameter, while several measured one and a half, and one that I picked up measured fully two inches in diameter and weighed nearly an ounce. In shape, to give a fairly practical comparison, it resembled a piece of sugar-candy, and as an illustrative comparison it resembled a picture of a hailstone shown in figure 54, page 131, in Loomis's Treatise, but naturally on a small scale. Another piece of hail resembled a pear in shape, was flat, and had a round hole in the ice about in the middle. There were several others that were merely slabs of ice.

As it was nearly calm at the time little damage was done, a few glasshouses having some glass broken.

Before the hail began a roar was most distinctly heard in the air overhead, like the sound of water passing over a weir. I noticed this roar on the night of February 11th, 1931, before hail which fell during a line-squall. The squall had been in progress for about ten minutes, accompanied by thunder and lightning, when this roar became very audible, then down came the hail, and in about five minutes the ground was covered to a depth of nearly two inches."

Mr. R. T. Andrews, of Larkhill, Salisbury Plain, writes that thunder was heard at intervals throughout the day and two thunderstorms passed almost directly overhead, the second thunderstorm being "accompanied by torrential rain, at 12h. 30m. hail fell for a short time, the hailstones being about $1\frac{1}{4}$ inches in circumference." Between 13h. 15m. and 13h. 25m. a squall passed overhead during the passage of which the temperature fell 6° F. "While the thunderstorms were in progress each flash of lightning was followed by a tinkle of the telephone bell in the office."

Mr. A. E. Moon, of 39, Clive Avenue, Hastings, writes that though there was a sharp thunder shower between 10h. 10m. and

* See page 125.

10h. 30m., the morning and early afternoon were mainly sunny and warm. At 14h. it was still bright and the temperature had risen to 76·4°F., but " between 14h. 30m. and 14h. 45m. the wind rose very suddenly in a squall approaching gale force. It remained very strong for some time after the squall and then slowly moderated. . . . Temperature had by 15h. fallen to 60·0°F. and a few minutes later to 59·0°F., but about 16h. the sky cleared and the temperature rose slightly."

Mr. H. L. Wright, of Eskdalemuir Observatory, writes that " In the evening of Sunday, June 14th, 1931, rainfall of an intensity unparalleled within living memory occurred in the valley of the Esk and its neighbourhood. At the Observatory it was a warm, humid day with light breezes from between SSE. and NE. The sky was almost completely covered with stratus clouds, but a background of alto-stratus could be seen through rifts in the stratus. The relative humidity rose from 66 per cent. at 9h. to 96 per cent. at 11h., and remained above 95 per cent. from 13h. to 19h.

About 18h. there was a succession of bright flashes of lightning followed, betweeen five and ten seconds later, by loud peals of thunder. An intense gloom occurred and indoors it became so dark that it was impossible to read with ease. The rate of rainfall increased suddenly to an average of nearly 40mm./hr., and this persisted for about 20 minutes. At 18h. 30m. a line squall occurred, the wind veering from E. to W. and increasing in strength from force 2 to force 5 in a gust. This was the occasion of a further heavy burst of rain and an instantaneous rate of 115mm./hr. was recorded by the Jardi rate-of-rainfall recorder. The rain showed no signs of abating until 19h., and by this time 31mm. had fallen in the hour.

At about 18h. 20m. the Davington Burn, a small hill stream, began to overflow its banks in the village of Davington nearby, and continued to rise until 19h. 30m., eventually flooding cottages in the village. At 18h. 45m. the Esk, which is joined by this burn about 200 yards below Davington, burst its banks and began to flood the fields. Breaches further upstream followed in quick succession until a point was reached where the river bends. The rupture of the banks here led to the formation of a torrent pouring down the valley in a wide stream, carrying hayricks and wooden sheds as far as two or three hundred yards, sweeping livestock before it, and razing stone walls to the ground. Just before it reached Davington, where it was diverted towards the main stream, there was a uniform sheet of water about 400 yards wide. At Eskdalemuir, three miles further downstream, greater havoc was wrought. A farmer who was endeavouring to rescue some cattle became surrounded by the torrent and lost his life. In one place six or seven tall fir trees were seen to be uprooted in quick succession and carried away. Numerous wooden suspension bridges across the river, and even three reinforced concrete bridges, were speedily and completely demolished.

Associated with a flash of lightning and a particularly loud thunderclap which occurred about 18h. 5m. was a set of circumstances related to me independently by three people. In Davington a low rumbling noise was heard, distinct from the thunderclap and described as more similar to the sound associated with an earth tremor; the windows of the Observatory were heard to rattle; and most curious of all was the experience of Mr. L. H. J. Stone, of the Observatory. He was bicycling along the road to the south, about four miles from the Observatory, when a blinding flash of lightning occurred and immediately afterwards he was thrown off his bicycle, but suffered no serious injury. It seems probable that these three events were synchronous and are possibly due to an air wave set up by the thunderclap. Mr. Stone estimated the height of the cloud at 100 feet. At the Observatory the cloud height at the time was 300 feet.

A disturbance on the micro-barogram is shown at this time, but the amplitude is not much greater than that of similar disturbances earlier in the day, and is much smaller than that which occurred at the time of the line squall. Presumably, however, a great deal of the energy of the wave would have been spent by the time its front reached the Observatory."

Limits of Visibility

I remember seeing, some 25 years ago, from the slopes of Kirikee Hill, Co. Wicklow, Holyhead Island with the South Stack light, Braich-y-pwll and Snowdon behind them, all roughly due east, Snowdon 90 miles, the others some 25 miles less. These are probably visible from any eastern slopes of the Wicklows on a clear day.

Will any Richmond (Surrey) reader tell us whether Hindhead is often visible now from the Terrace? (30 miles, 218° or S. 38° W.). I saw it many times many years ago, but have failed to do so lately even on days when Nettlebed Hill, Oxfordshire (33 miles, 285° or N. 75° W.) is quite plain. Is it because I cannot get to Richmond now in the morning hours (the afternoon sun being almost in the same direction) or is increasing atmospheric pollution the cause? The square tower of Hampton Church (4 miles, 225° or SW.) acts as a guide and the neighbouring chimney of the Metropolitan Water Board at Hampton, no longer burning smokeless coal, affords another guide and a possible explanation of the disappearance of Hindhead.

The tower on Leith Hill (but no more of the hill) used to be visible from the path through Hampton Churchyard, and I have often seen the beacon fire there on occasions of national rejoicings, &c. It is due south, 17 miles, and would be visible now but for the growth of the trees on a river island.

J. C. RIDGWAY.

31, *Belgrade Road, Hampton, Middlesex. May 23rd,* 1931.

Northerly Winds at Lerwick

During the course of another investigation it was found necessary to obtain a ten-year mean of the frequency of winds from a northerly direction at Lerwick in the Shetland Isles. The observations used were chosen from 7h. data and were extracted from the annual summaries of the *Monthly Weather Report* for the years 1917-23 and 1928-30. The method adopted was to report as a northerly wind all winds from north-westerly. northerly and north-easterly directions. These were added together to give (T) the total number of northerly winds for each month of the year and so on for each of the ten years investigated (see table). The average frequency for any month in the year was also obtained.

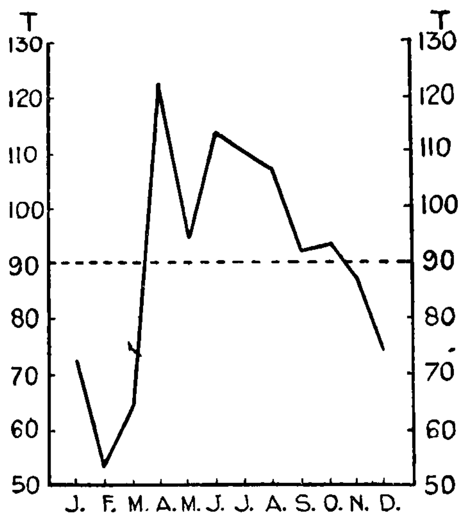


TABLE.

Month.			(T.)
January	...	...	73
February	...	...	53
March	...	...	64
April	...	...	122
May	...	...	94
June	...	...	113
July	...	...	111
August	...	...	107
September	...	...	92
October	...	...	93
November	...	...	87
December	...	...	74
Mean	...	...	90

The results plotted in diagram form show that, during the months of April-October inclusive, winds from a northerly direction were in excess of the ten-year mean whilst during the remaining months of the year the frequency was markedly below the average value. Assuming that this is a true representation of affairs, the obvious explanation seems to be that there is a greater tendency for high pressure to form westwards of the British Isles during the summer months than in the winter half of the year. Furthermore the table shows that the month of April has a greater frequency of northerly winds than any other month. If this fact has real significance, the result may be the consequence of some special feature of the pressure distribution in our neighbourhood just when the first tendency occurs for the more frequent formation of the western high-pressure area.

That there is any relation between the above and the spells of cool easterly weather which we experience annually every spring is open to doubt. The results are none the less interesting since they present evidence of a definite activity of the atmospheric circulation from the poles at a time when we are led to look for a polar source of the supply of air to our neighbourhood.

JOHN HARROWER.

95, *St. John's Road, Corstorphine, Edinburgh. May 11th*, 1931.

Some relationships between the weather of July and of August in London over a long period

In an interesting note in the *Monthly Weather Review* for August, 1930, p. 332, it is stated that "there seems to be a well-marked tendency for abnormal Iowa (U.S.A.) weather in July to perpetuate itself through August."

This statement prompted the thought that there may a similar perpetuation of July weather in London, and this present note, using data for Kew, examines the matter for the three elements of rainfall, sunshine and mean maximum temperature.

The table below gives the number of cases when the rainfall, sunshine and mean maximum temperature of August were similar and dissimilar to that of the preceding July:—

Table I. No. of Cases.

July below normal	Following August below normal	Following August above normal	July above normal	Following August below normal	Following August above normal
Rainfall, 1866-1930.					
36	24	12	29	12	17
Sunshine, 1881-1930.					
29	18	11	21	9	12
Mean Monthly Maximum Temperature, 1871-1930					
32	21	11	28	11	17

The normals employed for each of the three elements considered were those for the period 1881-1915, published by the Meteorological Office in "The Book of Normals."

It remains to state that in the case of each of the three elements, rainfall, sunshine and mean maximum temperature. there is a distinct tendency—though only a tendency—for August to repeat the conditions of the immediately preceding July. This is an interesting result and one that is confirmatory in some degree of the results obtained for Iowa (U.S.A.) mentioned in the opening paragraph.

WILLIAM H. PICK.

April 13th, 1931.

[An alternative way of treating this problem is to consider the frequency with which the general pressure distribution over north-west Europe is the same in July and August. For this we may use the ten major types described by Brooks and Quennell.* During the 58 years from 1873 to 1930 the type in August was the same as that in July on 12 occasions, while if the succession of types is governed purely by chance the frequency would be between 7 and 8. Taking only the larger groups, I, characterised by high pressure near the Faroes, and II, characterised by low pressure in the same region, we find that the same group occurred in both months on 34 occasions, opposite groups on 24.

The most frequent cause of the persistence of similar weather conditions in summer appears to be the establishment of a type marked by pressure below normal near or over the British Isles, with pressure above normal directly to the south-east.†—Ed., *M.M.*]

Old Sussex Weather

Reading in "Old Sussex Diarists," by A. J. Rees (Bodley Head, 1929), I came across some interesting entries of a meteorological character, notably in extracts from the diary of Richard Stapley, Esq., Hickstead Place, Twineham, Sussex, who wrote 1682-1724:—

"1696/7. In June and July there was such abundance of rain that ye rivers and low meads were extraordinary much flouded; abundance of grasse drove in ye rivers, insomuch yt people pulled it out and made dung therewith."

"1698/9. Mem. Tuesday May 3rd in ye evening fell a great snow wch was not gone in many places all ye next day: & there was a very great frost for several nights. The snow lay on ye hills on Thursday morning in several places.

Mddm, in April the same year on Crawley ffair day, there was a very great hail shower whose stones were judged to be two inches about.

In many places ye snow lay above a fortnight, as an ye hills and in drifts and in liew places."

This entry is particularly interesting in the view of the lateness of the date, which it must be remembered is, of course, Old Style.

1703/4. July 29th. "a very great floud" and "August

London, Meteorological Office, Geophysical Memoirs, No. 31.

†*London, Meteorological Magazine*, 63, 1928, p. 291.

1st on Sunday morning a terrible tempest and rain wch was a bigger water in ye south river than ye former wch did abundance of damage and harm.''

CICELY M. BOTLEY.

Guildables, 17 *Holmesdale Gardens, Hastings. March* 19*th*, 1931.

NOTES AND QUERIES

Unusual Gustiness at Cardington on the night of February 25th-26th, 1930

In an article by Mr. C. S. Durst under the above heading, in the *Meteorological Magazine* of August, 1930, the author points out that anemobiagraph traces show a large gustiness coincident with a temperature inversion. The inversion is shown on the temperature gradient recorder at Cardington as persisting throughout the day up to a height of at least 150 feet. The synoptic charts and upper air observations at Duxford suggest that Leafield and Cardington were in the same air stream, and hence should be under the influence of similar conditions. At Leafield (12 miles west of Oxford) the temperature gradient recorder showed, in the early afternoon, a lapse indicated by a temperature difference of 1°F. in the first 40 feet; followed by a small lapse of about 0.5°F. in the next 60 feet interval; and surmounted by approximately the adiabatic lapse rate up to 285 feet. The lapse reached its maximum value as given above between the hours of 12h. and 14h. G.M.T. on the 25th. The inversion set in at 15h. G.M.T. in the lowest layers, and by 22h .G.M.T. had reached its maximum, giving 2°F. difference in the first 40 feet interval, 0.5°F. in the next 60 feet, and practically zero gradient from 100 feet up to 285 feet.

The anemometer traces for 50 feet and 310 feet, and the Baxendell trace for 50 feet showed a maximum gustiness in the early afternoon, and a minimum gustiness between 22h. and 23h. G.M.T., the latter corresponding to the maximum recorded inversion. Similar conditions were recorded at Porton up to a height of 60 feet. Thus at Porton and Leafield the gustiness during the whole period followed the usual laws, large gustiness being connected with large lapse rates, and small gustiness with inversions.

The most surprising part of Mr. Durst's paper is the persistence of the inversion during the day. Measurements of the vertical temperature gradient in the surface layers of the atmosphere have been recorded at Porton since 1922 and at Leafield since 1925, and there has been no record of an inversion persisting throughout the day. Temporary inversions lasting from 15 to 20 minutes do occur during the passage of fronts. Mr. Durst explains the persistent inversion by the presence of a warm south-easterly current flowing over previously cooled ground. If such conditions produce an inversion during the day, then an inversion should be recorded every time cyclonic conditions cause the onset of a warm current on a morning following a clear calm night, when outgoing radiation—the most efficient cooling agent—has lowered the ground temperature.

The essential difference between the temperature gradient installation at Cardington and those at Leafield and Porton is in the housing of the resistance elements. At Cardington these are housed in small Stevensen screens, while at Leafield and Porton the elements are housed in carefully designed anti-radiation housings, which are mechanically aspirated, the rate of aspiration being 5·6 m/s. at Leafield and 3 m/s. at Porton. A definite steady aspiration is essential before one can place any reliance on the records obtained from these electrical temperature recorders.

E. LL. DAVIES.
H. GARNETT.

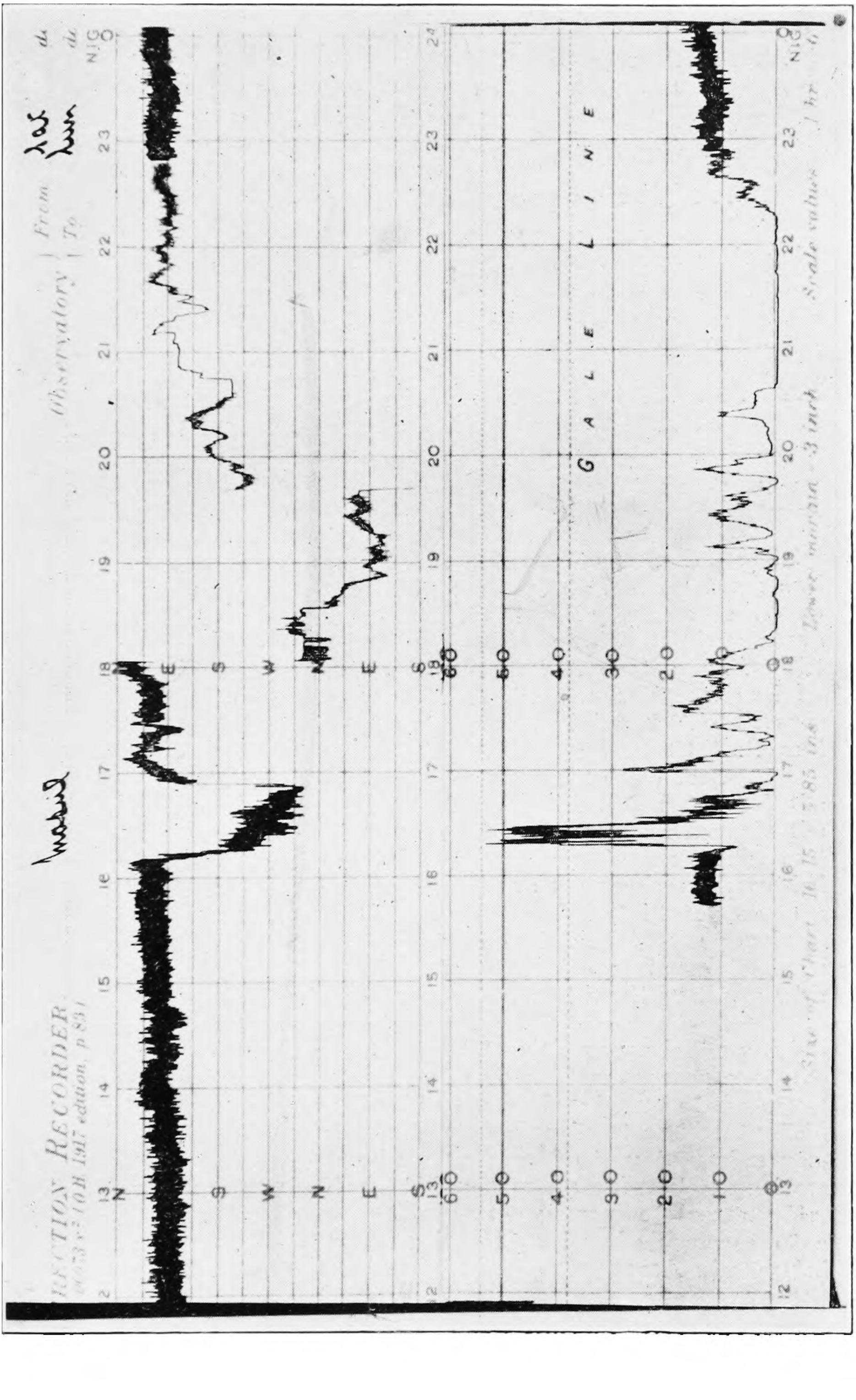
Report on Line Squall observed at Mosul, April 11th, 1931

On April 10th a depression centred over Cyprus was approaching Iraq. Winds became south-easterly to east in the centre and south, causing a dust storm at Diwaniyah during the evening, followed by slight rain. Slight showers occurred in the early morning at Mosul. On the 11th the depression was centred over Syria, with a " V "-shaped secondary over Iraq. Thunderstorms were experienced in the centre and south accompanied by heavy rain and squalls, the wind reaching gale force in the evening. Dust storms preceded the thunder at Hinaidi and Diwaniyah.

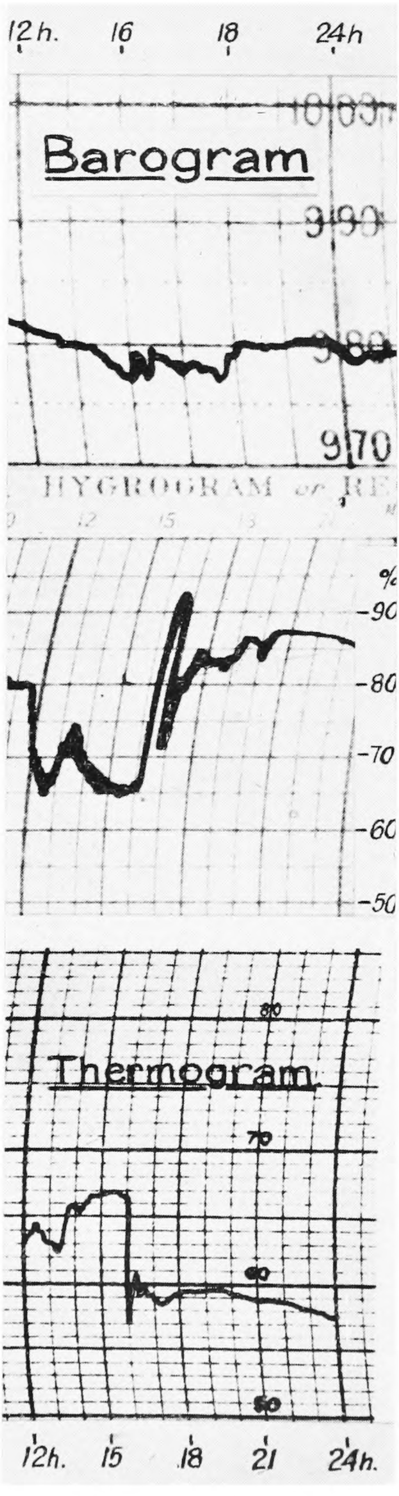
At Mosul on the 11th rain commenced in the early morning and continued throughout the day. At approximately 13h. 20m. G.M.T. a thunderstorm was observed approaching the station from south-east, accompanied by a dense mass of yellowish cloud, which decreased the visibility to about 1,000 yards. As the cloud approached it was noticed that there was very heavy precipitation, and the approach was very rapid.

At this stage the barograph was behaving very erratically and subsequently rose and fell 2mb., immediately rising 2·5mb. and again falling 2·5 mb., all in the space of a few minutes. The temperature (see Thermogram) recorded a fall of 10°F. in two minutes; the wind suddenly veered from ENE. to SSW., with gusts of 40 m.p.h. and 54 m.p.h., and a mean wind velocity of 45 m.p.h. over a period of ten minutes was recorded.

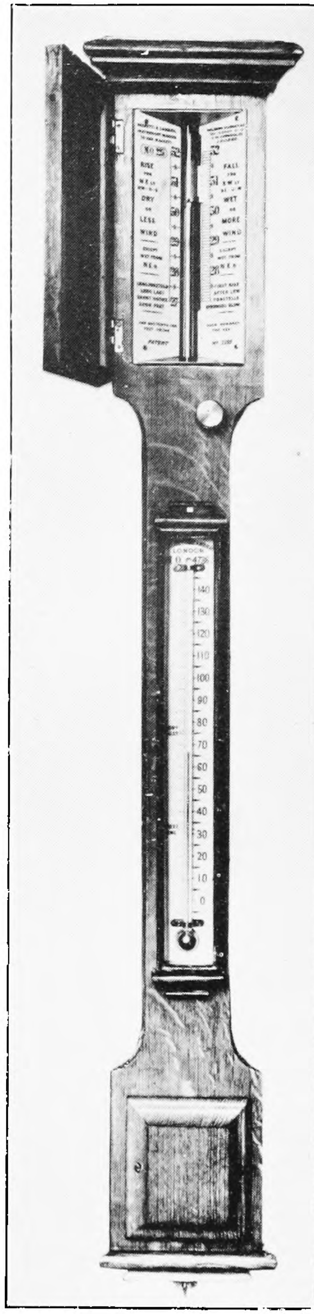
As the squall passed over the station very heavy rain fell (21mm. in 10 minutes) and appeared as a solid sheet of water, and was driven with such force that there is no doubt that a true record was not obtained. This rain was accompanied by



ANEMOGRAM, MOSUL, APRIL 11TH, 1931



AUTOGRAPHIC RECORDS,
MOSUL, APRIL 11TH, 1931



FISHERY BAROMETER

heavy thunder and continuous vivid lightning flashes, the visibility being about 50 yards with partial darkness. Some idea of the intensity of the squall may be gained from the fact that within a few minutes from comparative calm a corrugated iron roof was lifted bodily from the Corporals' Mess and deposited some 30 yards distant. Both short and long wave steel masts of the W/T station were blown completely away.

The squall was observed to travel in a north-easterly direction, eventually disappearing in the hills. This is borne out by the fact that 30 hours of heavy rain was reported at Diana.

Although it was apparent that dangerous phenomena were imminent, no warning could be despatched as the W/T were out of communication for about two hours previously, owing to electrical disturbances, which in itself constituted sufficient warning of the proximity of a storm.

W. Thomas.
L. Rougier.

Fishery Barometers

From time to time fishery barometers become available for disposal by the Meteorological Office. These are mercurial barometers in wooden or steel frames, which have been lent for the use of fishing communities. They are at the present time gradually being replaced by barographs. Arrangements have been made to dispose of these barometers *in situ* at a price of 10s. each as and when they become available.

Those desirous of purchasing should send in their names to the Superintendent of the Instruments Division, Meteorological Office, Exhibition Road, London, S.W.7. As the instruments become available they will be offered in turn to those whose names are received by the Superintendent. The barometers are in different ports and villages, and the purchaser would be required to pay the cost of transport of the barometer and to make his own arrangements for this.

The general type of instrument in a wooden case is illustrated, but the Meteorological Office cannot undertake that an instrument will conform exactly to the illustration nor accept any responsibility for the condition of the instrument. Intending purchasers would, however, be informed whether the barometer offered to them was in a wooden or a steel case.

Reviews

The Literature of Climatology. By Robert De C. Ward. Reprinted from Ann. Ass. Amer. Geog., March, 1931, pp. 34-51.

Prof. R. de C. Ward has performed a useful service to those interested in meteorology by producing this guide to climatological literature. The more important books and papers are discussed under nine heads: tabulated meteorological data, descriptive climatology, general climatology, human, medical and agricultural climatology, changes of climate, atlases and bibliographies.

Aviation Instrument Catalogue. pp. 16, *Illus.* Short and Mason, Ltd., Walthamstow, London. 1930.

A catalogue of instruments for aviation has recently been received from the well-known firm of Messrs. Short and Mason, Ltd., who point out in the preface that they have been manufacturers of aneroid barometers for 70 years, and have been pioneers in the production of height measuring instruments for aircraft. A full range of altimeters and altigraphs suitable for aircraft is described in the catalogue. Particulars are also given of meteorological instruments for installing at air ports, including cup anemometers, wind vanes and airmeters, barographs and thermographs. The barographs include the so-called microbarograph, which gives a very sensitive record of pressure on an open scale and was developed by Short and Mason, Ltd., some years ago. Of particular interest to meteorologists is the inclusion in the catalogue of the Dines balloon meteorograph and Baker release attachment for releasing the meteorograph from the balloon at a predetermined pressure.

The catalogue which is printed in English, French and Spanish, consists of 16 pages, and is in loose-leaf binding so that if additional sections are added at a future time, they can readily be included.

Books Received

Summary of the meteorological observations made at the meteorological stations in the Netherlands West Indies during 1929. Compiled by the Royal Dutch Meteor. Inst., The Hague, 1930.

Report on rainfall registration in Mysore for 1929. By C. Seschachar, Bangalore, 1930.

Thermometric lag. By Negretti and Zambra, London, 1930.

Obituary

Major Thomas Ford Chipp, M.C., D.Sc.—We regret to hear of the unexpected death on June 28th, 1931, of Major Chipp, Assistant Director of the Royal Botanic Gardens, Kew, at the early age of 45. Although his life work was botanical, his experience in several parts of the Empire had convinced him of the importance of climatology in limiting the plant provinces, and he frequently corresponded with the Meteorological Office on the subject. In March, 1930, he carried out botanical explorations in the Sahara and took meteorological instruments with him; his observations were published in the *Meteorological Magazine* for July, 1930. He leaves a wife and young daughter.

We also regret to learn of the death on June 9th, 1931, at the age of 82 of Mr. W. F. Denning, a leading authority on meteors, and discoverer of several comets. In 1898 he was awarded the Royal Astronomical Society's Gold Medal for his meteoric observations and other astronomical work.

News in Brief

Staff News.—Air Ministry Tennis Tournament. Ladies' Singles, winner, Miss Geake; Singles, runner-up, J. Glasspoole.

The retirement is announced on February 20th, 1931, of Mr. Wilson Lloyd Fox from the Honorary Secretaryship of the Observatories Committee of the Royal Cornwall Polytechnic Society after 54 years' service. For many years the Observatory work at Falmouth has been under his charge. He is succeeded by Mr. H. D. Gardner, M.Sc.

The Weather of June, 1931

Pressure was above normal from north-east Canada and Newfoundland across Greenland to Spitsbergen and Iceland, over central and southern Europe and the Mediterranean, and over Mexico, the greatest excesses being 8·8mb. at Julianehaab and 4·6mb. at Cagliari. Pressure was below normal over Alaska, southern Canada, most of the United States and of the North Atlantic, including the Bay of Biscay and over northern and western British Isles, Scandinavia and north Russia, the greatest deficits being 9·1mb. at Kuopio and 4·6mb. at Point Barrow. Temperature was below normal over Scandinavia and the northern British Isles, but above normal in Spitsbergen, central Europe and England. The deficit in Sweden decreased from 7°F. in Norrland to 2°F. in the south-west. Rainfall in Sweden was nearly twice the normal in Norrland, but deficient elsewhere being only 33 per cent of the normal in the district of Uppsala

Cool unsettled weather prevailed generally over the British Isles except in the south, where conditions were mostly warm and often sunny, during the early part of June. Towards the end of the month fine warm weather tended also to spread northwards. Widespread thunderstorms occurred on several days and mist was frequent round the coasts. Rainfall totals were above normal except in the south-east. From the 1st-12th an extensive low pressure area was maintained from the Mid-Atlantic across the British Isles giving cool easterly winds in the northern districts while warmer conditions were enjoyed in the south. Secondary disturbances from the south-west brought rainy periods to most districts with heavy falls in the west and north, notably on the 2nd when 2·20in. fell at Killybegs (Donegal). Widespread thunderstorms occurred on the 5th, following a fine warm day in England and Ireland when 70°F. was exceeded locally and sunshine records reached 12-14 hours. The storms were accompanied by heavy rain in the Midlands and Ireland, 2·10in. fell at Rathnew (Wicklow), 1·66in. at Hatton Grange (Shropshire), and were followed by a marked drop in temperature, places in the north having maxima below 45°F. on the 6th, 43°F. being registered at Eskdalemuir and 44°F. at Edinburgh and Marchmont. Sunshine was variable in amount and location; over 14 hours was registered at Mallarany on the 12th. Severe thunderstorms with heavy rain occurred over most of the country on the 14th, when a deepening depression moved in from the south-west; 2·52in. fell at Eskdalemuir,* 2·20in. at Blackpool. Birmingham experienced a destructive tornado.† In the south-east the day was very warm, maxima reaching 80°F. at Greenwich and 81°F. at Croydon, the highest temperature for the month. From the 15th-19th there was a period of cooler weather as a complex area of low pressure passed across the country, rain fell at times in most places and there were local thunderstorms but bright periods. Subsequently a belt of high pressure extended from the Azores to central Europe, bringing fine warm weather generally until the end of the month. There was a temporary change to cool weather on the 24th and 25th, and occasionally the depressions near Iceland moved far enough south to cause rain in the north and west and on the 24th even in the south-east, but the amounts measured were usually small. The sunniest days in the south were the 26th and 27th, in the north, the 24th and 25th; Deerness had 16·6hrs. and Aberdeen 16·3hrs. on the 25th. Temperature rose above 70°F. at numerous places on the 21st-23rd and 27th-28th. The distribution of bright sunshine for the month was as follows:—

	Total (hrs.)	Diff. from normal (hrs.)		Total (hrs.)	Diff. from normal (hrs.)
Stornoway	..	..	Liverpool	140	—60
Aberdeen	153	— 31	Ross-on-Wye	181	—16
Dublin	133	— 56	Falmouth	197	—24
Birr Castle	132	— 32	Gorleston	204	— 6
Valentia	93	— 95	Kew	174	—25

The special message from Brazil states that rainfall was irregular in the northern and southern regions and scarce in

* See page 137. † See page 125.

the central region, the averages being 0·12in. and 0·20in. above normal and 0·98in. below normal respectively. During the later part of the month five anticyclones passed across the country and a depression was situated over the coast. Rainy cold weather prevailed generally during the month on the south, where frost was affecting the grazings and crops. At Rio de Janeiro pressure was normal, and temperature 0·5°F. above normal.

Miscellaneous notes on weather abroad culled from various sources. A heat wave held Spain in its grip during the week ending the 14th, but showed signs of breaking on the 15th. On the 14th the French pleasure steamer, *Saint Philibert*, foundered off Saint Nazaire during a sudden storm and 342 people were drowned. On the 17th a whirlwind swept up the Valley of the Else in Westphalia.* The high passes on the Great Dolomite Road were free of snow on the 9th and the road over the Great Saint Bernard Pass on the 24th (*The Times*, June 9th-24th).

The Monsoon was steadily advancing up the Malabar coast on the 9th and reached Bombay, where temperatures had previously been 3° to 4°F. above normal, on the 12th; the rain area worked steadily inland after this. Only 2¾in. of rain, however, fell in Bombay, and temperature continued above normal for about 10 days (*The Times*, June 13th-24th).

A tornado struck north Adelaide on the morning of the 11th doing much material damage (*The Times*, June 12th).

The drought in the Prairie Provinces continued until about the 10th, when rain fell generally. Between then and the 27th rain fell at times bringing relief, but the amounts were not sufficient to repair the continuous deterioration through drought, insect plagues, &c., which have been in progress for some time past. The heavy rains varying from 1-3in. which fell on the 29th came too late to help the crops in most districts except the fodder crops, but helped save some of the live stock (*The Times*, June 6th-July 1st). Temperature was above normal over the western part of the United States throughout the month and over the eastern part during the later half of the month. Very high temperatures were registered towards the end of the month, Tuma, Arizona, recorded 112°F., and Huron, south Dakota, 106°F. on the 27th. Many people died from the heat in the south, south-west and middle-west States. Rainfall in the United States was mainly below normal. (*Washington, D.C., U.S. Dept. Agric., Weekly Weather and Crop Bulletin and Daily Weather Map.*)

Rainfall, June, 1931—General Distribution

England and Wales	148	per cent of the average 1881-1915.
Scotland	193	
Ireland	174	
British Isles	165	

* See page 126.

Rainfall: June, 1931: England and Wales

Co.	Station	In.	Per-cent of Av.	Co.	Station	In.	Per-cent. of Av.
Lond .	Camden Square.........	1·41	70	*Leics* .	Belvoir Castle...........	2·28	119
Sur .	Reigate, Alvington.....	1·56	75	*Rut* .	Ridlington...............	2·32	122
Kent .	Tenterden, Ashenden...	·86	45	*Linc* .	Boston, Skirbeck.......	2·48	136
,, .	Folkestone, Boro. San..	·87	...	,, .	Cranwell Aerodrome...	2·85	170
,, .	Margate, Cliftonville...	·48	27	,, .	Skegness, Marine Gdns	1·89	105
,, .	Sevenoaks, Speldhurst	1·48	...	,, .	Louth, Westgate........	2·63	122
Sus .	Patching Farm.........	1·69	84	,, .	Brigg, Wrawby St.....	3·62	...
,, .	Brighton, Old Steyne..	1·34	74	*Notts* .	Worksop, Hodsock.....	3·54	179
,, .	Heathfield, Barklye....	1·94	92	*Derby* .	Derby, L. M. & S. Rly.	3·32	147
Hants .	Ventnor, Roy. Nat. Hos.	1·59	87	,, .	Buxton, Devon Hos....	5·76	179
,, .	Fordingbridge, Oaklnds	2·94	159	*Ches* .	Runcorn, Weston Pt...	5·65	219
,, .	Ovington Rectory.......	1·84	79	,, .	Nantwich, Dorfold Hall	4·74	...
,, .	Sherborne St. John.....	1·58	74	*Lancs* .	Manchester, Whit. Pk.	5·59	211
Berks .	Wellington College.....	1·26	58	,, .	Stonyhurst College.....	6·91	225
,, .	Newbury, Greenham...	1·81	83	,, .	Southport, Hesketh Pk	5·91	272
Herts .	Welwyn Garden City...	1·34	...	,, .	Lancaster, Strathspey	6·75	...
Bucks .	H. Wycombe, Flackwell	1·51	...	*Yorks* .	Wath-upon-Dearne.....	4·73	213
Oxf . .	Oxford, Mag. College..	3·70	174	,, .	Bradford, Lister Pk....	5·16	219
Nor .	Pitsford, Sedgebrook...	1·83	95	,, .	Oughtershaw Hall......	7·36	...
,, .	Oundle....................	1·61	...	,, .	Wetherby, Ribston H.	4·38	209
Beds .	Woburn, Crawley Mill	2·83	144	,, .	Hull, Pearson Park.....	3·45	167
Cam .	Cambridge, Bot. Gdns.	...	...	,, .	Holme-on-Spalding.....	5·23	...
Essex .	Chelmsford, County Lab	1·25	66	,, .	West Witton, Ivy Ho.	4·80	235
,, .	Lexden Hill House....	·95	...	,, .	Felixkirk, Mt. St. John	4·76	217
Suff .	Hawkedon Rectory.....	1·56	75	,, .	Pickering, Hungate....	4·07	192
,, .	Haughley House........	·99	...	,, .	Scarborough.............	3·79	206
Norf .	Norwich, Eaton...... ...	2·19	113	,, .	Middlesbrough..........	3·29	174
,, .	Wells, Holkham Hall	1·33	68	,, .	Baldersdale, Hury Res.	..	...
,, .	Little Dunham..........	1·45	65	*Durh* .	Ushaw College...........	3·95	183
Wilts .	Devizes, Highclere......	2·62	116	*Nor* .	Newcastle, Town Moor	2·84	131
,, .	Bishops Cannings.......	3·07	127	,, .	Bellingham, Highgreen	4·69	203
Dor .	Evershot, Melbury Ho.	3·48	153	,, .	Lilburn Tower Gdns....	4·03	195
,, .	Creech Grange..........	2·69	117	*Cumb* .	Geltsdale.................	5·21	...
,, .	Shaftesbury, Abbey Ho.	4·15	179	,, .	Carlisle, Scaleby Hall	6·12	243
Devon .	Plymouth, The Hoe....	4·05	188	,, .	Borrowdale, Seathwaite	11·75	180
,, .	Polapit Tamar...........	3·59	167	,, .	Borrowdale, Rosthwaite	10·67	...
,, .	Ashburton, Druid Ho.	...	...	,, .	Keswick, High Hill.....	7·40	...
,, .	Cullompton.......	3·01	142	*West* .	Appleby, Castle Bank..	4·62	202
,, .	Sidmouth, Sidmount...	3·62	172	*Glam* .	Cardiff, Ely P. Stn.....	3·58	144
.	Filleigh, Castle Hill....	3·33	...	,, .	Treherbert, Tynywaun	8·45	...
,, .	Barnstaple, N. Dev. Ath	3·17	142	*Carm* .	Carmarthen Friary.....	4·09	142
,, .	Dartm'r, Cranmere Pool	5·90	...	*Pemb* .	Haverfordwest, School	2·37	88
Corn .	Redruth, Trewirgie.....	3·11	125	*Card* .	Aberystwyth............	4·04	...
,, .	Penzance, Morrab Gdn.	3·67	165	,, .	Cardigan, County Sch.	2·32	...
,, .	St. Austell, Trevarna...	3·37	130	*Brec* .	Crickhowell, Talymaes	5·00	...
Soms .	Chewton Mendip........	3·68	124	*Rad* .	Birm W. W. Tyrmynydd	4·00	122
,, .	Long Ashton.............	3·50	138	*Mont* .	Lake Vyrnwy...........	...	...
,, .	Street, Millfield	2·82	132	*Denb* .	Llangynhafal............	4·64	222
Glos. .	Cirencester, Gwynfa....	3·77	157	*Mer* .	Dolgelly, Bryntirion...	7·29	209
Here .	Ross, Birchlea............	3·35	154	*Carn* .	Llandudno................	3·02	149
,, .	Ledbury, Underdown..	3·44	152	,, .	Snowdon, L. Llydaw 9	15·85	...
Salop .	Church Stretton.........	5·57	230	*Ang* .	Holyhead, Salt Island	4·10	191
,, .	Shifnal, Hatton Grange	4·85	218	,, .	Lligwy....................	4·03	188
Worc .	Ombersley, Holt Lock	3·89	172	*Isle of Man*			
,, .	Blockley..................	4·30	...		Douglas, Boro' Cem....	6·00	248
War .	Birminghm, Edgbaston	3·59	155	*Guernsey*			
Leics .	Thornton Reservoir....	2·57	119		St. PeterP't. GrangeRd.	1·39	75

Rainfall: June, 1931: Scotland and Ireland

Co.	Station	In.	Per cent of Av.	Co.	Station	In.	Per cent. of Av.
Wigt .	Pt. William, Monreith	5·31	226	*Suth* .	Loch More, Achfary ...	6·37	172
,, .	New Luce School......	4·68	162	*Caith* .	Wick........................	...	...
Kirk .	Carsphairn, Shiel	8·89	223	*Ork* .	Pomona, Deerness......	2·06	112
Dumf.	Dumfries, Crichton, R.I	6·14	...	*Shet* .	Lerwick	2·49	140
,, .	Eskdalemuir Obs........	10·25	325	*Cork* .	Caheragh Rectory......	4·08	...
Roxb .	Branxholm	5·68	252	,, .	Dunmanway Rectory...	4·34	124
Selk .	Ettrick Manse	8·59	238	,, .	Ballinacurra..............	3·39	130
Peeb .	West Linton	5·94	...	,, .	Glanmire, Lota Lo......	4·32	160
Berk .	Marchmont House......	4·49	194	*Kerry*.	Valentia Obsy...........	5·80	181
Hadd.	North Berwick Res....	4·31	260	,, .	Gearahameen............	7·00	...
Midl	Edinburgh, Roy. Obs.	4·25	230	,, .	Killarney Asylum.......	5·07	174
Lan .	Auchtyfardle	5·13	...	,, .	Darrynane Abbey	6·19	197
Ayr .	Kilmarnock, Agric. C.	...	...	*Wat* .	Waterford, Brook Lo...	2·64	98
,, .	Girvan, Pinmore	4·26	147	*Tip* .	Nenagh, Cas. Lough ...	4·44	181
Renf .	Glasgow, Queen's Pk. .	5·25	227	,, .	Roscrea, Timoney Park	3·71	...
,, .	Greenock, Prospect H.	7·01	213	,, .	Cashel, Ballinamona ...	2·80	122
Bute .	Rothesay, Ardencraig.	6·39	208	*Lim* .	Foynes, Coolnanes	4·13	160
,, .	Dougarie Lodge.........	4·66	..	,, .	Castleconnel Rec........	4·90	...
Arg .	Ardgour House	9·75	...	*Clare* .	Inagh, Mount Callan...	5·48	...
,, .	Manse of Glenorchy...	8·60	...	,, .	Broadford, Hurdlest'n.	3·99	...
,, .	Oban......................	4·09	138	*Wexf*.	Gorey, Courtown Ho...	2·60	107
,, .	Poltalloch	5·51	181	*Kilk* .	Kilkenny Castle	3·01	124
,, .	Inveraray Castle........	7·02	177	*Wic* .	Rathnew, Clonmannon	4·44	...
,, .	Islay, Eallabus	...	...	*Carl* .	Hacketstown Rectory..	4·80	171
,, .	Mull, Benmore	13·30	..	*Leix* .	Blandsfort House.......	4·42	170
,, .	Tiree......................	3·90	...	,, .	Mountmellick...........	5·55	...
Kinr .	Loch Leven Sluice......	4·76	217	*Off'ly* .	Birr Castle	4·01	174
Perth .	Loch Dhu................	8·45	203	*Kild'r*.	Monasterevin	4·24	...
,, .	Balquhidder, Stronvar	6·31	...	*Dubl* .	Dublin, FitzWm. Sq....	3·69	189
,, .	Crieff, Strathearn Hyd.	7·16	271	,, .	Balbriggan, Ardgillan.	4·39	218
,, .	Blair Castle Gardens...	4·32	218	*Me'th* .	Beauparc, St. Cloud...	6·09	...
Angus.	Kettins School..........	3·99	213	,, .	Kells, Headfort	5·80	219
,, .	Dundee, E. Necropolis	4·50	250	*W.M* .	Moate, Coolatore......	4·38	...
,, .	Pearsie House...........	5·82	...	,, .	Mullingar, Belvedere...	5·42	209
,, .	Montrose, Sunnyside...	4·17	251	*Long* .	Castle Forbes Gdns......	4·76	185
Aber .	Braemar, Bank.........	2·65	135	*Gal* .	Ballynahinch Castle...	7·54	213
,, .	Logie Coldstone Sch....	3·34	171	,, .	Galway, Grammar Sch.	4·46	...
,, .	Aberdeen, King's Coll.	2·98	174	*Mayo* .	Mallaranny........... ...	6·77	...
,, .	Fyvie Castle	3·94	188	,, .	Westport House.........	4·57	169
Moray.	Gordon Castle............	2·44	120	,, .	Delphi Lodge............	10·23	178
,, .	Grantown-on-Spey......	2·64	117	*Sligo* .	Markree Obsy......... ...	5·97	198
Nairn.	Nairn, Delnies	3·16	179	*Cav'n*.	Belturbet, Cloverhill...	5·10	209
Inv .	Kingussie, The Birches	2·97	...	*Ferm* .	Enniskillen, Portora...	5·55	...
,, .	Loch Quoich, Loan......	10·25	...	*Arm* .	Armagh Obsy	5·00	198
,, .	Glenquoich	8·89	181	*Down*.	Fofanny Reservoir	7·08	...
,, .	Inverness, Culduthel R.	3·44	...	,, .	Seaforde	5·59	202
,, .	Arisaig, Faire-na-Squir	4·52	...	,, .	Donaghadee, C. Stn....	3·78	162
,, .	Fort William............	6·40	...	,, .	Banbridge, Milltown...	4·33	...
,, .	Skye, Dunvegan.........	5·21	...	*Antr* .	Belfast, Cavehill Rd...	5·50	...
R & C.	Alness, Ardross Cas....	3·85	170	,, .	Glenarm Castle.........	5·91	...
,, .	Ullapool	3·28	143	,, .	Ballymena, Harryville	4·46	153
,, .	Torridon, Bendamph...	...	...	*Lon* .	Londonderry, Creggan	6·76	240
,, .	Achnashellach	6·09	...	*Tyr* .	Donaghmore	...	...
,, .	Stornoway	3·12		,, .	Omagh, Edenfel.........	5·90	209
Suth .	Lairg.......	3·48	172	*D.n* .	Malin Head..............	4·89	...
,, .	Tongue	3·07	150	,, .	Dunfanaghy.............	4·87	...
,, .	Melvich	2·93	...	,, .	Killybegs, Rockmount .	6·04	159

Climatological Table for the British Empire, January, 1931.

STATIONS	PRESSURE: Mean of Day M.S.L. (mb.)	PRESSURE: Diff. from Normal (mb.)	TEMPERATURE: Absolute Max. (°F.)	TEMPERATURE: Absolute Min. (°F.)	TEMPERATURE: Mean Values Max. (°F.)	TEMPERATURE: Mean Values Min. (°F.)	TEMPERATURE: Mean Values ½ max. and min. (°F.)	TEMPERATURE: Mean Values Diff. from Normal (°F)	TEMPERATURE: Mean Wet Bulb (°F.)	Relative Humidity (%)	Mean Clou'd Am'nt (0—10)	PRECIPITATION: Am'nt (in.)	PRECIPITATION: Diff. from Normal (in.)	PRECIPITATION: Days	BRIGHT SUNSHINE: Hours per day	BRIGHT SUNSHINE: Per-cent-age of possible
London, Kew Obsy.	1013·0	— 4·6	53	27	43·5	34·2	38·9	0·0	36·0	89	7·5	1·07	— 0·69	19	1·7	21
Gibraltar	1020·2	— 1·0	72	38	62·4	48·0	55·2	+ 0·4	48·1	82	3·4	1·28	— 3·78	8	..	..
Malta	1013·5	— 3·5	68	43	59·2	51·3	55·3	0·0	51·5	79	7·5	7·69	+ 4·48	19	4·6	47
St. Helena	1013·6	+ 0·8	70	57	67·1	59·6	63·3	— 0·7	60·7	93	9·3	2·44	..	19	..	..
Sierra Leone	1012·3	+ 1·5	91	68	86·7	72·6	79·7	— 1·6	74·7	78	2·6	1·62	+ 1·21	2	..	..
Lagos, Nigeria	1008·9	— 1·0	92	74	88·5	77·2	82·9	+ 2·0	78·1	87	7·4	0·94	— 0·13	6	..	..
Kaduna, Nigeria	1014·8	+ 0·1	96	..	91·5	..	..	..	69·1	69	..	0·00	0·00	0	..	..
Zomba, Nyasaland	1008·8	+ 1·4	82	61	77·6	65·3	71·5	— 1·3	..	82	8·6	15·06	+ 3·96	27	..	..
Salisbury, Rhodesia	1007·9	+ 1·9	85	55	78·3	61·0	69·7	0·0	63·5	74	7·5	8·82	+ 1·50	22	6·3	48
Cape Town	1012·8	— 0·6	100	59	84·4	64·6	74·5	+ 4·6	65·7	67	2·1	0·00	— 0·68	0	..	..
Johannesburg	1011·4	+ 0·8	87	50	73·9	55·5	64·7	— 2·0	57·9	77	6·5	8·56	+ 2·39	20	6·4	47
Mauritius	1012·2	+ 0·3	89	73	85·1	74·5	79·8	+ 0·5	76·3	77	7·1	11·80	+ 4·04	25	6·9	52
Calcutta, Alipore Obsy.	1015·4	+ 0·2	88	53	81·8	59·5	70·7	+ 4·1	60·0	86	1·9	0·06	— 0·36	0*	..	..
Bombay	1012·8	— 0·8	94	63	87·0	68·9	77·9	+ 2·4	66·0	71	0·9	0·00	— 0·10	0*	..	..
Madras	1013·7	— 0·4	86	64	84·1	68·8	76·5	+ 0·3	70·4	79	4·5	0·05	— 1·09	0*	..	..
Colombo, Ceylon	1011·3	+ 0·5	92	68	87·1	72·6	79·9	+ 0·4	73·7	74	4·7	4·25	+ 1·00	11	6·9	58
Singapore	1010·3	..	92	71	87·2	73·3	80·3	— 0·4	..	..	..	11·56	+ 1·68	23	5·1	42
Hongkong	1019·0	— 0·7	79	40	66·5	57·2	61·9	+ 1·7	57·1	75	6·4	0·33	— 0·96	4	5·2	48
Sandakan	..	..	89	73	86·3	74·8	80·5	+ 0·7	77·3	83	..	10·14	— 9·26	8	..	..
Sydney, N.S.W.	1010·6	— 1·8	97	60	79·4	65·0	72·2	+ 0·6	65·8	64	5·9	2·02	— 1·65	17	8·2	58
Melbourne	1012·3	— 0·6	91	49	74·7	54·1	64·4	— 3·0	57·1	61	7·4	1·25	— 0·64	12	6·4	44
Adelaide	1014·5	+ 1·5	103	51	81·9	59·9	70·9	— 3·0	57·7	39	5·4	0·64	— 0·08	7	9·4	67
Perth, W. Australia	1014·4	+ 1·9	104	51	86·0	63·1	74·5	+ 0·7	63·6	48	2·0	0·03	— 0·31	2	11·6	83
Coolgardie	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..
Brisbane	1011·5	+ 0·2	100	67	88·9	71·7	80·3	+ 3·1	71·9	61	5·5	4·54	— 1·96	10	8·2	60
Hobart, Tasmania	1006·4	— 3·9	86	43	67·0	50·6	58·8	— 3·2	51·2	53	6·2	1·25	— 0·58	16	7·6	51
Wellington, N.Z.	1008·8	— 4·5	70	45	64·2	53·8	59·0	— 3·5	55·6	73	6·3	3·84	+ 0·51	13	8·1	55
Suva, Fiji	1009·7	+ 2·2	89	70	86·5	75·5	81·0	+ 1·1	76·2	78	6·4	10·42	— 1·01	25	7·8	60
Apia, Samoa	1006·1	— 1·8	87	73	84·4	76·7	80·5	+ 1·5	77·3	84	7·4	17·20	+ 0·15	22	5·2	41
Kingston, Jamaica	1014·3	— 0·8	89	67	85·8	69·8	77·8	+ 1·0	68·0	85	2·1	0·85	— 0·11	5	9·3	83
Grenada, W.I.	1013·2	+ 0·4	90	71	86·5	73·5	80·0	+ 2·9	73·8	76	4·7	2·43	— 1·95	16	..	..
Toronto	1016·2	— 1·7	45	0	31·6	18·2	24·9	+ 2·7	21·0	75	7·6	2·62	— 0·17	11	2·8	30
Winnipeg	1016·2	— 4·7	39	—13	17·2	2·7	9·9	+13·8	..	..	5·7	0·26	— 0·65	8	2·0	23
St. John, N.B.	1011·0	— 4·5	41	— 6	27·4	12·2	19·8	+ 0·6	14·2	61	5·0	4·41	— 0·39	16	4·2	46
Victoria, B.C.	1015·3	— 0·7	56	37	47·0	41·6	44·3	+ 5·3	42·8	95	8·6	4·66	+ 0·12	23	1·7	19

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

New Meteorological Office at Wellington, New Zealand (see p. 167)

M.O. 340.

The Meteorological Magazine

Air Ministry :: Meteorological Office

Vol. 66

Aug., 1931

No. 787

LONDON: PUBLISHED BY HIS MAJESTY'S STATIONERY OFFICE
To be purchased directly from H.M. STATIONERY OFFICE at the following addresses: ADASTRAL HOUSE, KINGSWAY, LONDON, W.C.2; 120, GEORGE STREET, EDINBURGH; YORK STREET, MANCHESTER; 1, ST. ANDREW'S CRESCENT, CARDIFF; 15, DONEGALL SQUARE WEST, BELFAST; or through any Bookseller.

The Splashing of Rain

By LIEUT.-COL. E. GOLD, D.S.O., F.R.S.

The funnel of a rain-gauge is so constructed that any splashing of raindrops falling into the gauge is not likely to result in the splashed drops leaving the gauge. They will generally be caught by the vertical sides of the funnel. If therefore the gauge is to record the correct amount of rainfall it must be set at such a height that the drops of rain falling outside the gauge will not splash as high as the gauge. If they do, then, in addition to the rain which falls from above, entering the gauge, there will be splashed rain going into it.

Gauges in England are set at a height of 1 foot above the ground, and it has been generally assumed that this height is great enough to prevent any appreciable amount of splashed water entering the gauge. The height has been accepted mainly because it seemed reasonable; but I know of no experimental evidence for the selection of a height of 1 foot as being sufficient to ensure freedom from errors due to splashing; evidence might be obtained by letting artificial rain fall around a rain-gauge above which was placed a concentric cylinder of larger diameter, to prevent any rain falling directly into the rain-gauge. The base of the cylinder must not be at a greater height above the top of the funnel of the rain-gauge than $(R-r)\frac{v}{V}$ where R and r are the radii of the cylinder and the gauge and v and V are

(95107) 107/27 1,125 8/31 M. & S. *Gp.303*

the vertical velocity of the raindrops and the horizontal velocity of the wind. If this condition were satisfied any drops carried by the wind which missed the bottom of the cylinder would be below the top of the funnel when they reached it, and would not therefore enter the gauge. Any water which was caught by the gauge would be due to the splashing of the drops.

In natural rain the drops are usually of different sizes, and it would not be practicable to disentangle the effect of the smaller drops which were carried into the gauge by the wind from the drops carried in by splashing. It would be necessary to make an artificial rain with drops approximately all of one size.

Another way of approaching the problem is to utilise the known facts that raindrops do not in practice exceed a limiting diameter of about 7mm., and that the greatest velocity of raindrops is about 25 feet per second; this occurs with drops of about 5mm. diameter; the larger drops take a form in which the increased resistance of the air more than balances the increased weight of the drop. When a raindrop strikes the ground it cannot rebound with a greater vertical velocity than that which it has before impact. Consequently a raindrop cannot start splashing upwards with a greater vertical velocity than 25 f./s. If there were no air resistance the greatest height to which such a drop could reach would be $\frac{25 \times 25}{64}$ *i.e.*, about 10 feet. Actually there would be appreciable air resistance. In fact at the commencement the air resistance would be equal to the weight of the drop so that initially the retardation in the ascending motion of the drop would be twice the value of gravity. At the end of the motion there would be no air resistance, because the drop would have no vertical velocity. Thus the retardation being initially equal to 2 g and finally equal to g, would be on the average about $1\frac{1}{2}$ g. The effect of this would be to reduce the maximum height to $\frac{25 \times 25}{96}$ or about 7 feet. More exact calculation gives a value of $\frac{25 \times 25}{64} \log_e 2 = \frac{25 \times 25}{92}$

In practice drops of 5mm. diameter would not rebound with the velocity with which they struck the ground. They would normally break up into smaller drops, and the height to which these smaller drops would ascend would be very much less than 7 feet. Drops of 5mm. diameter would only be met with in thunderstorm rain. In ordinary rain the drops would be of much smaller diameter. In moderate rain they appear to vary from about 0·5mm. to 2 or 3mm. If we consider a drop of 2mm. diameter this would have a limiting velocity of about 20 feet per second. If such a drop rebounded with the velocity with which it struck the ground it would not ascend to a height greater than 4 feet.

The assumption that the drops rebound with a velocity equal to that with which they strike the ground is equivalent to taking the drops as solid bodies of perfect elasticity and the calculation of heights depends upon the assumption that there is no wind and no carrying up of the splashed drops by turbulence in the air. It may be noted that if a comparatively large drop of 2mm. in diameter breaks up into eight small drops, each of 1mm. in diameter, these small drops could not rise to a greater height than about 2 feet or half the maximum height to which the 2mm. drop could rise, if it rebounded as a single drop.

In anticipation of more precise experiments on the splashing of falling drops, I thought it would be of interest to make one or two observations on isolated drops falling on a glass plate. I let the drops fall from the end of a camel-hair brush; actually I took on each occasion the last drop which fell; it appeared to be about 4mm. in diameter. The diameter of the drop can be obtained by weighing the drop. I have since weighed drops from the brush I used; they weighed approximately 65mgm. corresponding with a diameter of approximately 5·0mm. The drops fell from two heights, one about 40cm. (16 inches) and the other about 140cm. (4½ feet). The velocity with which the drop struck the plate, assuming a limiting velocity of 20 f./s., would be about 9 f./s. and 14 f./s. respectively. When the drop struck the plate it neither rebounded nor broke up; it just spread out in a circular patch, practically a perfect circle. This surprised me; I thought at first that it was due to the small height from which the drop fell, viz., 40cm. But when I tried the larger height, the result was the same, only the circle was larger. The edge of the circle was nearly a continuous line, but in some cases it was broken by one or two minute spurts from the main mass of liquid. When the drop fell from a height of 40cm. the radius of the circle on the plate was approximately 1·3cm.; when it fell from a height of 140cm. the radius was approximately 1·8cm. In rain in thunderstorms drops form circles on a glass plate: the largest I caught made a circle of about 4cm. diameter (2cm. radius), there were many of about 1¼ to 1½cm. radius. Ordinary rain after the storm made patches of diameter from 1mm. to 6mm. mainly.

The explanation of the spreading out of the drops is briefly this—when the drop strikes the plate the kinetic energy of the falling drop is converted into potential energy of surface tension. This latter is proportional to the area of the surface of the water in contact with the air (assuming that the drop wets the plate. If we assume that the drop is spherical (actual drops are not truly spherical), of radius r, then the potential energy of the surface tension of the falling drop $=4\pi r^2 T$ (the value of T in C.G.S. units is approximately 76). If the radius of the circle into which the drop spreads out is R then the potential energy of the surface tension of the circular patch is πR^2T or $\pi R^2(T+T^1)$ if there is a surface tension T^1 on the water in contact with the glass. The difference between these two, viz., $\pi T(R^2-4r^2)$ + πR^2T^1 ought to be approximately equal to the kinetic energy of the falling drop.

If L is the limiting velocity of the falling drop, *i.e.*, the velocity which it would attain after falling a very long distance through the air, it is possible to compute the kinetic energy which the drop will have after falling a distance h. The actual formula is $\frac{1}{2}mL^2(1-e^{-2gh/L^2})$ where m is the mass of the drop and g is the acceleration of gravity. The limiting velocity L does not vary much with the size of the drops after they have reached a diameter of about 2mm. We may therefore assume approximately for the drops with which I made experiments a value of L of about 20 f./s. (=600cm./sec.).

With this limiting velocity the formula gives as the kinetic energy of a drop which has fallen a distance of 40cm. a value of 35400 × m, m being the mass of the drop. (If there were no air resistance the corresponding value would be 39200 × m—not very different, as one would anticipate because the air resistance cannot produce much effect in a small fall like 40cm.). The actual velocity of the drop after falling 40cm. would therefore be 266cm./sec. allowing for the air resistance, or 280cm./sec. allowing for no air resistance. The corresponding values of kinetic energy for a fall from a height of 140cm. are 83400 × m allowing for air resistance and 137500 × m allowing for no air resistance. The difference in this case is very considerable; the air resistance reduces the terminal velocity from 525cm./sec. to 410cm./sec. For spherical drops of water the value of m is $\frac{4}{3}\pi r^3$. If these values for the kinetic energy and the measured values of the diameters of the circular patches are used to calculate the diameter of the drops on the assumption that T^1 is negligible, they come out as 2·8mm. and 2·6mm. for the 40cm. and for the 140cm. fall respectively. These are smaller than the true diameter found by weighing, viz., 5·0mm., the explanation probably is that T^1 is of appreciable size and that part of the kinetic energy is used in overcoming the skin friction between the glass and the water as the latter spreads out.

The fact that when the drops strike a hard surface like a sheet of glass they spread out was new to me. I had often observed, as other people have done, that the first drops of rain falling on a hard pavement spread out into circles, but I had, rather casually, assumed that this was due to the warmth and dryness of the pavement, and had not realised that it was due to the surface tension of the drop acting in the manner I have mentioned.

When a drop falls on a water surface the effect is quite different. It cannot dispose of its kinetic energy by spreading out and increasing the potential energy of the surface tension; if it spreads on a water surface it merely replaces the potential energy of the water over which it spreads by a new surface of equal potential energy: there is no increase in area of the film. Since this avenue of disposing of the kinetic energy is closed, the drop splashes and the kinetic energy of the drop falling on water is transformed partly into waves on the water surface and partly into kinetic energy of the splash; even for a drop falling quite a short distance there is a definite splash when it falls on a water surface.

I do not know of any experimental or theoretical evidence as to the partition of energy between the wave and the splash; but if we assume that the energy is equally divided between the wave and the splash then the heights to which different drops will splash when they fall upon a water surface is shown in the following table. The heights are given on the assumptions—

(*a*) that the drop is equal in size to the falling drop;

(*b*) that there are two splashing drops each half the size of the falling drop;

(*c*) that there are eight small drops each one-eighth the size, *i.e.*, half the diameter of the falling drop.

(*d*) that there are 64 small drops each one-quarter the diameter of the falling drop.

Diameter of drop. mm.		Heights of splash. (*a*)	(*b*)	(*c*) feet.	(*d*)
1	...	1·3	1·2	1·1	0·5
2	...	2·4	2·1	2·0	1·4
3	...	3·3	3·0	2·9	1·9
4	...	4·2	3·8	3·8	2·2
5	...	4·2	4·2	4·2	2·7

These are maximum values: when the drop breaks up the smaller drops do not start vertically but fly out at a comparatively small angle with the horizontal—30° or less. These values suggest that a height of 1 foot is not sufficient to avoid with certainty the effect of splashing, and that from this aspect a height of 3 or 4 feet is necessary.

After I had made the observations mentioned here, I had an opportunity of watching the splashing of raindrops falling with thunderstorm intensity practically in a calm. Individual drops of appreciable size appeared to rise to a height of about 6in. Smaller drops I could not see individually, but I was able to estimate roughly the height to which these drops of smaller size rose by observing the mist which they produced. The upper limit of this mist when viewed at a distance of about 100 yards is fairly definite. On the occasion in question it was well above the level of the hubs of motor cars, and nearly as high as the tops of the wheels, *i.e.*, the mist rose to a height of about two feet. This value may be compared with the values in column (*d*) of the table above which corresponds with a large number of small splashed drops. (These observations were made from the door of Adastral House facing Aldwych about 6 p.m. on August 5th, 1931.)

It is clear to me now that the ordinary splashing of rain is due to the rain falling on a wet surface, and is not due to its falling on a hard surface. In fact, the best way to avoid any splashing of rain would be to keep the surface, on which it falls, dry.

Thunderstorms, August 3rd to 5th

A spell of thundery weather was experienced early in August, and commenced in a most abnormal manner. On August 3rd there was a large and recently formed anticyclone extending from the Atlantic across Scotland to Norway, with a pressure of about 1030mb. along the axis. There was a steep gradient for NE. winds over most of England and Wales, and many places on the coast had strong winds all day. Pressure over France was still relatively low, but had risen about 10mb. in the preceding 24 hours, and was still rising. NE. to E. winds extended up to high levels. Rain and local thunder occurred during the early hours of the 3rd in a belt from Yorkshire to the west Midlands, and broke out after dusk over south-east England, soaking many of the Bank Holiday crowd. The storms moved westward as far as Pembroke during the latter part of the night. Taking into account the strength and depth of the NE. wind, it would be difficult, if not impossible, to find any close precedent to these storms. The general warmth over land areas, and also the upper air temperature at Duxford on the morning of the 4th, showed that the surface air had been cooled over the North Sea. There was a wind discontinuity over northern France, apparently a cold front with the cooler air on the south side. The evening storms might possibly be regarded as a case of pre-cold-frontal rain, an unusual variety of a common, but unexplained phenomenon.

The NE. winds began to decrease immediately after the storm and became light within 36 hours. On August 5th the northern anticyclone collapsed and a complex shallow depression moved northward from France to the North Sea and deepened. Thunderstorms occurred at many places in the south on the 4th, over most of England on the 5th, and near the south-east coast on the morning of the 6th, and were severe locally. On the 4th 4.44in. of rain fell at Langford, Salisbury, between 6.5 and 7.35 p.m. (*The Times*, August 7th. The time is probably summer time.) Between 10.40 and 10.50 p.m. G.M.T, fully half an inch fell at Ross-on-Wye. During the afternoon of the 5th 2·90in. of rain were recorded at Petersfield in about an hour, and 2·15in. in 55 minutes at Stoner Hill, a few miles off. On the same evening 2·22in. fell at Greenwich after 6 p.m. G.M.T., and about an inch at Kingsway between 4.55 and 5.25 G.M.T. At Kensington there was none at that time, and only 0·08in. altogether, while Westminster had only 0·04in. Flooding ooccurred at King's Cross, with derangement of traffic, and also in some other parts of London, though the heavy rain was patchy. Heavy hail fell at Biggin Hill and in the Caterham Valley. The thunder and lightning were not frequent during the heavy rain in central London, but subsequently were fairly frequent and severe, especially over some of the south-west and west suburbs about 7 p.m. G.M.T. A number of houses were struck in various parts of the town. The storm lasted for three hours in the London area, and its movement was extremely slow and somewhat irregular. The average drift of the main thunder-clouds was from about south-east, but was rather variable, and as the result of complex movements and developments, the centre, north and east of London had the storm about two hours earlier than the south-west. The first storm broke directly over central London and moved very slowly towards north-north-east, joining on to others forming in the east and south-east.

Humidity was high throughout the period, the dew point being up to 67°F. locally on the 4th, though this must have been partly due to the previous night's rain. The air at 2,000 feet can be traced back from south England to south Russia, using gradient winds, and it is difficult to see why it was so damp. Possibly a depression over south Russia on July 31st was connected with it. The dampness was undoubtedly the main factor in producing the storms. An upper air observation at Duxford at 6.15 a.m. on the 4th showed that the upper air temperature was above the August normal, but that the lapse rate above 3,000 feet was slightly above the saturated adiabatic, with a very high humidity. Observations at four German stations on the 3rd showed similar features as regards temperature, but somewhat lower humidities, though the total water content was considerable. Thunderstorms occurred on that day in south Germany, but were not reported from north Germany or Holland. In parts of France there were storms from the 1st till the 6th, and they were especially severe over northern France late on the 4th, when there were at least 12 deaths from lightning and great material damage. It is quite common to have an adequate moisture supply for thunderstorms and heavy rainfall in air which has been over land for a considerable period.*

C. K. M. DOUGLAS.

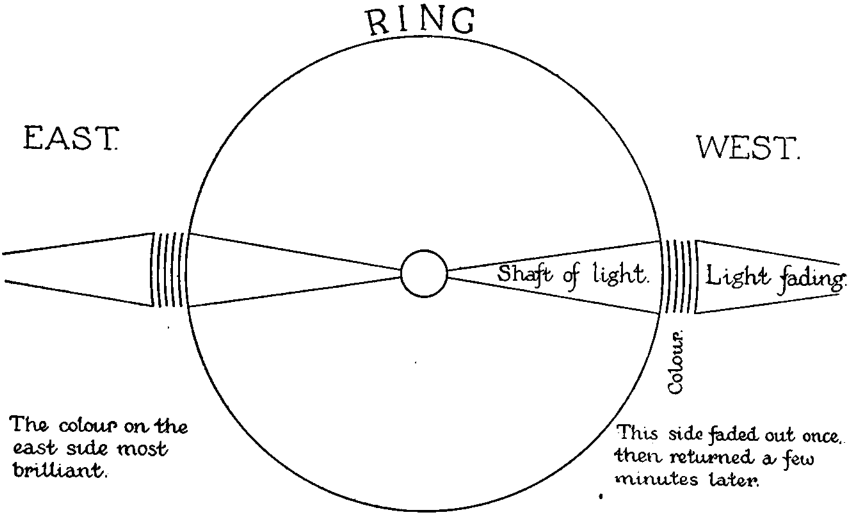
* See *Meteorological Magazine* 65 (1930) p. 130, also 61 (1926) p. 156.

Correspondence

To the Editor, *The Meteorological Magazine.*

Mock Moons

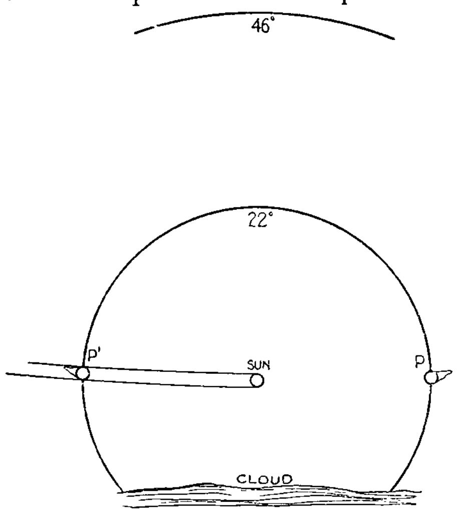
Mr. Hobday of 29, Cecil Street, Stockton-on-Tees, writes, that "At Thornaby-on-Tees, Saturday, March 7th, 1931, at 3.30 a.m., we witnessed a sight which must be of a rare occurrence. At the time stated the moon was very bright and surrounded by a large narrow ring. From the moon two shafts of light extended, one east, one west. When these shafts of light reached the ring the colours of the rainbow appeared, then the shafts of light gradually tapered away. The remarkable thing about it all was the distinctness of the rainbow colours, which were as clear as such seen during summer showers. The shafts of light were exactly similar to the beam from a searchlight. We first noticed it as stated at 3.30, and it lasted until 3.50 a.m. The sketch gives an idea of the shape



and position of the parts mentioned. The diameter of the ring was about thirty times the diameter of the moon. A seafaring man who also saw it says that he has seen the same before, but always in the tropics. The sailors called it 'The Wind Dogs,' and it was a sign of very bad weather." Mr. Sargent of the Observatory, Durham, who sent Mr. Hobday's observation, writes that "Weather conditions here leave it quite possible from that point of view, as clouding was very partial, and snow storms brief with fair intervals. Thornaby, from whence the appearance was seen, lies (practically) between Stockton-on-Tees and Middlesbrough, really an 'across river' part of Stockton itself." In commenting on the above observation, Dr Whipple says that "I feel sure that Mr. Hobday saw the 22° halo, the mock-moon ring and mock moons. The mock-moon ring is attributed to the reflection of light from ice crystals with vertical axes. It is possible that the diffraction by such crystals also plays a part in the phenomena. The mock-moons are due to refraction by crystals of the same class. The brilliance of the colours implies that the crystals were exceptionally numerous. As to the size of the halo it may be surmised that the circle was not complete or, more probably, that there is a mistake about the time. The fact that the mock-moons were on the outside of the halo implies that the moon must have been a considerable height above the horizon and therefore favours the hypothesis that the time is at fault. The mock-sun ring is not often seen in this country. I do not remember any instance of the mock-moon ring."

Halo Phenomena

Throughout to-day there was a halo of 22°. About 16h. two brilliant parhelia developed with white tails about ½° long. On examination in the black mirror the parhelic circle could be traced from the sun to the left parhelion, which was especially bright, and about 4° or so beyond it. The right parhelion also had a tail but cloud prevented exact observation. The halo itself, which was faint, appeared in cirro-nebula, the sky being only slightly milky. About 17h. the upper part of the halo of 46° was observed, faintly, but distinctly enough for the greater purity of the colours as compared with the 22° halo to be noted.



CICELY M. BOTLEY.

Guildables, 17 Holmesdale Gardens, Hastings. May 1st, 1931.

Sun Pillar, May 18th, 1931

A sun pillar was observed at Holyhead on May 18th, at 20h. G.M.T., as a well-defined column of light, pale orange in colour with a " background " of fine cirrus cloud of a darker reddish tint.

The base of the pillar, about ½° in width was some 5° above the horizon due to mist out at sea. The column rose to an altitude of from 10° to 15°. The sky was 2/10ths clouded with cirrus cloud in the west and alto-cumulus cloud in the east. The phenomemon lasted until 20h. 20m. G.M.T. Unfortunately no observations were made when the sun was visible.

H. L. PACE.

Salt Island, Holyhead. May 20th, 1931.

Limits of Visibility

Mr. J. C. Ridgway inquires in the July number of the Magazine whether Hindhead is often visible from the Terrace at Richmond. Though not a resident in Richmond, I often walk along the Terrace either in the morning or evening, and Hindhead is frequently visible in summer. Visibilities of over 30 miles are fairly common in the south-east in summer, but the extreme limit is difficult to determine owing to absence of suitable objects. From the air I have seen the coast line up to 100 miles' distance. Clouds or mountains are sometimes visible much further. There is no reason to doubt Major Goldie's conclusion that he saw clouds 200 miles off over Norway.

C. K. M. DOUGLAS.

In connexion with the note on the above subject by A. H. R. Goldie in the May number of the magazine, it may be of interest to note the great distances at which mountain peaks and ranges are frequently visible in north-west India. To the north-west of Peshawar, which is 1,500 feet above sea-level, the Hindu Kush mountains, a large branch of the western Himalayas in Afghanistan, can quite often be seen—especially in the winter months. The range has a general height of 12/13,000 feet—with peaks extending up to 18,000 feet—the nearest point being 175 miles away from Peshawar. After the passage of a western disturbance, the peaks are generally remarkably clear and seem to be much nearer than they really are. Occasionally in the cold weather, the high peaks over 200 miles away to the north of Peshawar (where the Hindu Kush joins the Pamirs) can also be seen from the air at a height of 5,000 feet. These peaks are all over 20,000 feet high—Terichmir, for example, is 25,000 feet above sea-level—but they cannot be seen from the ground owing to the intervening hills. Another famous mountain which can sometimes be seen from certain points in the Peshawar district is Nanga Parbat. This mountain is in the Gilgit Agency of Kashmir and extends to a height of 26,620 feet—towering many thousand feet above the adjacent hills. It is situated north-east of Peshawar and is approximately 200 miles away.

R. G. VERYARD.

No. 1 (Indian) Group Headquarters, R.A.F., Peshawar. June 24th, 1931.

Cloudless Days

The sky was almost cloudless yesterday—but not quite. During the last fifteen years there have been only twenty-three entirely cloudless days in this district (the period April to December, 1919, is not covered by my record). I have no record of a cloudless day in 1919, 1920, 1923 and the present year so far. Days which were quite free from cloud, since March, 1916, are as follow :—

2nd April, 1916		12th Mar., 1924	
6th Feby., 1917		10th June, 1925	
31st Jany., 1918	2	13th April, 1926	
9th April, 1918		10th Feby., 1927	
8th April, 1921	6	15th July, 1928	
22nd May, 1921		8th Mar., 1929	5
9th July, 1921		28th Mar., 1929	
10th July, 1921		6th April, 1929	
8th Sept., 1921		24th May, 1929	
18th Oct., 1921		7th Sept., 1929	
27th May, 1922	2	4th Nov., 1930	
7th June, 1922			

MILES W. BINNS.

47, Leicester Road, Lutterworth, Rugby. June 27th, 1931.

Week-end Weather in 1931

The wet weather that has prevailed during several recent week-ends has been the subject of much newspaper press comment. On Monday last in particular such striking headlines as " Dreary Week-End ! " " Why are Week-Ends Always Wet ? " appeared in many leading dailies. The emphatic statement that 25 out of the 30 week-ends in 1931 have been wet in south-east England has led me to examine the records of Lympne to see how far such a statement can be substantiated. Lympne is no great distance from any of the numerous popular holiday resorts of Kent, so that it seems fair to use its records for the present investigation. For this analysis a week-end has been taken as comprising the two days Saturday and Sunday.

Of the 30 week-ends in the first seven months of 1931, eight had no measurable rain, eleven had rain on either Saturday or Sunday, and eleven had rain on both Saturday and Sunday; five week-ends had more than 10mm. (·40in.), the wettest being April 18-19th, with 21·3mm. and July 25th-26th with 14·5mm.

Sunshine is such an important element in any consideration of week-end weather that it is worth while noting that in the period under review no week-end was absolutely sunless. There were, however, eight week-ends when either Saturday or Sunday had no sunshine, and a further thirteen when the duration for the two days was less than 50 per cent. of the possible amount.

Of the nine week-ends remaining, which with more than 50 per cent. of the possible duration might perhaps be described as "sunny," six were also rainless, so that conditions have not been so dismal as the newspaper press would have us believe. The highest sunshine values, 28·8 hours, occurred in the brilliant week-end of June 27th-28th.

Nevertheless it is a fact that conditions on Saturdays and Sundays have generally been markedly inferior to those prevailing from Monday to Friday, as may be gathered from the following data :—

January—July 1931	Rainfall		Sunshine	
	Total	Average per day	Total	Average per day
	mm.	mm.	hrs.	hrs.
Mondays—Fridays, 152 days	213.1	1.4	792.6	5.2
Saturdays and Sundays, 60 days	128.1	2.1	282.0	4.7

The striking facts emerge that the mean daily rainfall on Saturdays and Sundays in 1931 has been 50 per cent. greater, and the duration of sunshine 10 per cent. less than on other days of the week.

The normal rainfall at Lympne for the first seven months of the year is 340mm., giving a daily rate of fall of 1·6mm. The total fall for the first seven months of 1931 had been 341mm., so that the year so far has been remarkable in that, while the total precipitation is almost exactly normal, Mondays to Fridays have had appreciably less than their normal rainfall, while Saturdays and Sundays have had considerably more than the normal.

H. E. CARTER.

Lympne Air Port, Hythe, Kent. August 1st, 1931.

Rainstorms of July 5th and 6th, 1931

Dr. G. F. Barbour, of Fincastle, Pitlochry, writes that the rainfall for the 24 hours from 9h. on the 5th to 9h. on the 6th during which the thunderstorm took place was 1·50in.—0·52in. less than the very exceptional rainfall on June 14th, but it was more concentrated, as a large portion fell between 6 and 8 p.m. (summer time). At Fincastle Ho. the storm began within a few minutes of 6 p.m. with a hailshower of exceptional severity lasting about 8 minutes, the largest hailstones being approximately ½in. in diameter. No hail was observed at neighbouring stations.

Mr. J. Gibson, of Waringstown, near Lurgan, Co. Down, writes that thunderstorms were experienced to the south, north-east and north-west of the station, most of the afternoon of the 6th. In the evening another thundersorm occurred at Annaghannon 1¼ miles south of Waringstown. The thunder ceased when the storm-cloud got overhead, and before the rain commenced a noise resembling a distant waterfall was heard. Immediately, precipitation began in a dense sheet obliterating objects 50 yards away. This was at 7.0 p.m. B.S.T. About seven minutes later hail began which pelted and rang off the gauge like small shot, and destroyed much rose bloom. At 8 o'clock the precipitation ceased as suddenly as it began. 0·27in. of rain had fallen during the ten minutes.

Heavy Rain

I was able to record particulars of a heavy shower this morning which seemed to be very unusual in intensity.

The rain lasted for less than five minutes; the amount measured was 0·10in. The screened thermometer fell 6°, from 69° to 63°F., and began to rise again immediately the rain ceased. Rain began at 9h. 37m. and ceased at 9h. 42m. G.M.T. approx.

M. A. CARLISLE CROWE.

Pye Hill, Finchampstead, Berks. July 19th, 1931.

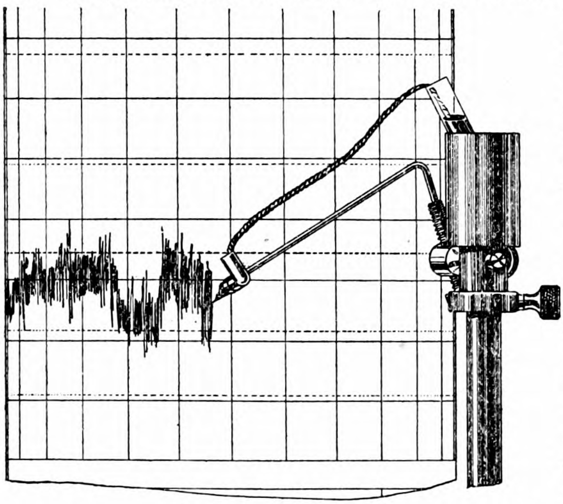
Severe Rainstorms in America

One of the heaviest and longest rainstorms for years was experienced in Maine and Massachusetts from June 7th-10th. Mr. Earl Austin of 52, James Street, Auburn, Maine, has sent the following details. The storm appeared as a slight depression centred over Kansas at 8h. (75th W. Meridian Time) on Friday, June 5th. At that time an anticyclone was centred over South Dakota, pressure was comparatively low over the north-eastern part of the United States and high to the south-east. By Saturday the depression had deepened and moved north-eastwards, causing showers and thunderstorms from Nebraska and Kansas to Ohio and Michigan; 1·46in. fell at Chicago, but in Maine the weather was clear and fine with northerly winds. On Sunday as the depression approached the weather in Maine became overcast and showery, and two thunderstorms accompanied by torrential rain occurred in the afternoon. From then until Wednesday heavy rain and thunderstorms continued at intervals. Usually the storms move away north-eastwards, but a high pressure area formed over Nova Scotia and Cape Breton Island, and there was also a wedge of high pressure from Ontario to Florida. "Thus the storm was wedged between both highs, and therefore rain continued to pour down." Boston had 4·22in. in the 24 hours ending at 8h. on the 10th. At Fitchburg, Mass., 6·12in. fell in the four days 7th-10th; at Lewiston 3·21in. or nearly a month's rainfall in four days. But for the numerous power dams and storage lakes on the rivers concerned there would have been serious flooding. The flow over the dams was four to five times the normal. The Merrimac River at Lowell rose 5ft. in 24 hours; cellars were flooded and cattle marooned. On the 9th and 10th gales also were experienced along the coasts of Maine and Massachusetts. On Thursday, the 11th, the storm, still blocked by the high pressure area over Cape Breton Island, retreated towards Bermuda, which is very unusual.

New Ink-Feed for the Dines Pressure Tube Anemograph

Owing to failure on several occasions of the ink supply to the velocity pen of the Dines pressure tube anemograph, especially during periods of high winds at night time, an endeavour was made to maintain a continuous flow of ink in the following manner:—

A small and light glass tube 1¾in. long and ¼in. diameter (the one actually employed being of a type often used to contain flints) was placed at a slant in the shot cup on the float rod and shot removed to allow for the extra weight. The ink was then fed from this reservoir to the pen by a single strand unravelled from the three-strand wick as used for the wet bulb; a complete wick maintains too copious a supply. This strand should be soaked in water before use. It is found that with the tube at a slant no support is necessary to keep the wick clear of the shot cup. The arrangement described has worked satisfactorily for a month in calm and boisterous weather, and the ink supply to the velocity pen has always been adequate without being excessive. The supply may be controlled in two ways: either by using thinner wick or by altering the amount of ink in the reservoir and thus a satisfactory flow may be found by experiment. Another important feature is to ensure that the end of the wick is within one millimetre of the penpoint. Once a correct flow has been obtained the velocity pen will work without attention for periods of a week or more.



F. E. Coles.

502, Ulster Bomber Sqdn., R.A.F., Aldergrove, Co. Antrim. *April 9th,* 1931.

NOTES AND QUERIES

New Meteorological Office at Wellington, New Zealand

By the courtesy of Dr. E. Kidson we are enabled to publish a photograph (see frontispiece of this number of the Magazine) of the new building of the Meteorological Office at Kelburn, Wellington, which was officially opened on October 28th, 1930. It is situated on an eminence overlooking the city, at an altitude of 400 feet. The upper room, which has windows on all sides, is the forecasting room and the upper roof is used for pilot balloon observations. A fireproof safe for the storing of records is provided in the basement.

Visibility Observations at Nuremberg

A note recently issued by the German Aviation Weather Service (Flugwetterdienst—April 6th, 1931) gives an account of a series of observations of visibility made at Nuremberg during the 4 months November, 1930, to February, 1931, inclusive.

The observations were made from a tower, in the middle of Nuremberg, which rises about 50 metres (160 feet) above the general level of the housetops. The observations were made both by day and by night, the observations at night depending upon observations of lights at different distances. The following tables shows the percentage frequency of visibility less than 1Km. (occurrence of fog) at the different hours of observation. The observations in bold type are those which depended upon observations of light, the other observations depending upon the ordinary daylight.

Time	00	01	02	03	04	05	06	07	08	09	10	11	12	13	14	15	16	17	18	19	20	21	22	23 h
Nov. 30	**3**	**3**	**3**	**3**	**3**	**3**	**3**	**0** 29	33	40	27	27	23	17	13	7	10	**10** 10	**7**	**7**	**7**	**3**	**0**	**3**%
Dec. 30	**6**	**13**	**19**	**16**	**16**	**16**	**16**	**19**	78	84	84	61	42	36	29	23	29	**26**	**26**	**19**	**16**	**3**	**6**	**6**%
Jan. 31	**8**	**8**	**3**	**3**	**3**	**0**	**8**	**10**	55	55	39	32	29	26	19	16	13	25 **27**	**19**	**16**	**10**	**3**	**3**	**3**%
Feb. 31	**4**	**11**	**7**	**11**	**11**	**11**	**14**	**28** 60	64	57	57	43	28	18	14	14	14	**6** 6	**11**	**7**	**4**	**7**	**4**	**4**%
Mean per cent.	**5**	**9**	**8**	**8**	**8**	**8**	**10**	**16** 45	58	59	52	41	31	24	19	15	14	14 **17**	**16**	**12**	**9**	**4**	**3**	**4**%

The great increase in the percentage of fog just after dawn finds no corresponding decrease in the percentage of fog after sunset, indicating that the effect is real and not due to the difference between observations of daylight visibility and observations of lights. It appears to be largely due to the smoke caused by Nuremberg itself, because the percentage frequency of fog at the aerodrome outside Nuremberg is much less in absolute value and does not show any great increase after dawn.

(The observations on the aerodrome were daylight observations only.)

A feature of more than usual interest in the note is a diagram based upon the observations of a searchlight situated on an aerodrome 9Km. west of the observation tower. The searchlight was turned on for 5 minutes every hour during the night. It was a very powerful searchlight (190,000 candlepower) and the light was directed towards the observation tower. On the average the light was visible in about 80 per cent. of the cases. The following diagrams show the percentage of occasions on which

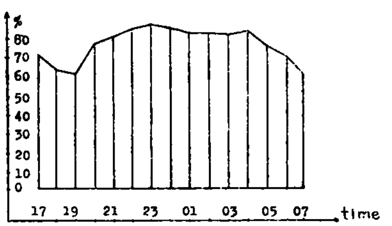


Fig 1. Percentage frequency of visibility of a searchlight.

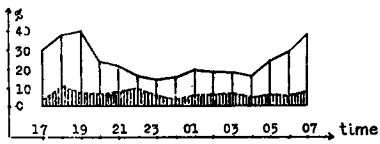


Fig. 2. Percentage frequency of invisibility of a searchlight.

|||||||||||||| Invisible owing to snow.

——— Invisible from all causes including snow.

it could be seen and the percentage of occasions on which it was not visible either through snow or through fog and haze. (While the number of occasions of snow are distributed practically uniformly throughout the period, there is a very definite maximum number of occasions of fog or haze in the evening after sunset and in the morning just before sunrise.)

E. GOLD.

High-Level Thunderstorms in Switzerland

During the afternoon and evening of June 23rd, I observed a series of thunderstorms from an Alpine hut at 11,000 feet, commanding a wide view over the mountains, and also over the foot-hills and plains to north-west. The base of the cumulonimbus clouds was at about 12,500 feet, both over the mountains and the plains. The storms over the lower ground were more numerous and pronounced, and had not crossed the Alps, but were moving quickly from south-west, roughly parallel to them. They were elongated from south-west to north-east. There were some lower clouds with a base at about 7,000 feet and some of these slowly grew up into the thunderstorms, but it was evident that the thunder clouds were not drawing on the lower layers to any considerable extent. There were a few flashes right down to the lower hills, but most of the flashes observed were complex and more or less horizontal, ranging up to perhaps ten miles in length, roughly 1,000 feet below the cumulo-nimbus base. Brush discharges caused much hissing, and were often pronounced under cirriform anvils of little opacity. On one occasion a marked brief intensification of the discharges occurred immediately after a long flash some miles off. The noise of a brush discharge is quite different from the peculiar noise caused by a very near flash, just before the thunder, which resembles that of a red hot poker plunged into water, but is extremely brief.

A storm on July 6th moved rapidly from south-west, although the lower clouds up to 8,000 feet moved from north-east. This storm left the lower hills white with hail, and there was almost continuous thunder in the anvil.

It is of some interest to note that the cool out-rushing squalls associated with heavy precipitation in local thundersorms are not purely superficial, but extend up to 8,000 feet in storms arriving in the hills from lower ground.

C. K. M. DOUGLAS.

Whirlwind in Dungavel

The following is extracted from the climatological return made by Mr. P. E. Kirton, Observer, at Dungavel, Lanarkshire, for July:—

"A whirlwind of some violence occurred at the farm of High Dykes, situated approximately 1 mile north-east from this station. Time—5.10 p.m. on the 14th. Direction—Travelling east to west.

Considerable structural damage to farm buildings—one side of a roof being completely removed; currant and gooseberry bushes uprooted.

Owner of farm states that there was considerable noise of a hissing character. The occurrence was visible in the form of a pillar of white vapour, and he places the height at approximately 1,500 feet.

A track in the grass some 16 feet wide was visible over some 500 yards. Trees were drawn together as by suction. Slates were carried high in the air and remained poised aloft for a short period.

There was no appreciable wind at the time and no rain fell."

A. H. R. GOLDIE.

Snow in June

The climatological station at Roade reported slight snow on June 2nd, 1931; Mr. R. W. Janes, who is in charge of this station confirmed that a few snowflakes occurred, unaccompanied by rain. The minimum temperature measured at 9 a.m. G.M.T. on that day was 50°F., and at 9 a.m. next day 48°, temperature reaching 63° at some time between those hours. The synoptic weather chart for that day revealed an exceptionally well-marked nearly stationary front across northern England separating northerly winds from very high latitudes behind a Scandinavian depression and southerly winds in front of a depression far out on the Atlantic south-west of Ireland. Very heavy rain fell on the night June 2nd-3rd in northern England, but there was no measurable precipitation at Roade. Observations of temperature in the upper air showed that at South Farnborough the freezing point occurred at about 8,000 feet in the morning and at fully 10,000 feet in the afternoon; at Duxford (near Cambridge) all observations gave the corresponding heights as a little over 8,000 feet. It would be of interest to know whether any reader of this magazine observed the occurrence of sleet or snow on that day. E. V. NEWNHAM.

Insplashing into and outsplashing from the funnel of a rain-gauge

With reference to the note published under the above title,* [and to Col. Gold's article on page 153] the following comments from Mr. C. E. Golding, Forest Gate, London, may be of some interest. For June 18th, 1930, Mr. Golding measured 2·24in. of rain. Of this about 1·61in. fell in 65 minutes, and after an interval of an hour about ·63in. in 38 minutes. He writes "when the mud splashes on the outside of the gauge had dried, the highest splash was about half an inch from the top edge of the gauge. No mud had dried inside, which looks as though there was no rebound into the gauge." The gauge is of the standard pattern with the rim eleven inches above the ground. The gauge stands on short grass "rather sparse." The rain in the gauge was noted to be clean. J. GLASSPOOLE.

Totland Bay Meteorology, 1930

It gives us much pleasure to receive each year copies of the annual meteorological reports compiled by the authorities in control of various municipal and private stations. Many of these reports contain valuable summaries of data for past years and thus constitute very substantial contributions to local climatology. One of the best is supplied by Mr. John Dover, M.A., of Totland Bay, Isle of Wight. The summary for 1930, a copy of which has recently been received, contains a number of interesting tables and diagrams, including a comparison between daily mean maximum and minimum temperatures at Totland Bay and Greenwich. The Totland figures are based on 44 years' observations, while Greenwich is represented by normals for both 65 and 90 years beginning in 1841. In regard to the maximum, Greenwich is markedly warmer than Totland in spring and summer, the greater warmth at Greenwich beginning early in February and ending late in October. The mean minimum, on the other hand, is always lower at Greenwich, the effect being smallest in June.

* London, *Meteorological Magazine* 64, 1929, pages 118-9.

Readers interested in the climate of the Isle of Wight would do well to consult this report, which is, we notice, the thirty-first of the series.

News in Brief

At a meeting of the Prussian Academy of Sciences on July 30th, Dr. G. C. Simpson, C.B., F.R.S., Director of the Meteorological Office, London, was elected a Corresponding Member of the Physical-Mathematical Section of the Academy.

The Rainfall Atlas of the British Isles was published by the Royal Meteorological Society at the price of 15s. 9d. (Fellows 10s. 9d.). The Council has now decided to issue a limited edition at the price of 7s. 6d., and arrangements have been made for Fellows to obtain copies at the special price of 5s. 6d.

The Weather of July, 1931

Pressure was below normal over Canada and the United States, Iceland, Spitsbergen, north-west, central and south-west Europe including the British Isles and France, south-west Asia and a small area from Algiers to Madeira, the greatest deficits being 4mb. in Utah, 8·1mb. at Thorshavn and 6mb. south-east of the Black Sea. Pressure was above normal over Mexico, in a wedge extending over the western North Atlantic to Newfoundland and Greenland, over the southern Iberian Peninsula and most of Russia, the greatest excesses being 3·9mb. at Lat. 40° N., Long. 40° W. and 4·9mb. at Ekaterinburg. Temperature was above normal over Spitsbergen and western Europe generally except in the extreme south-west. In Sweden it was 2°-3°F. above normal in Norrland, but elsewhere normal or a little below. The rainfall in Sweden was irregularly distributed, being deficient in eastern Svealand and about twice the normal in Scania and Vesterbotten.

Unsettled weather with a moderate temperature prevailed generally over the British Isles during July. Thunderstorms were frequent, accompanied in some cases by reavy rain and sunshine was markedly below normal. A depression persisted off north-west Scotland during the first few days of the month, and dull conditions with rain at times prevailed in the north and west, 2·07in. of rain fell at Hawkshead (Lancashire) on the 3rd, although amounts elsewhere were small. In the south-east the weather was mainly dry and often sunny. Lowestoft reported 15·3hrs. of sunshine on the 3rd, when maxima exceeded 75°F. locally on the east coast. Subsequently to the 5th this depression developed into a complex low pressure area which influenced the weather over the country generally until the 20th. During this time conditions were mainly unsettled and changeable. Thunderstorms were experienced on the 5th-7th, 9th, 12th-15th and 19th. Rainfall amounts were usually small except during some of the thunderstorms and at the onset of fresh secondaries, 1·99in. fell at Oving House (Buckinghamshire) on the 7th, 1·78in. at Falmouth on the 11th, 2·07in. at Crossdoney (Co. Cavan) on the 13th, and 2·03in. at Nettlebed (Oxfordshire) on the 14th. Bright sunny periods were frequently experienced, especially earlier in the month; 14·5hrs. bright sunshine occurred at Ballinacurra (Co. Cork) on the 6th, 14·9hrs. at Deal on the 9th, 14·3hrs. at Dover on the 11th, 12·9hrs. at Rhyl on the 13th, and 12·3hrs. at Oban on the 15th. The 9th was a very warm day in east Scotland, 78°F. being reached at Leuchars and 76°F. at Dundee, but after severe thunderstorms the temperature fell considerably and maxima only rose to 51°F. and 52°F. locally on the 10th. Maxima were also below 60°F. at some places over the whole country on several other days in the month. High day temperatures occurred in south-east England on the 12th, when Greenwich reported 81°F. and Shoeburyness 80°F. On the 20th an anticyclone moved eastwards across the British Isles, and fine warm weather was experienced over most of the country on that day and the 21st. On the 23rd a depression approaching the north-west coasts caused the weather there to deteriorate, but it still remained fine and warm in the south and east; 80°F. was again reached at Greenwich on the 23rd and 24th; 14·3hrs. bright sunshine occurred at St. Ives on the 21st and 13·9hrs. at Hastings and Eastbourne on the 23rd. On the evening of the 24th the depression to the north-west moved across the country and rain, heavy at times, occurred over the whole country on the 25th, 1·59in. was recorded at Barnsley (Yorkshire). From then until the end of the month conditions were very unsettled, rain falling on most days except in parts of the south-east, but there were long bright intervals, 13·8hrs. bright sunshine occurred at St. Ives on the 27th. Rainfall was generally above normal for the month. For the fourth successive month sunshine was deficient over practically the whole country, the distribution during July being as follows:—

	Total (hrs.)	Diff. from normal (hrs.)		Total (hrs.)	Diff. from normal (hrs.)
Stornoway	104	— 41	Liverpool	150	—43
Aberdeen	83	— 76	Ross-on-Wye	131	—68
Dublin	93	— 77	Falmouth	163	—62
Birr Castle	100	— 44	Gorleston	179	—52
Valentia	145	— 14	Kew	151	—50

The special message from Brazil states that the rainfall in the northern and central regions was generally scarce, with an average 0·04in. and 0·43in. below normal and in the southern regions irregular with an average 0·20in. above normal. Pressure distribution was abnormal with 3 anticyclones passing across the country and depressions over the south and west. The crops were generally in good condition in spite of frosts.

At Rio de Janeiro pressure was 0·4mb. above normal and temperature 1·1°F. above normal.

Miscellaneous notes on weather abroad culled from various sources.

All the Swiss Alpine roads were open to vehicular traffic by the 2nd. After a long drought there were heavy rainstorms over Denmark on the 8th; the hay crops were spoiled and many bridges carried away. A severe gale occurred at Lublin (Poland) on the 21st (*The Times*, July 2nd-23rd).

It was announced on the 6th that the Nile was lower than it had been for 20 years (*The Times*, July 7th).

The monsoon was fully established at Bombay by the 3rd, and was extremely active during the month, Bombay having a heavier rainfall than normal. Good rains were reported in north Hyderabad, Malabar, Central India, and in the Central Provinces during the first part of the month, but elsewhere the rains were local. The floods in Kwangtung, which extended as far as Canton, were subsiding on the 7th. On the 26th the continuance of heavy rain in the Chinése coastal provinces and in the interior beyond Hankow were causing increasing anxiety especially for the rice crops, though farmers were endeavouring to drain their paddy fields; the railway lines had been breached in several places by the floods. Snow fell on Fujiyama on the 11th, an almost unprecedented occurrence in July. Heavy rains had fallen throughout Japan for more than a week previous to this, and also local storms (*The Times*, July 3rd-27th).

Four people were killed in a violent storm in Sydney on the 6th. The wind reached a speed of 70 m.p.h. and 5ins. of rain fell in 18hrs. Very cold weather accompanied by much snow occurred in the southern half of South Island, New Zealand, during the earlier part of the month. A severe gale was experienced in the Chatham Islands from the 17th-20th (*The Times*, July 7th and 21st).

High temperatures occurred over eastern Canada during the first few days, 96°F. being recorded at Montreal on the 1st. After this general rains fell over Canada and improved the crop prospects slightly, but later high temperatures caused further damage to crops in some sections of the prairies. Excellent conditions for the crops prevailed east of the Great Lakes. Temperature was above normal over most of the United States, being as much as 15°F. above normal at Sheridan and Reno, Mountain Regions, for the week ending the 28th. Rainfall was variable. (*The Times, July 2nd-21st, and Washington, D.C., U.S. Dept. Agric., Weekly Weather and Crop Bulletin.*)

Rainfall, July, 1931—General Distribution

England and Wales	153	per cent of the average 1881-1915.
Scotland	136	
Ireland	121	
British Isles	142	

Rainfall: July, 1931: England and Wales

Co.	Station	In.	Per-cent of Av.	Co.	Station	In.	Per-cent of Av.
Lond	Camden Square	3·00	126	*Leics*	Belvoir Castle	4·41	181
Sur	Reigate, Alvington	2·99	133	*Rut*	Ridlington	3·35	133
Kent	Tenterden, Ashenden	2·29	109	*Linc*	Boston, Skirbeck	5·18	235
,,	Folkestone, Boro. San.	3·23	...	,,	Cranwell Aerodrome	3·73	160
,,	Margate, Cliftonville	3·92	198	,,	Skegness, Marine Gdns	4·29	197
,,	Sevenoaks, Speldhurst	3·00	...	,,	Louth, Westgate	3·91	157
Sus	Patching Farm	4·28	178	,,	Brigg, Wrawby St.	4·49	...
,,	Brighton, Old Steyne	3·01	138	*Notts*	Worksop, Hodsock	3·88	171
,,	Heathfield, Barklye	4·15	166	*Derby*	Derby, L. M. & S. Rly.	3·49	147
Hants	Ventnor, Roy. Nat. Hos.	2·87	142	,,	Buxton, Devon Hos.	4·44	113
,,	Fordingbridge, Oaklnds	3·33	166	*Ches*	Runcorn, Weston Pt.	2·53	92
,,	Ovington Rectory	3·81	148	,,	Nantwich, Dorfold Hall	4·27	...
,,	Sherborne St. John	3·72	167	*Lancs*	Manchester, Whit. Pk.	3·71	112
Berks	Wellington College	4·44	214	,,	Stonyhurst College	4·23	109
,,	Newbury, Greenham	4·10	185	,,	Southport, Hesketh Pk	2·69	94
Herts	Welwyn Garden City	3·31	...	,,	Lancaster, Strathspey	5·86	...
Bucks	H. Wycombe, Flackwell	3·71	...	*Yorks*	Wath-upon-Dearne	3·29	132
Oxf	Oxford, Mag. College	3·09	136	,,	Bradford, Lister Pk	3·28	119
Nor	Pitsford, Sedgebrook	3·53	149	,,	Oughtershaw Hall	6·57	...
,,	Oundle	2·89	...	,,	Wetherby, Ribston H.	4·13	165
Beds	Woburn, Crawley Mill	3·74	168	,,	Hull, Pearson Park	3·77	161
Cam	Cambridge, Bot. Gdns.	3·30	153	,,	Holme-on-Spalding	3·45	...
Essex	Chelmsford, CountyLab	3·17	149	,,	West Witton, Ivy Ho.	3·12	119
,,	Lexden Hill House	3·49	...	,,	Felixkirk, Mt. St. John	3·80	139
Suff	Hawkedon Rectory	3·15	129	,,	Pickering, Hungate	4·19	156
,,	Haughley House	3·10	...	,,	Scarborough	3·33	137
Norf	Norwich, Eaton	3·28	127	,,	Middlesbrough	4·78	187
,,	Wells, Holkham Hall	3·65	157	,,	Baldersdale, Hury Res.	4·14	...
,,	Little Dunham	3·91	142	*Durh*	Ushaw College	3·48	125
Wilts	Devizes, Highclere	4·55	196	*Nor*	Newcastle, Town Moor	3·43	129
,,	Bishops Cannings	4·61	185	,,	Bellingham. Highgreen	5·08	154
Dor	Evershot, Melbury Ho.	4·38	173	,,	Lilburn Tower Gdns.	3·77	152
,,	Creech Grange	4·31	176	*Cumb*	Geltsdale	6·86	...
,,	Shaftesbury, Abbey Ho.	3·93	153	,,	Carlisle, Scaleby Hall	4·23	129
Devon	Plymouth, The Hoe	4·82	175	,,	Borrowdale, Seathwaite	15·90	188
,,	Polapit Tamar	6·78	251	,,	Borrowdale, Rosthwaite	11·12	...
,,	Ashburton, Druid Ho.	...	..	,,	Keswick, High Hill	7·20	...
,,	Cullompton	4·30	160	*West*	Appleby, Castle Bank	5·51	174
,,	Sidmouth, Sidmount	4·26	170	*Glam*	Cardiff, Ely P. Stn.	4·41	142
,,	Filleigh, Castle Hill	5·81	...	,,	Treherbert, Tynywaun	10·94	...
,,	Barnstaple. N.Dev.Ath	5·39	199	*Carm*	Carmarthen Friary	6·39	182
,,	Dartm'r, Cranmere Pool	9·60	...	*Pemb*	Haverfordwest, School	5·80	181
Corn	Redruth, Trewirgie	6·82	223	*Card*	Aberystwyth	4·12	...
,,	Penzance, Morrab Gdn.	5·17	190	,,	Cardigan, County Sch.	3·11	...
,,	St. Austell, Trevarna	7·47	223	*Brec*	Crickhowell, Talymaes	3·70	...
Soms	Chewton Mendip	4·99	143	*Rad*	BirmW.W.Tyrmynydd	5·01	122
,,	Long Ashton	4·45	157	*Mont*	Lake Vyrnwy	4·44	129
,,	Street, Millfield	4·11	164	*Denb*	Llangynhafal	1·54	66
Glos.	Cirencester, Gwynfa	...	...	*Mer*	Dolgelly, Bryntirion	5·71	134
Here	Ross, Birchlea	4·48	197	*Carn*	Llandudno	1·22	51
,,	Ledbury, Underdown	3·77	167	,,	Snowdon, L. Llydaw 9	16·75	...
Salop	Church Stretton	3·81	155	*Ang*	Holyhead, Salt Island	1·71	65
,,	Shifnal, Hatton Grange	3·19	142	,,	Lligwy	2·56	99
Worc	Ombersley, Holt Lock	2·54	119	*Isle of Man*			
,,	Blockley	4·29	...		Douglas, Boro' Cem.	2·89	94
War	Birminghm, Edgbaston	3·21	138	*Guernsey*			
Leics	Thornton Reservoir	3·65	147		St. PeterP't. GrangeRd.	3·28	162

Rainfall: July, 1931: Scotland and Ireland

Co.	Station	In.	Per-cent. of Av.	Co.	Station	In.	Per cent of Av.
Wigt	Pt. William, Monreith	3·61	128	*Suth*	Loch More, Achfary	7·21	135
,,	New Luce School	3·65	107	*Caith*	Wick	2·93	111
Kirk	Carsphairn, Shiel	6·79	129	*Ork*	Pomona, Deerness	...	...
Dumf.	Dumfries, Crichton, R.I	4·50	...	*Shet*	Lerwick	3·87	169
,,	Eskdalemuir Obs.	5·74	140	*Cork*	Caheragh Rectory	2·19	...
Roxb	Branxholm	3·71	123	,,	Dunmanway Rectory	3·53	91
Selk	Ettrick Manse	3·70	83	,,	Ballinacurra	2·22	79
Peeb	West Linton	4·22	...	,,	Glanmire, Lota Lo.	2·89	100
Berk	Marchmont House	4·63	152	*Kerry*	Valentia Obsy.	3·84	102
Hadd	North Berwick Res.	4·29	166	,,	Gearahameen	6·80	...
Midl	Edinburgh, Roy. Obs.	3·57	136	,,	Killarney Asylum	4·11	124
Lan	Auchtyfardle	4·44	...	,,	Darrynane Abbey	2·92	77
Ayr	Kilmarnock, Agric. C.	...	...	*W'at*	Waterford, Brook Lo.	3·23	100
,,	Girvan, Pinmore	3·46	95	*Tip*	Nenagh, Cas. Lough	4·55	145
Renf	Glasgow, Queen's Pk.	3·65	125	,,	Roscrea, Timoney Park	4·59	...
,,	Greenock, Prospect H.	4·40	112	,,	Cashel, Ballinamona	3·87	133
Bute	Rothesay, Ardencraig.	6·60	150	*Lim*	Foynes, Coolnanes	2·87	93
,,	Dougarie Lodge	3·83	..	,,	Castleconnel Rec.	4·44	...
Arg	Ardgour House	9·14	...	*Clare*	Inagh, Mount Callan	5·11	...
,,	Manse of Glenorchy	7·70	...	,,	Broadford, Hurdlest'n.	4·18	...
,,	Oban	4·11	106	*Wexf.*	Gorey, Courtown Ho.	3·96	135
,,	Poltalloch	3·95	96	*Kilk*	Kilkenny Castle	5·33	189
,,	Inveraray Castle	5·97	120	*Wic*	Rathnew, Clonmannon	2·94	...
,,	Islay, Eallabus	4·47	131	*Carl*	Hacketstown Rectory	4·57	133
,,	Mull, Benmore	13·20	..	*Leix*	Blandsfort House	3·44	110
,,	Tiree	3·59	...	,,	Mountmellick	...	...
Kinr	Loch Leven Sluice	5·27	183	*Off'ly*	Birr Castle	3·92	133
Perth	Loch Dhu	...	...	*Kild'r.*	Monasterevin	3·31	...
,,	Balquhidder, Stronvar	6·67	...	*Dubl*	Dublin, FitzWm. Sq.	3·62	141
,,	Crieff, Strathearn Hyd.	4·82	162	,,	Balbriggan, Ardgillan.	3·72	137
,,	Blair Castle Gardens	5·65	221	*Me'th*	Beauparc, St. Cloud	3·19	...
Angus	Kettins School	3·64	154	,,	Kells, Headfort	3·54	111
,,	Dundee, E. Necropolis	4·95	181	*W.M.*	Moate, Coolatore	3·39	...
,,	Pearsie House	4·60	...	,,	Mullingar, Belvedere	4·39	138
,,	Montrose, Sunnyside	4·44	169	*Long*	Castle Forbes Gdns.	4·66	149
Aber	Braemar, Bank	4·10	159	*Gal*	Ballynahinch Castle	4·76	115
,,	Logie Coldstone Sch.	4·03	136	,,	Galway, Grammar Sch.	4·24	...
,,	Aberdeen, King's Coll.	2·93	104	*Mayo*	Mallaranny	5·70	...
,,	Fyvie Castle	3·24	100	,,	Westport House	3·18	103
Moray	Gordon Castle	4·06	127	,,	Delphi Lodge	7·32	110
,,	Grantown-on-Spey	5·53	180	*Sligo*	Markree Obsy.	4·44	128
Nairn	Nairn, Delnies	4·41	165	*Cav'n*	Belturbet, Cloverhill	3·01	96
Inv	Kingussie, The Birches	4·62	...	*Ferm*	Enniskillen, Portora	...	...
,,	Loch Quoich, Loan	8·75	...	*Arm*	Armagh Obsy	5·74	198
,,	Glenquoich	9·54	149	*Down*	Fofanny Reservoir	6·54	...
,,	Inverness, Culduhtel R.	4·91	...	,,	Seaforde	2·74	86
,,	Arisaig, Faire-na-Squir	5·28	...	,,	Donaghadee, C. Stn.	2·71	97
,,	Fort William	5·11	...	,,	Banbridge, Milltown	2·74	...
,,	Skye, Dunvegan	4·51	...	*Antr*	Belfast, Cavehill Rd.	3·45	...
R & C.	Alness, Ardross Cas.	4·03	133	,,	Glenarm Castle	4·08	...
,,	Ullapool	3·11	98	,,	Ballymena, Harryville	4·19	122
,,	Torridon, Bendamph	...	...	*Lon*	Londonderry, Creggan	4·41	120
,,	Achnashellach	6·48	...	*Tyr*	Donaghmore	...	...
,,	Stornoway	2·07	..	,,	Omagh, Edenfel	5·54	163
Suth	Lairg	3·57	114	*D.n*	Malin Head	3·00	...
,,	Tongue	3·51	115	,,	Dunfanaghy	4·71	...
,,	Melvich	4·55	...	,,	Killybegs, Rockmount	4·51	104

Climatological Table for the British Empire, February, 1931.

STATIONS	PRESSURE		TEMPERATURE							Relative Humidity	Mean Cloud Am'nt	PRECIPITATION			BRIGHT SUNSHINE	
			Absolute		Mean Values				Mean							
	Mean of Day M.S.L.	Diff. from Normal	Max.	Min.	Max.	Min.	½ max. and min.	Diff. from Normal	Wet Bulb			Am'nt	Diff. from Normal	Days	Hours per day	Percentage of possible
	mb.	mb.	°F.	°F.	°F.	°F.	°F.	°F	°F.	%	0—10	in.	in.			
London, Kew Obsy.	1012·1	− 3·9	54	28	45·0	34·2	39·6	− 0·5	36·0	88	8·3	1·46	− 0·08	17	2·1	22
Gibraltar	1020·5	+ 0·5	70	42	63·9	47·7	55·8	− 0·1	47·4	77	3·5	0·18	− 4·04	6	..	..
Malta	1009·6	− 6·5	63	42	56·6	48·0	52·3	− 3·0	47·7	73	7·0	4·70	+ 2·50	20	5·6	52
St. Helena	1011·9	− 0·3	73	59	69·4	61·0	65·2	− 0·7	62·4	92	8·7	1·46	..	8	..	..
Sierra Leone	1008·4	− 2·4	92	70	89·4	72·7	81·1	− 1·2	73·3	70	3·4	0·03	− 0·27	1	..	..
Lagos, Nigeria	..	..	95	74	90·8	78·2	84·5	+ 2·3	78·9	83	9·3	1·47	− 0·60	5	..	..
Kaduna, Nigeria	1014·7	+ 1·3	97	..	92·1	..	..	..	69·9	72	..	0·00	− 0·04	0	..	..
Zomba, Nyasaland	1008·1	+ 0·2	84	65	80·3	66·6	73·5	+ 1·5	..	79	7·7	10·25	− 0·40	15	..	..
Salisbury, Rhodesia	1008·2	+ 0·7	85	57	80·6	60·6	70·6	+ 1·8	63·6	67	4·8	5·17	− 1·65	12	8·0	63
Cape Town	1014·1	+ 0·7	100	56	81·9	62·4	72·1	+ 1·8	62·6	71	3·0	1·28	+ 0·70	4	..	..
Johannesburg	1011·5	+ 1·1	86	51	77·8	56·6	67·2	+ 1·6	59·1	66	3·4	2·44	− 2·78	14	8·5	65
Mauritius	1011·9	+ 0·9	88	66	84·0	73·2	78·6	− 0·7	75·6	78	7·0	21·45	+ 13·05	24	7·4	58
Calcutta, Alipore Obsy.	1014·0	+ 0·7	91	52	83·1	63·0	73·1	+ 1·9	63·1	83	3·0	2·90	+ 1·91	5*	..	..
Bombay	1012·1	− 0·6	87	65	83·7	68·5	76·1	+ 0·4	65·6	69	0·5	0·00	− 0·03	0*	..	..
Madras	1013·0	+ 0·1	90	63	86·4	68·7	77·5	− 0·2	72·2	83	2·9	0·00	− 0·30	0*	..	..
Colombo, Ceylon	1011·3	+ 0·5	92	71	88·1	73·9	81·0	+ 0·6	75·9	74	4·2	3·48	+ 1·54	6	8·9	75
Singapore	1010·5	..	92	71	90·4	73·8	82·1	+ 2·4	..	..	..	5·91	− 0·71	10	7·1	60
Hongkong	1016·9	− 1·7	78	50	64·7	58·5	61·6	+ 2·5	58·8	85	9·9	0·55	− 1·20	9	1·0	9
Sandakan	..	..	89	74	86·9	75·2	81·1	+ 0·9	77·3	83	..	4·19	− 6·78	5	..	..
Sydney, N.S.W.	1015·5	+ 1·6	104	51	77·0	64·6	70·8	− 0·5	65·7	67	5·5	1·48	− 2·72	14	7·3	54
Melbourne	1015·6	+ 1·1	99	47	77·6	53·4	65·5	− 2·1	58·3	56	5·4	1·20	− 0·51	7	8·6	63
Adelaide	1016·6	+ 2·4	103	51	83·5	57·9	70·7	− 3·3	57·3	36	4·2	0·30	− 0·42	6	10·2	77
Perth, W. Australia	1016·1	+ 3·1	102	52	81·7	60·1	70·9	− 3·2	61·3	54	3·8	0·04	− 0·41	1	9·5	72
Coolgardie	1015·1	+ 2·6	105	50	87·9	60·5	74·2	− 2·0	59·6	39	2·3	1·21	+ 0·36	2	..	..
Brisbane	1013·5	+ 1·0	90	59	82·1	67·1	74·6	− 1·9	69·5	70	7·0	19·09	+ 12·91	13	8·0	61
Hobart, Tasmania	1011·7	− 1·5	85	41	71·0	51·6	61·3	− 1·0	56·4	50	5·2	2·10	+ 0·62	11	8·2	59
Wellington, N.Z.	1014·7	− 1·1	73	42	63·2	50·8	57·0	− 5·6	53·7	73	6·5	1·63	− 1·51	7	7·9	58
Suva, Fiji	1005·2	− 2·6	88	72	84·9	75·6	80·3	0·0	76·1	83	8·0	21·52	+ 10·80	21	4·8	38
Apia, Samoa	1005·4	− 3·0	88	73	85·2	75·8	80·5	+ 1·5	77·7	83	8·2	19·71	+ 4·42	23	4·5	36
Kingston, Jamaica	1013·2	− 2·1	91	62	86·2	69·5	77·9	+ 1·4	67·2	81	2·9	0·16	− 0·44	3	9·6	83
Grenada, W.I.	1013·3	− 0·2	90	71	87·3	73·2	80·3	+ 3·2	73·6	75	4·2	3·34	+ 0·56	19	..	..
Toronto	1018·2	+ 0·2	43	0	33·2	20·0	26·6	+ 5·5	22·5	75	6·2	1·13	− 1·25	8	4·2	40
Winnipeg	1019·6	− 2·2	40	−21	26·3	9·5	17·9	+17·8	..	..	5·0	0·18	− 0·56	2	5·2	51
St. John, N.B.	1013·6	− 0·3	43	− 6	29·7	16·9	23·3	+ 3·4	17·5	69	7·0	3·61	− 0·29	12	3·1	30
Victoria, B.C.	1016·8	+ 0·2	51	32	47·4	38·9	43·1	+ 2·6	40·9	90	7·5	3·22	− 0·04	14	3·9	38

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

M.O. 340.

The Meteorological Magazine

Vol. 66

Sept., 1931

No. 788

Air Ministry :: Meteorological Office

LONDON: PUBLISHED BY HIS MAJESTY'S STATIONERY OFFICE
To be purchased directly from H.M. STATIONERY OFFICE at the following addresses: ADASTRAL HOUSE, KINGSWAY, LONDON, W.C.2; 120, GEORGE STREET, EDINBURGH; YORK STREET, MANCHESTER; 1, ST. ANDREW'S CRESCENT, CARDIFF; 15, DONEGALL SQUARE WEST, BELFAST; or through any Bookseller.

The Meteorological Office Library and Museum

The centenary meeting of the British Association will bring to South Kensington scientists from all parts of the Empire, and on September 25th a party will visit the adjacent building of the Meteorological Office. The occasion seems to be opportune for a brief description of our library and museum, with references to some of the exhibits of historic interest.

The Meteorological Office was first constituted in 1855 as the "Meteorological Department of the Board of Trade" under the leadership of Admiral Fitzroy. In the early reports of the new Office no mention is made of the formation of a library, but no doubt a number of publications were received in exchange for the series of *Meteorological Papers of the Board of Trade* which began in 1857, and some of the earliest volumes in our library bear the stamp "Board of Trade, Meteorological Department." Thus the library of the Meteorological Office may be said to have been founded soon after 1855. The three-quarters of a century which has elapsed since that date covers almost the whole history of the development of meteorology as a separate science, and thanks to this early beginning our library is one of the most representative in the world.

In 1867 the control of the Meteorological Office was transferred to a Meteorological Committee appointed by the Royal Society, and the estimates for the following year contain for

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the first time provision for the purchase of books. In 1871 we find the first mention of a librarian, Mr. J. S. Harding, Junr. The number of books grew rapidly, but the arrangements for housing them were crude, until the erection of the new Meteorological Office building at South Kensington, which was completed in 1910, gave an opportunity for the provision of more adequate accommodation. The library now includes upwards of 25,000 volumes, apart from reprints and pamphlets. Two manuscript catalogues are maintained, author and subject, and in addition there is a comprehensive index, arranged geographically, to the literature of local climatology and a less complete index of upper air data. A classified list of meteorological literature is issued monthly, and forms the basis of the semi-annual *Bibliography of Meteorological Literature* published by the Royal Meteorological Society.

In addition to the library, space is provided for a small museum, permitting the display of books, diagrams and instruments of historic or scientific interest. Among the books exhibited may be mentioned part 3 of Dampier's "Voyages and Descriptions," entitled "A discourse of trade winds, breezes, storms, seasons of the year, tides and currents of the torrid zone throughout the world . . ." (London, 1700); "The general history of the air, designed and begun by the Hon. Robert Boyle" (London, 1692); "The storm," by Daniel Defoe (First edition, London, 1704); and a treatise on barometers, thermometers and hygrometers, published at Amsterdam in 1688. There is also a reproduction of the earliest known (British) journal of the weather, kept by the Rev. W. Merle from 1337 to 1344. Other exhibits include a selection illustrating the history of the *Daily Weather Report* from 1851 to date, and weather logs kept on board H.M.S. *Beagle* in 1843. Some of the instruments of historic interest are described below.

Some Instruments of Historic Interest exhibited at the Meteorological Office, London

By J. E. Belasco, B.Sc.

The 17th and 19th centuries are landmarks in the history of the science of meteorology. The 17th century saw the invention of the barometer, thermometer, hygrometer, anemometer and the earliest scientific rain-gauge. In the 19th century regular meteorological services were established in England and other countries, the first synoptic chart was produced and the first *Daily Weather Report* issued. The *Daily Weather Report* needs, as one of the foundations for its success, accurate instruments, easy to manipulate so that reliable observations can be obtained rapidly. The period between the experiment of Torricelli in 1643 and the publication of the first *Daily Weather Report* in 1851—a period which included the first explorations of the upper atmosphere—was marked by the appearance and improvement of a large number of instruments of ever-increasing accuracy. True it is that many of these instruments are crude and cumbersome in comparison with those we use to-day, but none the less as pioneers they are worthy of our regard and respect. Some of these in use about the middle of the 19th century have been preserved and are exhibited at the Meteorological Office, South Kensington. It is thought that it might be of some interest to our readers to bring them to their notice. Short descriptive notes, indicating the method of working, are added for the benefit of those who might wish to see the instruments.

Sunshine Recorders.—There are two main methods by which the duration of sunshine has been recorded in this country, photographically or by concentrating the sun's rays so that it scorches or chars a piece of cardboard or wood. In both cases the effect travels along by virtue of the earth's rotation, thus leaving a record of the duration of the sunshine.

The first burning type was invented by John Campbell in 1853. The instrument consisted of a hemispherical bowl of wood in the middle of which rested a spherical water or glass lens whose centre was coincident with that of the bowl. The sun's rays, focussed by the lens, burnt into the wood, the position of the burn altering from day to day with the changing declination of the sun. In this manner it was possible to obtain, between one period and another, a rough comparison of the duration and intensity of the sunshine. Later a better comparison than that made by mere inspection was obtained by rubbing wax into the grooves. The wax was then weighed after melting. Two such bowls used at Kew during the periods from December 21st, 1885, to June 21st, 1886, and from June 21st to December 21st, 1889, as well as an unused one, are exhibited.

In 1879 Stokes placed the glass lens upon a pedestal and substituted for the wooden bowl a zodiacal frame containing slots into which a strip of cardboard was placed daily to receive the focussed rays of the sun. An example of one such frame used at Dublin University from 1879 to 1914 is shown. In this instrument there is no adjustment for latitude. Such an adjustment was introduced in 1901 by Curtis, and there is a model illustrating this improvement.

When the solid glass spherical lens is exposed near the coast in sandy districts it is sometimes so pitted by sand blown about by the wind that it entirely loses its transparency and looks like ground glass. An example of a sphere exposed at Spurn Head so transformed is shown.

Hygrometers.—The humidity of the air can be determined in various ways, and those instruments which determine it without any assumption as to the properties of materials or the laws of evaporation from wet surfaces are called "absolute" hygrometers. Such hygrometers as those named after Daniell, Dines and Alluard are well-known examples by means of which the dew point can be determined. Examples of these are exhibited.

As early as 1696 Fontana determined the increase in weight of a glass of cold water resulting from the condensation of vapour on the outside, and Soldner in 1809 noted the temperature at which dew appeared. It was in 1819 that Daniell designed his hygrometer, and this is the first instrument of its kind which can lay claim to precision. It consists, as the specimen shows, of a glass tube bent twice with a bulb at each end. One bulb is blackened and partly filled with ether, and in the limb above it is a thermometer. The other bulb is covered with muslin and is filled with ether vapour. The tube rests upon a support to which is attached a thermometer. To use the instrument a little ether is poured on the muslin until a ring of dew is formed on the black bulb, when both thermometers are quickly read. These give respectively the temperature of the air and the dew point. It was from observations of the dew point by this instrument compared with the dry and wet bulbs that James Glaisher produced his table of factors for obtaining the dew point from the readings of the wet and dry bulb thermometers and so obtained his tables of relative humidity.

G. Dines produced his hygrometer in 1871. In this instrument the dew point is determined by noting the temperature at which dew is deposited on a sheet of glass. Three specimens are shown. In two of these the sheet of glass is horizontal, in the third it is vertical. Ice-cold water is poured into the cistern, whence it flows under a thermometer to a small chamber covered by a thin black glass plate and in which rests the bulb of the thermometer. The temperature of the glass plate is lowered as the water flows out at the extremity of the hygrometer, and when lowered to the dew point a film of moisture forms on it. The temperature as indicated by the thermometer at this instant is the dew point.

Alluard's hygrometer is a modification of that used by Regnault and was brought out in 1877. A brass box containing ether is fitted with tubes to allow the passage of air through the ether. The front of the box is gilt and highly polished, and it is upon this surface that the dew is deposited.

An interesting form of psychrometer, not of great scientific value and now obsolete, is the one exhibited and made by West. It is a combination of Six's thermometer, used as the dry bulb, with a mercurial wet bulb attached. This instrument is therefore a combination of four instruments, namely, maximum, minimum and true temperature thermometers and a hygrometer of the evaporation type.

Evaporimeters.—These instruments attempt to deal with the difficult problem of the loss of water by evaporation. The Lamont evaporimeter exhibited was designed in 1868 and in essence consists of a curved pan from the middle of which is a narrow pipe leading to a vertical cylindrical reservoir containing a close fitting piston, the position of which is adjustable by means of a screw and its height determined by a scale. The piston is screwed up so as to allow the water in the evaporation pan to run into the reservoir leaving the connecting tube full so that the water just makes the curved surface of the bottom of the pan continuous. The scale is then read and the water driven by the piston to within a little of the top of the pan and evaporation allowed to proceed. The piston is then raised so that the water sinks once more from the pan to the same point as before and the scale read. The difference of readings in scale divisions gives the depth of water evaporated.

Another form of evaporimeter exhibited is De La Rue's atmidometer produced in 1879. Here water evaporates from a surface of wet parchment paper stretched over a shallow drum full of water. The water is supplied from a reservoir giving about 6 inches head. The reservoir is connected by a long narrow metal tube to a graduated glass cylinder about 6 inches high. This cylinder is filled with water and the tube which leads from it and which dips into the reservoir is perforated laterally. Hence, when by reason of evaporation, the lateral opening is exposed to the air, water flows from the glass cylinder to the reservoir so that a constant level of water is maintained in the reservoir and the amount of water evaporated is therefore indicated by the graduations in hundredths of an inch on the glass cylinder. Both the Lamont and De La Rue evaporimeters are now obsolete.

Sympiesometer.—This form of barometer was mainly used in the early half of the 19th century to obtain more satisfactory observations of pressure at sea. Its use became obsolete upon the adoption of the Kew barometer after 1856. In the sympiesometer the atmospheric pressure is balanced partly by a liquid and partly by air enclosed above this liquid. Since the indications of the instrument depend upon the temperature as well as the pressure of the air, it is also an air thermometer and is thus often called a thermo-barograph. In the log of H.M.S. *Beagle* (1843), which carried Darwin, observations with the sympiesometer are recorded three times a day.

A sympiesometer, invented by Runketti in 1839, is exhibited. This instrument consists of a U-tube, the shorter arm of which has two bulbs, one above the other, while the longer arm is closed by a screw cap. Enclosed in the sealed upper bulb is the bulb of a thermometer, the lower bulb being filled with mercury which rises to a considerable height in the longer arm. A tap, below the lower bulb, enables one arm to be shut off from the other. On one side of the longer arm is fixed a graduated scale similar to the scale of the thermometer, and on the other side is mounted an adjustable barometer scale in which a vernier with a pointer slides. To take a reading the arrow on the barometer scale is set opposite the same scale reading as that registered by the thermometer and the height at which the mercury stands is read off on the barometer scale and vernier after bringing the pointer to the top of the mercury column.

There is also to be seen a sympiesometer on similar lines by Cox; the closed bulb at the top of the tube probably contained hydrogen, the tube itself being filled with oil or sulphuric acid. The readings obtained were set on the revolving scale at the bottom of the instrument.

Aneroids.—Very early in the history of the aneroid barometer —it was introduced by Vidie in 1843—is the metallic barometer of Bourdon which can be seen. It was invented in 1851 and consists of a thin elastic metal tube exhausted of air. The tube is bent and the ends approach or recede from each other according as the pressure increases or decreases. The motion, by suitable gearing, is communicated to a central shaft which carries an index hand moving over a dial graduated in inches. Another form of aneroid exhibited is that by Dent, introduced in 1848. Like the Vidie aneroid it consists of a shallow capsule of thin metal almost exhausted of air, the amount of air left over being used to make automatic corrections for temperature.

Barograph.—The Redier barograph exhibited is a modification by Redier in 1875 of Regnard's barometrograph of 1857. It provides a continuous record of a syphon barometer by the differential action originating from a clock, the motive force of the mercury being too small to overcome the friction of the pen on the paper.

Storm Glass.—Mention must be made of this instrument which Admiral Fitzroy attached to his barometer. It consists of a glass tube filled, it is thought, with crystals of potassium nitrate and ammonium chloride in an alcoholic solution of camphor and distilled water. Air fills the upper part of the tube. It was claimed that in stormy weather the liquid became turbid while in fine weather the liquid was clear, the crystals remaining at the bottom of the tube. Opinions differ as to the cause of these changes in the appearance of the liquid. Admiral Fitzroy regarded the changes as dependent upon the direction of the wind, Tomlinson as due to changes of light and heat. In this connexion the opinion of Faraday is of interest at this juncture. In a letter to Fitzroy in 1861, a photograph of which is exhibited, Faraday says that he regarded the instrument as an old friend for it used to absorb much of his attention when he was younger. He was not quite sure of the materials used to make up the instrument, but he thought it contained alcohol, water, carbonate of potassium and hydrochlorate of ammonium. As far as he knew the changes were the effect of changes of temperature taking place with more or less rapidity, the time being important in relation to the appearance of the crystals.

Portable Anemometers.—A form of anemometer for ascertaining the strength of the wind invented by Lind in 1775 is exhibited and consists of a U-tube one end of which is closed, the other open and facing the direction of the wind. The pressure of the air is measured in terms of the altitude of a column of water at any desired instant. In other forms of Lind's anemometer both limbs were open, but a partition separated them at the top so that one mouth was protected from the wind. A modification of Lind's anemometer by Sir Snow Harris in 1858 is shown. It consists of a long bent glass tube closed at one end, the other end terminating in a bulb open to the air. The upper portion of the tube is provided with a scale. Coloured liquid is poured into the bulb until it reaches the zero of the scale. When the instrument is levelled the tube is turned so that the bulb faces the wind. The portion of the liquid column along the scale indicates the pressure and velocity of the wind, while the direction of the wind is obtained from the compass at the base of the instrument. Another modification of Lind's anemometer by Sir Snow Harris is also exhibited. Here the mouth of the limb which receives the wind has a movable cup closed at one end so that on inserting it the tube can be closed in order to record any desired gust.

The Hagemann Hand anemometer exhibited is a modification by Ellery in 1881 of Hagemann's original instrument. It consists of a U-tube mounted on a wooden frame. Alongside both limbs of the tube is a graduated scale. The shorter limb has a funnel-shaped opening and faces the direction of the wind. The longer limb is also open to the air. The difference of level of the liquid in the two limbs gives the pressure of the wind.

The *Munro Air Meter* is an early forerunner of the modern vane air meter. The specimen exhibited shows that it consists of a vane of thin aluminium of helicoid shape which is revolved by the wind. A train of wheels and a dial record the number of revolutions made in any desired interval of time.

The Rainfall of the Past Summer

The series of violent gales and rainstorms which characterised the month of August, 1931, completed one of the wettest summers experienced in England and Wales since comparable records began. Further, when allowance is made for the usual seasonal variation by expressing the amounts as percentages of the normal for the 35 years 1881-1915, the period April to August, 1931, stands out as one of the wettest series of five consecutive months known. The comparative figures are as follows, those for earlier years being extracted from a table by Dr. J. Glasspoole*; 1927 is from the *Meteorological Magazine* :—

WET PERIODS OF 5 MONTHS, PERCENTAGE OF NORMAL.

	England and Wales	Scotland	Ireland	British Isles
1931 Apr. to Aug. ...	153	128	130	141
1927 June to Oct. ...	151	145	125	142
1924 May to Sept. ...	149	141	150	147
1911 Nov. to 1912 Mar. ...	151	121	134	139
1903 June to Oct. ...	156	144	139	150
1891 Aug. to Dec. ...	139	126	129	133
1876 Sept. to 1877 Jan. ...	157	134	168	152
1872 Sept. to 1873 Jan. ...	152	146	160	152

The percentages of normal month by month during 1931 are shown below :—

	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.
England and Wales ...	103	124	36	173	150	148	153	143
Scotland ...	128	118	42	106	145	193	136	61
Ireland ...	88	104	101	111	162	174	121	81
British Isles	107	118	51	143	151	165	142	104

The weather of August in England and Wales was characterised by an extraordinary series of violent storms, hardly a day from the 3rd to the 20th inclusive passing without a " note worthy " fall. The following list shows the more outstanding records.

Aug. 3rd.—A violent thunderstorm occurred in London and south-east England shortly before midnight, 0·75in. of rain being recorded at Clacton between 5 p.m. on the 3rd and 9 p.m. on the 4th.

Aug. 4th.—Storms in Gloucestershire, Wiltshire and Oxfordshire. The heaviest totals recorded by the Press were 5·10in. at Wylye, 4·49in. at Steeple Langford, and 4·44in. at Salisbury, all in Wiltshire. Records communicated to the Meteorological Office include 3·03in. at Nailsworth (Glos.), and 1·89in. at Magdalen College, Oxford.

On the night of the 4th 1·14in. fell at Cleethorpes, Lincs., between 5 p.m. and 9 a.m., with a further 0·47in. during the following day.

Aug. 5th.—Storms in south-east England and in Cornwall. London was again affected, more than 1in. being recorded on the Air Ministry roof in 30 minutes. Other totals were 2·90in. at Petersfield (in less than an hour); 2·39in. at Heathfield, Barklye, Sussex; 2·05in. at Surbiton, 1·67in. at Bury St. Edmunds and 2·21in. at the Royal Observatory, Greenwich. At Kew Observatory an inch fell in 33 minutes and at Mostyn Road, Merton Park, 0·88in. in 25 minutes. At Launceston in Cornwall, Mr. R. B. Rogers recorded 2·05in. between noon and 5.30 p.m., including

* *London, Q.J.R. Meteor. Soc.*, 52, 1926, *p.* 367.

0·98in. in less than 25 minutes, while there had been a further fall of 0·85in. on the preceding night.

Aug. 7th.—2·00in. fell at Penrhyn Quarries, Carnarvon.

Aug. 8th.—Violent storm and severe floods at Boston. Mr. F. H. Tomes, A.M.Inst.C.E., writes that at Black Sluice, at the south end end of the borough of Boston, 6·10in. fell between 10 a.m. on the 8th and 1 a.m. on the 9th. The time between 10 a.m. and 1.45 p.m. accounted for 4·96in. The total between 6 a.m. on the 8th and 1 a.m. on the 9th was 6·55in. At Grand Sluice, the north end of the borough, the amount measured at 9 a.m. was 5·72in. Other falls in the 24 hours were:—

Bourne, 21 miles south-west of Boston	1·24in.
Bardney, 22 miles north-west of Boston	1·33in.
Lade Bank Engine. 8 miles north of Boston ...	2·01in.

Mr. Tomes continues: "The point of maximum rainfall appears to have been immediately south of Boston and the worst flooding occurred in the borough and the parishes of Skirbeck Quarter, Wyberton, Frampton and Kirton. Unfortunately I have no records for these latter areas."

It was unfortunate that the heaviest rain came at the time of high water. As the land is below sea-level the sewer outlets were closed and in one part, the streets were flooded to a depth of four feet. On the same day 3·63in. fell in 24 hours at Sheringham, Norfolk. The storm was associated with the rapid passage of a deep depression directly across England from the Bristol Channel to East Anglia.

Aug. 14th.—London was again visited by a severe thunderstorm. The records so far available include: 2·34in. at Worcester Park, 2·15in. at Streatham, 1·72in. at Catford, 1·17in. at the Royal Observatory, Greenwich, and 1·12in. at Kew Observatory. Flooding occurred in the London district. Falls exceeding an inch were also recorded at places in the west Midlands, and a short storm at Eastbourne gave 0·74in. in 20 minutes.

Aug. 17th.—A heavy fall at South Shields gave a total of 2·38in. in 24 hours, of which 1·95in. fell in 2 hours 20 minutes between 11.45 a.m. and 2.5 p.m.

Aug. 19th.—Lt.-Col. the Lord Wynford, D.S.O., recorded 2·28in. at Maiden Newton, Dorchester, between 2 and 4.30 a.m. on the 19th. The greater part fell between 3.45 and 4.30 a.m. At Ipplepin Vicarage, Devon, 1·93in. fell in the 24 hours ending at 9 a.m. on the 19th, and at Torquay 1·77in. fell between 5 p.m. on the 18th and 9 a.m. on the 19th. Later on the 19th falls of more than an inch occurred at many points along the south coast, including the Channel Islands. There was also a severe thunderstorm in Lancashire, and a total of 1·42in. was recorded at Leuchars, in Fife.

Aug. 20th.—Heavy rains fell in south and central Scotland, the record at Inchkeith being 1·38in. Heavy rains also fell in the Midlands of England, while a small whirlwind of unusual force passed over Chislehurst and Foot's Cray, doing some damage.

Aug. 24th.—Heavy rains fell in the Channel Islands. At St. Peter Port, Guernsey, the fall between 7 a.m. on the 24th and 7 a.m. on the 25th amounted to 2·72in., and at Jersey from 10 a.m. on the 24th to 10 a.m. on the 25th to 3·23in. In Jersey in the 40 hours from 6 p.m. on the 23rd to 10 a.m. on the 25th the total amount was no less than 4·53in.

In striking contrast to the heavy rains in the south of England, northern Scotland enjoyed the finest weather. The total rainfall of the whole of August at Lerwick, in the Shetland Isles, was only 0·25in. By the end of the month, the rivers and streams in the western Highlands were unusually low.

OFFICIAL NOTICE

Discussions at the Meteorological Office

The series of meetings for the discussion of recent contributions to meteorological literature, especially in foreign and colonial journals, will be resumed at the Meteorological Office, South Kensington, during the session 1931-2. The meetings will be held on alternate Mondays at 5 p.m., beginning on Monday, October 19th, 1931, when Dr. G. C. Simpson, C.B., F.R.S., will open the discussion.

The dates for subsequent meetings are as follows:—

November 2nd, 16th and 30th; December 14th, 1931; January 18th; February 1st, 15th and 29th; and March 14th, 1932.

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

OFFICIAL PUBLICATION

The following publication has recently been issued:—

Annual Report *of the Director of the Meteorological Office presented by the Meteorological Committee to the Air Council for the year ended March 31, 1931.*

The work of the Meteorological Office during the year has shown a steady increase resulting from the greater use of meteorology which is made in many different spheres. The Office was especially occupied in carrying into effect the decisions made at three important conferences held in 1929, namely, the International Conference on Safety of Life at Sea, the Conference of Empire Meteorologists and the International Conference of Directors of Meteorological Services.

These have involved certain changes in the collection of meteorological data both from land stations and from ships at sea. Owing chiefly to the growing requirements of aviation, the system by which each country broadcast data for its own stations tended to become unworkable because of interference, and arrangements have been made for the issue of grouped reports from powerful stations by the Meteorological Offices of France, Germany, Great Britain, Russia and the United States. The changes in the collection of reports from ships at sea are less fundamental because the conferences accepted in the main the practices which had already been developed by the British Meteorological Office.

During the summer of 1930 the organisation for the supply of meteorological information to airships was brought into action during the successful flight of R.100 to Canada and back, but on October 5th, the Office suffered a great loss in the death of Mr. M. A. Giblett, Superintendent of the Airship Services Division, in the disaster to the R.101 on the flight to India.

An important investigation into the strucure of wind, on which Mr. Giblett was engaged prior to these flights, was completed by his colleagues during the year.

Correspondence

To the Editor, *The Meteorological Magazine.*

Infra-lateral Arc of Contact

I was fortunate enough to observe on August 28th last the somewhat rare infra-lateral arc of contact to the solar halo of 22°. The halo was present nearly all day, and the arc appeared at 8h. 4m. for a few minutes and reappeared a little while after. It was a brilliant white, the intensity being about the same as that of the halo itself.

S. E. Ashmore.

Windwhistle Cottage, Grayshott, Hindhead, Surrey. September 2nd, 1931.

Alto-cumulus Castellatus and Mammato-cumulus Clouds

I am much interested to read Capt. Douglas's notes on the turret cloud, and also Mr. Pick's letter on the subject of mammato-cumulus. It struck me with regard to the latter that Mr. Humphrey's remarks apply to England also more than Mr. Pick suggested, because there are three distinct types of mammato-cumulus—

1. That associated with stratified cumulus.
2. The mammillated appearance immediately behind the edge in a trough-squall cloud and a northerly shower cloud.
3. Mammato-cumulus proper; the festooned under-side of a hybrid cirrus sheet. It seems likely that it is only this last that Mr. Humphreys referred to, and it must be admitted that generally only those cumulo-nimbus clouds which are sufficiently developed to produce slight thunder assume this form, though I have never seen it with a severe thunderstorm.

With regard to Capt. Douglas's observations of turret-cloud, I am surprised at the great preponderance of the south-west upper current. In most cases I have observed, the south-west upper current generally backs to south or to south-south-east before the actual occurrence of the storm, and practically all the severe turret-cloud storms I have noticed, such as those of May and July, 1925, have come with an upper current well in the south-east quadrant, and on three occasions the turret-clouds finally appeared moving from a point north of east.

Would it not be a good thing to designate the turret-cloud cumulo-nimbus, alto-cumulo-nimbus, as the behaviour and structure of the cloud both differ substantially from that of the ordinary cumulo-nimbus?

P. Petrocokino.

Jack Straw's Castle, Hampstead. July 11th, 1931.

Funnel-Cloud near Newquay, Cornwall

On August 22nd, 1931, at 13h. 45m. G.M.T. while attending motor-cycle races in a field 1·3 miles east of Newquay with the surface wind NW., force 3, we observed, to the south, a "funnel-cloud" projecting from the lower horizontal edge of a large dark cumulo-nimbus cloud. There was a sky line about a mile to the south, so that it was difficult to estimate the distance and position; but we judged it to be over somewhere near Summercourt to Newlyn Downs about four miles away. The cloud was drifting slowly from the left or east and rain was falling from it to the right or south-south-west. The sky was clear of heavy cloud from about east-south-east through north to south-west and in the zenith.

The conical funnel had mostly well-defined edges; the lower portion was roughly cylindrical and crooked and indistinct and hardly joined to the conical part and lasted only about a minute. The conical part lasted for 8 minutes from time of being first observed, and moved slowly, with the cloud, to the right.

C. C. VIGURS.
JOHN T. C. VIGURS.

St. Michael's House, Newquay. August 26th, 1931.

"Cold-front" Cloud

At about 4 p.m. on Wednesday, August 5th, 1931, I was flying towards Calais along the coast from Ostend and encountered a thunderstorm over the town. After an unsuccessful attempt to fly round it inland to the aerodrome at St. Inglevert, I returned to the eastern side of the town and commenced the Channel crossing.

I then observed that a small, detached, white cloud which I had seen about 10 or 15 minutes before floating low down over the water had apparently grown out across the Channel until, within the time stated, it was many miles in length and joined a narrow promontory of white cloud, not more than a hundred feet or so wide, lying within a few feet of the water and receiving frequent lightning discharges from above. I was flying from Calais on a true bearing of 311° and my course was parallel to and about half a mile east of this cloud, which I watched with considerable interest, feeling that it would be highly dangerous to cross over it.

After flying about eight miles out to sea I encountered rain and deemed it desirable to turn back and land at Ostend, which I did. The top of the cloud was similar in appearance to that of any harmless cumulus cloud. The under side was striated, as though rain were falling from it.

I regret that owing to lack of experience in these matters I cannot give a more accurate account of what I regarded as a very curious meteorological phenomenon.

R. P. J. DENMAN.

Kester, Kemsing, Kent. August 7th, 1931.

When forwarding the above letter from Mr. Denman, Mr. R. A. Watson remarks that:—

"It appears probable that Mr. Denman was flying along a 'cold front' in which the cold air above had over-run the cold air below, such as that described by Sutcliffe.* Probably the line of cumulo-nimbus above was the ordinary line-squall cloud, but below this a tongue of warm air protruded into the cold wedge forming another line-squall cloud immediately beneath. The point which impressed Mr. Denman was the extraordinary speed with which the lower "promontory" of cloud rushed out to sea . . . It is apparent, however, that an unstable shape might be propagated along a cold front (with all its attendant phenomena) at a speed far exceeding any which we ordinarily observe in meteorological elements."

The Splashing of Rain

Referring to Colonel Gold's interesting article on the splashing of rain in your August number, some data regarding the height to which water drops may splash was recently obtained by noting dirt marks on the glass side of a verandah. A leak in the roof permitted drops to fall through the verandah in one spot on to the ground below, which consisted of loose earth. A puddle formed here. Splashes of dirty water from this puddle left marks on the glass side of the verandah about a foot away. The highest mark was 2ft. 8in. above the floor and marks at 2ft. 6in. were fairly numerous. The dried splash marks consisted of crescents of dirt, not mere points; the splashes had, therefore, been of considerable size. At the time when the observation was made no rain was falling, so that the size of the falling drops which gave rise to the splashing could not be determined, but there can be little doubt that they would be fairly large drops. The distance through which they fell from the verandah roof was about 9 feet.

J. S. DINES.

Frost in August

The unusual occurrence of a screen minimum of 32°F. during August was recorded here at 6h. on August 26th. Thermometers exposed one inch and two feet above short grass fell to 26°F. and 30°F. respectively.

Heavy hoar-frost had developed by 22h. on the 25th, and at 6h. on the 26th the whole countryside was white. Ice about 1 mm. thick formed on shallow pools in the neighbourhood.

*London, Meteorological Office, Professional Notes, No. 62.

Valley mist from 22h. to 24h. on the 25th was followed by moderate fog until 6h.

E. L. HAWKE.

Caenwood, Rickmansworth, Herts. September 5th, 1931.

May and September Maximum Temperatures

On setting down the mean maximum temperatures at Kew for May and September for each of the three twenty-year periods from 1871 to 1930, as is done in the accompanying table, a curious result becomes apparent:—

Period	Mean Maximum Temperature May	September
1871-1890	61·1°F.	64·3°F.
1891-1910	61·4°F.	65·0°F.
1911-1930	63·7°F.	65·2°F.

The result is that there appears to have been a progressive rise in the temperature of each of the two months considered. It would be interesting to know whether this increase can be supported by other evidence and whether it is to be regarded as a real climatic fact.

WILLIAM H. PICK.

33, *Brunswick Square, London, W.C.*1. *August 5th,* 1931.

[The increase in the mean maximum temperatures of May and September is presumably connected with the increase in the average daily temperature of the winter half-year, which has been traced over a wide area in Europe*, reaching a maximum in Hungary. Examination of average curves of temperature at Kew for 1871-1900 and 1901-1929† shows that the second period was markedly warmer than the first in January, February, March, May, October and December, slightly warmer in July and September, and about the same in the other months.

It is open to discussion for how long a change of this nature must continue before it can be regarded as a real change of climate instead of a temporary fluctuation, but one would hesitate to say that the change pointed out by Mr. Pick has reached the former status as yet.—ED., *M.M.*]

NOTES AND QUERIES

Transparent Hail

Although hail showers are frequently observed in air currents of polar origin the occurrence of transparent hail is much less common, and the occasion of a rain and hail shower at Holyhead at 14h. G.M.T. on April 1st, 1931, is worthy of note.

The observations below were made by Mr. H. L. Pace. He states that the hail pellets were small and of no definite shape

* *Meteorological Magazine*, 57, 1922, *p.* 203.

† *London, Q.J.R. Meteor. Soc.*, 56, 1930, *p.* 377.

and melted a few seconds after reaching the ground. The sky was covered with stratus and alto-stratus clouds, the base of the stratus cloud being estimated at 4,000 to 5,000 feet. No cumulo-nimbus or similar cloud was observed. Measurements obtained during a pilot balloon ascent at 12h. G.M.T. gave a surface wind E. by S., 23 m.p.h., which veered to S. by E., 45 m.p.h. at 5,000 feet. Vertical velocities obtained by the tail method amounted to 160 ft./min. upwards in the 7th minute (3,000 to 3,500 feet) and to 180 ft./min. downwards in the succeeding minute, while at lower levels the vertical velocities were less than half these values. At the time of the hail shower the surface temperature was 45°F. and the relative humidity 50 per cent.

In attempting to provide an explanation of the formation of the transparent hail one cannot use any direct measurement of upper air temperatures. At Duxford on the morning of April 1st the air mass, at least in the lower levels, was quite different in origin from that at Holyhead. If, however, one assumes a temperature lapse rate at Holyhead of 3°F. per 1,000 feet, this would give a temperature of 33°F. at 4,000 feet or approximately freezing point at or near the cloud base. The lowest layers of the cloud would then form the supercooled region. The transparent nature of the hail and the small size of the pellets indicate the formation of drops in the supercooled region and a relatively short distance of fall in the cloud. For a drop of diameter 1mm. a vertical velocity of 196 ft./min. would be sufficient to keep the drop stationary, and this velocity is of the order measured just below the cloud.

The drops could have been formed only a short distance above the cloud base, and in falling would not increase in size very much. If locally the vertical currents were strong the drops would acquire various ellipsoidal shapes and solidify in these forms. Further, if the vertical currents did not extend into the region of snow in the cloud the drops observed would remain quite clear.

Such a scheme could account for the small size, irregular shapes and the clearness of the hail stones observed.

R. S. Read.

Mammato-cumulus at Amesbury, Wilts.

Very well-developed mammato-cumulus was observed at 18h. 40m. G.M.T. at Amesbury on April 17th, 1931. A heavy shower of rain and hail commenced about 18h. 15m. and continued until 18h. 40m. After the shower had ceased, looking towards the south-east, nearly the whole sky up to the zenith was filled with heavy mammato-cumulus. There was a clearance to the north-west. The " festoons " were well developed and very large. It was estimated that in some cases the bottom of the " festoons " were about 300 feet below the main cloud level. The mammato-cumulus occurred in polar air whose origin was to the north of the Arctic Circle.

It is of interest to examine the pressure distribution existing at the time. A depression over the North Sea was moving south-south-east, while a cold air current behind it had spread southwards over the British Isles. The main cold front associated with the depression over the North Sea passed Larkhill at 7h. 45m. on the 17th. An aeroplane ascent at Duxford at 9h. 15m. showed a steep lapse rate up to about 6,000 feet with a stable lapse-rate above. Another ascent at 13h. on the same day, when the front had moved southwards to north France, gave a lapse-rate almost equal to the dry adiabatic up to 14,000 feet. Rain and hail showers had developed by this time and " anvils " were numerous. At 13,000 feet there had been a drop in temperature of 12°F. since the morning ascent.

The heavy shower at 18h. 15m., after which the mammato-cumulus was observed, probably occurred at a secondary cold front. At Larkhill, two miles away, a gust of 54 m.p.h. was experienced at the passage of the front, temperature fell 7·5°F. without any recovery, while the barograph showed an upward " kick " of about 1mb.

L. Dods.

Reviews

Metropolitan Water Board. Twenty-fifth Annual Report on the results of the chemical and bacteriological examination of the London waters for the twelve months ended 31*st December*, 1930. By Sir Alexander Houston, Director of Water Examination. Size $13\frac{1}{4} \times 8\frac{1}{4}$, pp. 73, *Illus.* London: P. S. King and Son, Ltd., 1931. Price 21s.

This report worthily maintains the high standard of scientific worth, literary elegance and humour that we have come to associate with the name of Sir Alexander Houston. Seeing that this is the official report of the chemical and bacteriological department of so august a body as the Metropolitan Water Board, the mention of " humour " may appear surprising. To readers who have not seen the forerunners of this volume, it is necessary to explain that Sir Alexander Houston has for some years past achieved the rather surprising feat of producing a report in which the facts and statistics are presented in such a way as to afford considerable entertainment even to readers not professionally interested in the chemical problems associated with water supply. The whole report bears the impress of a most vivid and engaging personality.

Section IX (Meteorological Notes) gives a summary of the year's weather at home and abroad " extracted for the most part," as the author says in a footnote, "from the *Meteorological Magazine*, a journal of immense interest and importance." The style of the report may be judged by the following samples:—

July.— . . . It has been said of our climate that we never have two consecutive fine days. It was fine enough, at all events, on July 11th and 12th at Leeds to allow Don Bradman to complete his record Test Match score of 334 runs.

December.— . . It is remarkable, however, that double gilt-edged securities, War-savings certificates, and the funds of first-class building societies rode triumphantly through the crisis as if they had cornered the sunshine and security of the world. Their sunshine and safety will be ours when the tide turns, and meanwhile we are thankful that on Christmas Day, locally, at all events, and on the Sunday following, the temporary charms of the weather lured us back to the cheerful outlook which the Yuletide has planted imperishably in the hearts of all true Britishers.

Enough has been said to show that Sir Alexander's reports are veritable oases in the arid ground of official publications. The reader should on no account miss the article on the Kempton Park Works beginning on p. 57. The wealth of literary allusion in this section, ranging from *Punch* to the Holy Scriptures, is truly remarkable. It is impossible to refrain from one or two more quotations:—

"After the Exhibition was opened the story goes that a 'bright young thing' was asked if she were going to the Persian Exhibition, and her reply was: 'No. I simply loathe cats!'"

"Millions of passengers cross the Thames by these bridges every year, alas, they seldom, it is to be feared, give the river a thought, yet it is speaking to them all the time in the silent language of great rivers carrying messages full of history and romance to the sea. Those gifted with imagination can happily hear where there is no sound and see where there is no vision."

In reviewing the twenty-second volume of this series for the *Meteorological Magazine*, Mr. R. Corless suggested that the author might consider the question of altering the wording of the title-pages, making it indicate to a casual reader that something more than dry-as-dust statistics lay behind the cover. I am not sure that I agree. Delights are enhanced by being unexpected, and here is a case where the assiduous and dutiful delver into official records reaps a rich reward!

E. G. BILHAM.

Social and Economic Geography. By L. Brettle, M.A.(Oxon.), B.Litt., F.R.G.S. Size $8\frac{1}{2} \times 6$, pp. xvii + 459, *Illus.* London, Sir Isaac Pitman and Sons Ltd. 10s. 6d. net.

The "jacket" of this useful book describes it as "a concise treatment of the more important relationships existing between man and his environment in different characteristic parts of the world." This description is justified, for the author has the knack of stating his arguments clearly and driving them home with a few well-chosen details. The important part of "environment" which results from climate and weather receives ample treatment, far different from the perfunctory descriptions of climatic zones, which are only too often regarded as sufficient for books of this type. In fact, the whole arrangement of the first part of the book is climatic, successive chapters dealing with the equatorial rain-forest region; tropical transitional regions; sub-tropical regions; cool temperate regions having cyclonic weather; hot and warm deserts; taiga, tundra and polar ice-cap regions; and highland regions. Each section opens with a table showing the average temperature and precipitation of typical places in the region, followed by a brief summary of the main climatic characteristics, to which the economic peculiarities are related. It is in connexion with these tables that we must make one of our few criticisms, for though in general they appear to be sufficiently accurate, in some cases they depart rather widely from the latest published statistics. Thus on page 46 the rainfall of Singapore is shown as ranging from 2·2in. in April to 16·0in. in December, while the latest averages show only a variation from 6·6in. in February to 10·6in. in December, which accords better with the characteristic description of the equatorial rain-forest region.

The book is lavishly illustrated with photographs and maps. The diagram of the inter-relationships of temperature, wind and rainfall in fig. 14 would have been more useful if it had been less ideal, but the series of world maps in figs. 15 to 26 form a most remarkable testimony to the importance of climatic environment. For example, the map of "principal occupations" on land closely resembles those of temperature (not reduced to mean sea level) and precipitation, while at sea the meeting places of warm and cold currents faithfully mark the main fishing areas. Another interesting point is the general similarity, as regards the tropical regions, of the rainfall chart with that showing the extra premiums charged by a British Insurance Company for foreign residence. The changeable climate of western Europe is attributed to its position near the "polar front," the modern theory of which is described and illustrated by full-page reproductions of charts from two daily weather reports, though it is to be feared that the uninitiated will find difficulty in recognising on these the boundaries of the polar and equatorial air currents.

Another important feature is the series of questions at the end of each chapter, and here again the importance of climatology is fully recognised. The very numerous photographs are of great interest, and the general appearance of the book is excellent, especially when the moderate price is considered. The index is generous.

C. E. P. BROOKS.

The Weather of August, 1931

Pressure was below normal in a belt covering southern Canada and north-western United States, over the southern North Atlantic, Spitsbergen, Jan Mayen and most of Europe, with the exception of south-western Norway, Scotland and southern Spain; the greatest deficits were 4·8mb. at Spitsbergen and 4·7mb. at Brest. Pressure was above normal over northern Canada and the southern and north-eastern United States, Bermuda, northern North Atlantic to Norway, Iceland and in a belt from the Canary Islands across southern Spain, to the western Mediterranean and over the Kara Sea, the greatest excess being 4·9mb. at Reykjavik. Temperature was above normal over Spitsbergen, about normal in Scandinavia but below normal over central and southern Europe. Rainfall was below normal at Spitsbergen, northern Norway, south-east Sweden and Switzerland and above normal over Norrland, Sweden.

Cool, unsettled weather with frequent thunderstorms accompanied by heavy rain prevailed over the greater part of England during most of August. In many parts of Scotland and Ireland, however, the month was dry and sunny. With pressure high over Scotland and low over France a spell of warm, thundery weather was experienced in England from the 3rd to 5th.* The storms were accompanied by heavy local rain and flooding in southern England.† Meanwhile fair weather with good sunshine totals prevailed in the west and north of the British Isles; Markree Castle (Co. Sligo) had 14·3hrs. of bright sunshine on the 4th. The warmest spell of the month occurred at this time, temperature rising to 80°F. at Aberystwyth and 79°F. locally in Ireland and south-east England on the 4th. Subsequently pressure became high westward of Ireland and low over Scandinavia, with secondaries travelling southward over Great Britain. Cool, rather cloudy weather prevailed, with occasional heavy rain, though conditions continued fairer on the whole in the western districts; Ross-on-Wye had 13·5hrs. of bright sunshine on the 9th. On the 8th unusually heavy rain was reported in eastern England.† On the 11th the anticyclone off the south-west coasts extended northwards and then moved eastwards on the 13th; during these days temperature rose temporarily above 70°F. in the south. From the 14th to 23rd depressions passed eastwards across the country. Conditions continued very unsettled with frequent thunderstorms and heavy rain,† but some bright intervals. On the 18th and 19th temperature exceeded 70°F. in the south, but this was followed by a cold spell with maxima below 60°F. on the 21st-23rd. The 18th and 22nd were the sunniest days of this period with 13·0hrs. at Valentia on the 22nd and 12·7hrs. at Stonyhurst and York on the 18th. On the 24th a deep depression centred off Brest caused severe gales and heavy rain in the English Channel,† with gusts of 90 m.p.h. and 72 m.p.h. at Pendennis and

* See *Meteorological Magazine* 66, 1931, p. 158. † See p. 183.

Scilly Isles respectively. A welcome change to settled fair weather occurred in the north about the 25th and in the south about the 26th, but temperature remained low. On the 24th many maxima were below 55°F., even as far south as Dungeness and Leafield. Ground frosts were experienced on the 23rd to 27th, 26°F. being recorded on the ground at Rhayader on the 26th. Much sunshine occurred on several days at the end of the month. The total rainfall was well above the average in England but below average in Scotland and Ireland. The distribution of bright sunshine for the month was as follows :—

	Total (hrs.)	Diff. from normal (hrs.)		Total (hrs.)	Diff. from normal (hrs.)
Stornoway	178	+ 45	Liverpool	170	+ 6
Aberdeen	129	— 21	Ross-on-Wye	147	—27
Dublin	169	+ 7	Falmouth	175	—36
Birr Castle	175	+ 33	Gorleston	182	—24
Valentia	197	+ 42	Kew	136	—51

The special message from Brazil states that in the northern regions, the rainfall was irregular with 0·16in. above normal and in the central and southern regions generally scarce with 0·43in. and 0·91in. below normal respectively. Six anticyclones passed across the country. Crops generally were in good condition except in the north-east though affected by the frosts. At Rio de Janeiro pressure was 3·4mb. above normal and temperature 0·9°F. below normal.

Miscellaneous notes on weather abroad culled from various sources.

Several deaths from heat-stroke were reported from Italy at the beginning of the month owing to the high temperatures which prevailed there being accompanied by the enervating scirocco; the temperature also remained relatively high during the nights. Twelve deaths were caused by a thunderstorm of exceptional violence in northern France on the 4th, heavy thunder- and hailstorms occurred in south-west Germany on the 5th, followed by flooding, and a cloudburst was experienced in the Valle Aurina to the south-east of the Brenner Pass on the 6th. A violent storm, accompanied by hail, swept the coast near Toulon for 12 minutes on the 9th, and a waterspout was seen off La Rochelle during a thunderstorm. Bad weather was frequently experienced in Switzerland leading to several accidents. Serious forest fires broke out on the French Riviera on the 21st, but these were mastered by the 23rd, and rain fell on the 25th. Unusually heavy rain fell in Stockholm on the 23rd, and the Sahlgren Hospital was flooded. Heavy rain during the greater part of the month in Flanders and Germany caused serious losses to agriculture due to flooding. Paris had less than half the normal amount of sunshine for the month and more than twice the rainfall. Storms were experienced on the Atlantic coast of France and in the central Mediterranean on the 24th and 23rd respectively. (*The Times*, August 6th-September 2nd.)

A typhoon, during which the wind reached 136 m.p.h. in a gust, struck Hongkong on the 1st doing minor damage. Disastrous floods were experienced in China throughout the month owing to the occurrence of abnormally heavy rains simultaneously in several Yangtze regions at a time when the rivers were already high owing to the melting snows on the Tibetan borders and the dykes were in a neglected condition. Further heavy rain occurred during the month. From the 18th-20th the level of the Yangtze at Hankow, where the floods are worst, reached the record height of 53½ft. above Bund level. Millions of people are homeless and hundreds were drowned. The flood situation, on the Hoang Ho, of sections of Honan, north Anwhei, north Kiangsu and Shantung was almost as disastrous as that of the Yangtze as regards loss of life and damage. All the lower parts of the province of Szechwan are also suffering from similar unprecedented floods. High temperatures added to the misery of the people, but fortunately these had fallen by the 27th. By the 30th the floods were declining, but there was still risk of more water coming down from the upper rivers. The floods along the Brahmaputra and Padma caused much of the paddy harvest to be lost; these continued most of the month. Many people were drowned as the result of floods caused by the monsoon in the low-lying villages in the Malvan district of Bombay. Drought was ruining the crops in the zone between Meiktila and Mandalay, while crops on the lower reaches of the Irrawaddy were being ruined by floods. (*The Times*, August 5th-31st.)

Floods on the River Murray due to the exceptionally heavy rainfall caused much damage mainly to dairy settlements in South Australia; 25 miles of levées had collapsed by the 30th. (*The Times*, August 25th-31st.)

Cool, wet weather prevailed generally in Canada during the first part of the month with drier conditions later. Temperature was mainly above normal in the United States, except along the eastern coast at the end of the month. In the Argentine the weather was generally cool and dry. A cyclone did much damage in Paraguay about the 17th. (*The Times*, August 7th-29th, and *Washington, D.C., U.S. Dept. Agric., Weekly Weather and Crop Bulletin.*)

Rainfall, August, 1931—General Distribution

England and Wales	143	per cent of the average 1881-1915.
Scotland	61	
Ireland	81	
British Isles	104	

Rainfall: August, 1931: England and Wales

Co.	Station	In.	Per-cent of Av.	Co.	Station	In.	Per-cent of Av.
Lond .	Camden Square	5·03	227	*Leics* .	Belvoir Castle	3·30	126
Sur .	Reigate, Alvington	5·05	206	*Rut* .	Ridlington	2·98	119
Kent .	Tenterden, Ashenden	3·63	158	*Linc* .	Boston, Skirbeck	8·02	335
,, .	Folkestone, Boro. San.	3·89	...	,, .	Cranwell Aerodrome	3·45	127
,, .	Margate, Cliftonville	3·28	170	,, .	Skegness, Marine Gdns	3·14	129
,, .	Sevenoaks, Speldhurst	4·58	...	,, .	Louth, Westgate	3·65	130
Sus .	Patching Farm	3·15	125	,, .	Brigg, Wrawby St.	4·48	...
,, .	Brighton, Old Steyne	2·41	111	*Notts* .	Worksop, Hodsock	4·65	190
,, .	Heathfield, Barklye	6·13	227	*Derby* .	Derby, L. M. & S. Rly.	5·84	223
Hants .	Ventnor, Roy. Nat. Hos.	3·37	169	,, .	Buxton, Devon Hos.	6·63	151
,, .	Fordingbridge, Oaklnds	4·23	161	*Ches* .	Runcorn, Weston Pt.	5·88	163
,, .	Ovington Rectory	5·17	191	,, .	Nantwich, Dorfold Hall	6·05	...
,, .	Sherborne St. John	4·36	180	*Lancs* .	Manchester, Whit. Pk.	7·34	213
Berks .	Wellington College	3·31	143	,, .	Stonyhurst College	4·86	96
,, .	Newbury, Greenham	2·95	112	,, .	Southport, Hesketh Pk	4·58	132
Herts .	Welwyn Garden City	4·24	...	,, .	Lancaster, Strathspey	3·56	...
Bucks .	H. Wycombe, Flackwell	5·19	...	*Yorks* .	Wath-upon-Dearne	4·24	177
Oxf .	Oxford, Mag. College	4·29	190	,, .	Bradford, Lister Pk.	3·30	122
Nor .	Pitsford, Sedgebrook	2·70	112	,, .	Oughtershaw Hall	5·30	...
,, .	Oundle	3·02	...	,, .	Wetherby, Ribston H.	3·50	128
Beds .	Woburn, Crawley Mill	3·65	158	,, .	Hull, Pearson Park	4·04	139
Cam .	Cambridge, Bot. Gdns.	2·50	106	,, .	Holme-on-Spalding	3·50	...
Essex .	Chelmsford, County Lab	3·78	174	,, .	West Witton, Ivy Ho.	4·14	141
,, .	Lexden Hill House	3·35	...	,, .	Felixkirk, Mt. St. John	3·40	119
Suff .	Hawkedon Rectory	4·66	180	,, .	Pickering, Hungate	3·54	138
,, .	Haughley House	2·80	...	,, .	Scarborough	2·26	81
Norf .	Norwich, Eaton	3·24	137	,, .	Middlesbrough	2·15	78
,, .	Wells, Holkham Hall	3·09	129	,, .	Baldersdale, Hury Res.	...	...
,, .	Little Dunham	2·91	107	*Durh* .	Ushaw College	3·07	105
Wilts .	Devizes, Highclere	4·20	146	*Nor* .	Newcastle, Town Moor	3·40	116
,, .	Bishops Cannings	4·42	143	,, .	Bellingham, Highgreen	4·12	117
Dor .	Evershot, Melbury Ho.	3·86	123	,, .	Lilburn Tower Gdns.	2·67	95
,, .	Creech Grange	4·26	149	*Cumb* .	Geltsdale	3·55	...
,, .	Shaftesbury, Abbey Ho.	3·06	105	,, .	Carlisle, Scaleby Hall	2·72	66
Devon .	Plymouth, The Hoe	3·84	124	,, .	Borrowdale, Seathwaite	7·20	62
,, .	Polapit Tamar	6·11	192	,, .	Borrowdale, Rosthwaite	5·24	...
,, .	Holne, Church Pk. Cott.	5·63	126	,, .	Keswick, High Hill	4·25	...
,, .	Cullompton	4·07	133	*West* .	Appleby, Castle Bank	3·65	111
,, .	Sidmouth, Sidmount	3·14	112	*Glam* .	Cardiff, Ely P. Stn.	4·24	98
,, .	Filleigh, Castle Hill	4·86	...	,, .	Treherbert, Tynywaun	8·01	...
,, .	Barnstaple, N. Dev. Ath	3·89	118	*Carm* .	Carmarthen Friary	3·20	69
,, .	Dartm'r, Cranmere Pool	9·20	...	*Pemb* .	Haverfordwest, School	3·41	82
Corn .	Redruth, Trewirgie	4·48	131	*Card* .	Aberystwyth	3·39	...
,, .	Penzance, Morrab Gdn.	3·10	98	,, .	Cardigan, County Sch.	4·39	...
,, .	St. Austell, Trevarna	4·81	133	*Brec* .	Crickhowell, Talymaes	5·70	...
Soms .	Chewton Mendip	5·34	119	*Rad* .	Birm W. W. Tyrmynydd	5·64	105
,, .	Long Ashton	3·96	113	*Mont* .	Lake Vyrnwy	5·64	109
,, .	Street, Millfield	4·16	152	*Denb* .	Llangynhafal	6·77	219
Glos. .	Cirencester, Gwynfa	5·07	169	*Mer* .	Dolgelly, Bryntirion	6·38	113
Here .	Ross, Birchlea	5·15	201	*Carn* .	Llandudno	4·27	141
,, .	Ledbury, Underdown	4·78	183	,, .	Snowdon, L. Llydaw 9	15·45	...
Salop .	Church Stretton	6·16	189	*Ang* .	Holyhead, Salt Island	2·74	86
,, .	Shifnal, Hatton Grange	4·93	175	,, .	Lligwy	3·72	113
Worc .	Ombersley, Holt Lock	3·49	130	*Isle of Man*			
,, .	Blockley	5·88	...		Douglas, Boro' Cem.	4·07	107
War .	Birminghm, Edgbaston	4·65	172	*Guernsey*			
Leics .	Thornton Reservoir	4·73	169		St. Peter P't. Grange Rd.	6·85	292

Rainfall: August, 1931: Scotland and Ireland

Co.	Station	In.	Per-cent of Av.	Co.	Station	In.	Per cent of Av.
Wigt	Pt. William, Monreith	3·74	97	*Suth*	Melvich	1·04	...
,,	New Luce School	2·52	56	,,	Loch More, Achfary	1·79	31
Kirk	Carsphairn, Shiel	2·80	42	*Caith*	Wick	1·07	39
Dumf	Dumfries, Crichton, R.I	2·40	...	*Ork*	Pomona, Deerness	·51	18
,,	Eskdalemuir Obs.	1·80	35	*Shet*	Lerwick	·21	7
Roxb	Branxholm	3·81	118	*Cork*	Caheragh Rectory	3·35	...
Selk	Ettrick Manse	2·77	53	,,	Dunmanway Rectory	3·20	68
Peeb	West Linton	4·28	...	,,	Ballinacurra	3·54	95
Berk	Marchmont House	3·34	101	,,	Glanmire, Lota Lo.	3·89	106
Hadd	North Berwick Res.	4·46	141	*Kerry*	Valentia Obsy.	3·62	76
Midl	Edinburgh, Roy. Obs.	5·58	181	,,	Gearahameen	8·60	...
Lan	Auchtyfardle	1·91	...	,,	Killarney Asylum	...	...
Ayr	Kilmarnock, Agric. C.	...	...	,,	Darrynane Abbey	4·00	92
,,	Girvan, Pinmore	2·32	52	*Wat*	Waterford, Brook Lo.	2·73	71
Renf	Glasgow, Queen's Pk.	2·18	62	*Tip*	Nenagh, Cas. Lough	3·07	78
,,	Greenock, Prospect H.	1·88	34	,,	Roscrea, Timoney Park	2·75	...
Bute	Rothesay, Ardencraig.	2·69	55	,,	Cashel, Ballinamona	3·63	102
,,	Dougarie Lodge	1·43	.	*Lim*	Foynes, Coolnanes	2·31	60
Arg	Ardgour House	2·63	...	,,	Castleconnel Rec.	3·21	...
,,	Manse of Glenorchy	..	...	*Clare*	Inagh, Mount Callan	3·20	...
,,	Oban	1·05	23	,,	Broadford, Hurdlest'n.	3·94	...
,,	Poltalloch	1·56	32	*Wexf*	Gorey, Courtown Ho.	2·52	76
,,	Inveraray Castle	1·65	25	*Kilk*	Kilkenny Castle	2·17	62
,,	Islay, Eallabus	1·48	34	*Wic*	Rathnew, Clonmannon	3·45	...
,,	Mull, Benmore	2·40	..	*Carl*	Hacketstown Rectory.	3·04	75
,,	Tiree	...	...	*Leix*	Blandsfort House	3·97	101
Kinr	Loch Leven Sluice	...	...	,,	Mountmellick	3·53	...
Perth	Loch Dhu	2·65	39	*Off'ly*	Birr Castle	2·55	67
,,	Balquhidder, Stronvar	...	...	*Kild'r*	Monasterevin	2·99	...
,,	Crieff, Strathearn Hyd.	1·68	40	*Dubl*	Dublin, FitzWm. Sq.	3·12	103
,,	Blair Castle Gardens	1·09	32	,,	Balbriggan, Ardgillan.	3·73	109
Angus	Kettins School	3·35	101	*Me'th*	Beauparc, St. Cloud	3·69	...
,,	Dundee, E. Necropolis	3·39	100	,,	Kells, Headfort	3·60	87
,,	Pearsie House	...	...	*W.M*	Moate, Coolatore	2·90	...
,,	Montrose, Sunnyside	2·04	73	,,	Mullingar, Belvedere	3·62	87
Aber	Braemar, Bank	3·04	89	*Long*	Castle Forbes Gdns.	2·80	68
,,	Logie Coldstone Sch.	2·00	63	*Gal*	Ballynahinch Castle	4·02	73
,,	Aberdeen, King's Coll.	1·87	68	,,	Galway, Grammar Sch.	2·65	...
,,	Fyvie Castle	2·74	86	*Mayo*	Mallaranny	...	...
Moray	Gordon Castle	2·42	76	,,	Westport House	4·23	105
,,	Grantown-on-Spey	2·84	89	,,	Delphi Lodge	8·32	97
Nairn	Nairn, Delnies	1·98	82	*Sligo*	Markree Obsy	4·33	99
,,	Ben Alder Lodge	2·07	...	*Cav'n*	Belturbet, Cloverhill	3·37	91
Invs	Kingussie, The Birches	1·51	...	*Ferm*	Enniskillen, Portora	...	...
,,	Loch Quoich, Loan	...	...	*Arm*	Armagh Obsy	2·06	57
,,	Glenquoich	2·74	33	*Down*	Fofanny Reservoir	6·04	...
,,	Inverness, Culduthel R.	1·74	...	,,	Seaforde	3·63	97
,,	Arisaig, Faire-na-Squir	2·12	...	,,	Donaghadee, C. Stn.	3·30	99
,,	Fort William	3·31	...	,,	Banbridge, Milltown	3·03	...
,,	Skye, Dunvegan	1·31	...	*Antr*	Belfast, Cavehill Rd.	3·29	...
R&C	Alness, Ardross Cas.	2·18	74	,,	Glenarm Castle	3·68	...
,,	Ullapool	·64	18	,,	Ballymena, Harryville	3·13	73
,,	Torridon, Bendamph	...	...	*Lon*	Londonderry, Creggan	2·10	45
,,	Achnashellach	1·53	...	*Tyr*	Omagh, Edenfel	2·36	55
,,	Stornoway	1·38		*D.n*	Malin Head	1·41	...
Suth	Lairg	1·22	38	,,	Dunfanaghy	1·70	...
,,	Tongue	1·08	34	,,	Killybegs, Rockmount	2·19	39

Climatological Table for the British Empire, March, 1931.

STATIONS	PRESSURE		TEMPERATURE							Relative Humidity	Mean Cloud Am'nt	PRECIPITATION			BRIGHT SUNSHINE	
			Absolute		Mean Values				Mean							
	Mean of Day M.S.L.	Diff. from Normal	Max.	Min.	Max.	Min.	½ max. and min.	Diff. from Normal	Wet Bulb			Am'nt	Diff. from Normal	Days	Hours per day	Per-cent-age of possible
	mb.	mb.	°F.	°F.	°F.	°F.	°F.	°F.	°F.	%	0–10	in.	in.			
London, Kew Obsy.	1014.3	+ 0.9	66	18	47.8	34.2	41.0	− 1.4	34.7	81	8.4	0.32	− 1.37	5	4.0	34
Gibraltar	1013.2	− 3.8	74	49	66.2	53.6	59.9	+ 2.4	53.7	87	6.5	8.09	+ 3.30	16	..	..
Malta	1013.7	− 0.5	79	47	65.0	54.1	59.5	+ 2.4	54.0	73	6.1	0.38	− 1.10	6	6.8	57
St. Helena	1013.8	+ 1.5	72	61	69.4	62.1	65.7	− 0.6	62.7	93	9.2	3.09	..	18	..	..
Sierra Leone	1009.7	− 1.0	93	67	89.0	74.0	81.5	− 0.9	76.3	75	4.8	1.82	+ 0.66	2	..	..
Lagos, Nigeria	..	..	96	71	90.9	78.8	84.9	+ 1.6	79.8	79	7.4	5.89	+ 2.15	7	..	..
Kaduna, Nigeria	1013.0	+ 1.1	102	..	97.5	..	..	..	75.5	74	..	0.12	− 0.32	1	..	..
Zomba, Nyasaland	1009.9	+ 0.2	87	62	80.4	65.6	73.0	+ 1.7	..	75	6.5	2.48	− 6.60	10	..	..
Salisbury, Rhodesia	1010.0	+ 0.9	89	51	81.6	59.1	70.3	+ 2.1	61.9	66	3.9	0.72	− 3.98	9	7.4	61
Cape Town	1015.6	+ 1.1	97	53	82.0	62.0	72.0	+ 3.9	62.6	77	3.7	0.00	− 0.88	0	..	..
Johannesburg	1014.1	+ 1.5	84	49	75.7	54.7	65.2	+ 1.8	56.1	68	4.2	1.71	− 2.73	10	7.8	63
Mauritius	1009.9	− 2.1	87	67	84.4	73.4	78.9	+ 0.9	74.3	71	5.6	25.12	+ 15.75	15	8.1	66
Calcutta, Alipore Obsy.	1011.3	+ 1.4	99	62	91.7	70.6	81.1	+ 0.9	70.6	80	2.9	1.31	− 0.07	3*	..	..
Bombay	1011.5	+ 0.6	91	65	85.8	71.4	78.6	− 0.9	70.2	74	2.5	0.00	− 0.02	0*	..	..
Madras	1011.6	+ 0.7	93	69	89.6	72.6	81.1	0.0	75.2	78	1.9	0.00	− 0.34	0*	..	..
Colombo, Ceylon	1011.6	+ 1.5	92	72	89.4	75.0	82.2	+ 0.4	77.8	72	4.7	1.86	− 2.42	9	9.4	78
Singapore	1010.4	..	94	73	89.9	74.7	82.3	+ 1.5	..	..	..	5.18	− 2.22	17	6.3	52
Hongkong	1015.9	0.0	80	55	67.7	60.5	64.1	+ 0.8	59.9	79	8.0	3.17	+ 0.49	12	2.5	21
Sandakan	..	..	89	73	87.7	75.4	81.5	+ 0.5	77.5	81	..	4.39	− 4.08	7	..	..
Sydney, N.S.W.	1017.8	+ 1.5	91	56	76.4	64.4	70.4	+ 1.1	66.5	79	7.5	7.39	+ 2.41	20	4.9	40
Melbourne	1017.8	+ 0.9	96	44	72.8	53.6	63.2	− 1.3	58.0	69	6.1	5.50	+ 3.32	11	5.8	47
Adelaide	1018.6	+ 1.5	101	48	79.5	57.2	68.3	− 1.5	57.1	43	5.5	1.32	+ 0.29	6	7.7	63
Perth, W. Australia	1015.5	+ 0.2	99	55	83.5	62.0	72.7	+ 1.5	61.6	53	3.5	0.90	+ 0.09	4	9.2	75
Coolgardie	1015.7	+ 0.9	99	47	83.4	58.7	71.1	− 0.8	59.1	44	3.5	0.59	− 0.35	3	..	..
Brisbane	1017.9	+ 3.5	89	62	81.3	67.7	74.5	+ 0.2	69.8	77	6.6	14.92	+ 9.14	24	6.7	54
Hobart, Tasmania	1016.7	+ 2.5	84	43	66.0	51.5	58.7	− 0.6	53.1	71	6.8	4.16	+ 2.46	17	5.6	45
Wellington, N.Z.	1021.9	+ 4.7	70	44	62.8	51.5	57.1	− 3.5	53.8	75	6.5	0.64	− 2.69	10	6.4	52
Suva, Fiji	1010.4	+ 2.0	87	71	83.1	74.2	78.7	− 1.4	74.9	81	7.1	20.02	+ 5.53	28	4.6	38
Apia, Samoa	1009.9	+ 0.7	89	73	86.3	75.6	80.9	+ 1.6	78.2	82	6.4	10.26	− 3.72	22	5.3	43
Kingston, Jamaica	1013.1	− 1.8	90	64	86.7	70.2	78.5	+ 1.4	67.6	79	4.8	0.95	− 0.07	5	9.2	77
Grenada, W.I.	1013.8	+ 0.8	91	72	88.0	74.6	81.3	+ 3.5	74.0	75	3.2	0.74	− 1.92	12	..	..
Toronto	1014.8	− 2.5	48	19	38.8	28.1	33.5	+ 3.9	29.2	78	8.5	2.81	+ 0.40	12	4.1	34
Winnipeg	1024.5	+ 5.3	42	− 9	27.8	12.0	19.9	+ 4.9	..	..	5.0	0.89	− 0.27	8	..	..
St. John, N.B.	1012.9	− 1.2	53	20	38.7	28.2	33.5	+ 5.1	28.9	82	8.0	3.01	− 1.53	12	2.9	24
Victoria, B.C.	1018.1	+ 2.2	57	34	50.3	34.0	42.1	− 1.4	42.7	83	7.3	2.40	− 0.03	18	3.9	33

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

M.O. 340.

The Meteorological Magazine

Air Ministry :: Meteorological Office

Vol. 66

Oct., 1931

No. 789

LONDON: PUBLISHED BY HIS MAJESTY'S STATIONERY OFFICE

To be purchased directly from H.M. STATIONERY OFFICE at the following addresses: ADASTRAL HOUSE, KINGSWAY, LONDON, W.C.2; 120, GEORGE STREET, EDINBURGH; YORK STREET, MANCHESTER; 1, ST. ANDREW'S CRESCENT, CARDIFF; 15, DONEGALL SQUARE WEST, BELFAST; or through any Bookseller.

Meteorology at the Centenary Meeting of the British Association for the Advancement of Science, London, 1931

For the first time in its existence, the British Association met in London, from September 23rd to 30th. The number of members exceeded 5,000, among whom were many meteorologists, not only from this country, but also from abroad, and meteorological subjects occupied a considerable place in the programme.

On Thursday, September 24th, following the Presidential Address to Section A by Sir J. J. Thomson, O.M., F.R.S., several meteorological papers were read in the Department of Cosmical Physics, the chair being taken by Dr. G. C. Simpson. Dr. J. Bjerknes, under the title "Tropopause Waves," described the thermal structure of cyclones and anticyclones in the troposphere and stratosphere, and showed how in a series of depressions and highs the tropopause forms a series of undulations or waves. The mechanism of these is briefly as follows: where a tongue of polar air projects southwards, the tropical current passes across it, from west to east, and has thereby necessarily an upward component on the western slope and a downward component on the eastern slope of it. Above the region of upward motion, the air must spread out horizontally, and this horizontal divergence creates an anticyclonic curl. Above the region of descending motion the air must converge and that creates a cyclonic curl. The lines of flow in the upper

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part of the tropical current therefore assume an " S " shape with anticyclonic curvature over the westward and cyclonic curvature over the eastward slope of the polar tongue. Since the tropopause is tilting downwards towards the pole, the horizontal undulation of the westerly current of the upper troposphere causes a high tropopause at the places of pole-ward elongation and a low tropopause at the places of equator-ward elongation. The aerological observations also give the expected evidence for the tropopause crest over the western and the tropopause trough over the eastern slope of the tongue of polar air. The linking mechanism of tropopause and polar front waves thus defines a certain difference of phase angle between the two systems, but it does not point out any one of the wave systems as being the primary one.

Sir Gilbert Walker, in a paper on " Stratified clouds," described laboratory experiments carried out at the Imperial College of Science and Technology which reproduced typical cloud structures. An unstable liquid at rest forms a polygonal structure, usually rising in the middle of each polygon and descending at the edges, this being analogous to detached polygonal clouds separated by channels of blue sky. The reverse structure is rarely seen, rising at the edges and descending in the middle, forming a network in cloud round a series of holes or patches of blue sky. But in a wind channel in which the motion is indicated by titanium tetrachloride the air always descends in the middle of the polygons. When the air in the channel is moving rapidly with different velocities in different layers giving a marked shearing effect, a structure of longitudinal rolls or strips appears, also familiar in cloud forms. A smaller amount of shear gives a rectangular structure, while a yet smaller shear leads to transverse strips often possessing the forms characteristic of sand ripples. Cloud-photographs were shown illustrating these features.

Dr. C. G. Abbot then described " Twenty-five years' study of solar radiation," giving an account of the methods employed and results obtained by the Astrophysical Observatory of the Smithsonian Institution in measuring the solar constant, the distribution of energy through the solar spectrum and in different parts of the sun's disc. He showed how the agreement between observations in different parts of the world demonstrates the reality of changes of solar radiation, and briefly outlined the possibilities of solar studies for long-range forecasting. These subjects will occupy volume 5 of the *Annals of the Astrophysical Observatory of the Smithsonian Institution*, now about to be issued from the press.

Dr. F. J. W. Whipple read a paper on " The circulation of electricity through the atmosphere," of which the following is an abstract :—

Continuous records of the air-earth current are now available at Kew

Observatory, and provide new information with regard to the circulation of electricity through the atmosphere.

The potential of the Kennelly-Heaviside layer in the upper atmosphere is of the order 3×10^5 volts. Over the oceans the air-earth current is of about the same strength in the northern summer and the southern summer, so that it may be assumed that the mean potential of the K.H. layer is the same at all seasons. On the other hand there is a well-marked diurnal variation, the potential gradient over the oceans being 15 per cent. below the mean at 5h. G.M.T. and 20 per cent. above the mean at 19h. G.M.T. The potential of the K.H. layer must vary in the same way.

The fluctuations in the air-earth current at a place like Kew, where there is considerable atmospheric pollution, are governed partly by the potential difference between the K.H. layer and the ground and partly by the resistance of the air. It is estimated that in summer the resistance of a column reaching right up to the K.H. layer and with 1cm.^{2} cross-section varies between $2 \cdot 2 \times 10^{21}$ ohms at 2h. and $3 \cdot 3 \times 10^{21}$ ohms at 18h. whilst in winter the range is between $3 \cdot 4 \times 10^{21}$ ohms at 5h. and $8 \cdot 7 \times 10^{21}$ ohms at 17h. The resistance increases steadily during the hours in which pollution is being produced. The estimates are of the right order of magnitude, but the ratios are of more significance than the exact figures.

Potential gradient depends on the strength of the current and on the resistance of the air near the ground. The double oscillation of potential gradient in the course of the day is explained by the double oscillation in resistance. The specific resistance of the air has minima in the early morning and in the afternoon. The difference between the types of variation of total resistance of the atmosphere and of specific resistance close to the ground is explained by the fact that in the hours during which the ground is being warmed pollution diffuses to considerable heights. The high potential of the K.H. layer is attributable to the action of thunderstorms.

There is a well-known difficulty in evaluating the magnitude of the air-earth current. The vertical current in the free atmosphere is regarded as a pure conduction current, positive and negative ions moving in opposite directions. At the surface of the ground only the positive current is effective. The negative current is thought to be counterbalanced by the transport of space-charge by eddy diffusion. Such observations as are available for testing this hypothesis are considered in the paper but the need for more observations is stressed.

On Friday, September 25th, Sir Napier Shaw described "Meteorology after the century" in which he set out the development of the physical aspect of the science, especially at early meetings of the Association. He then passed to the development of the geographical aspect, culminating in the introduction of the weather map with forecasts and storm warnings. Sir Francis Galton endeavoured, as General Secretary to the Association in 1885, to combine the physical and geographical aspects in the solution of the problem of weather, and Sir Arthur Schuster appealed to the 71st meeting for the deliberate co-ordination of meteorological observations with definite scientific purposes, the specification of the probability of inferences and the extension of knowledge by the exploration of the upper air in respect of pressure and motion, heat, water-vapour, light and sound. Sir Napier concluded with accounts of the uncertainties of forecasting, including the reconsideration of the principles of weather-sequence by the Norwegian School and others, and of the distribution of entropy, acting through gravity, and of kinetic energy, with the aid of the conservation of angular momentum, as the controlling factors of weather.

Dr. B. F. J. Schönland, in a paper on "Lightning," gave an account of recent investigations upon thunderstorms in South Africa and their bearing upon the question of lightning discharges between the cloud and the ground. He presented evidence against the view that the branches in a lightning flash fork away from the positive pole of the discharge.

The last paper at this session was by Mr. R. A. Watson Watt and Mr. O. F. Brown on "Radio research in the British Empire," and discussed among other points the propagation of electro-magnetic waves and the nature and origin of atmospherics.

In the section of Archæology, Miss E. W. Gardner and Miss G. Caton-Thompson described "Preliminary work on the geology and archæology of the Kharga Depression, Egypt," which is of great importance in the study of climatic changes, and Mr. L. A. Cammiade and Mr. F. J. Richards described "Climatic changes in Palæolithic India."

On Monday, September 28th, the first part of the meeting of the Sub-section of Cosmical Physics of Section A was devoted to a discussion on magnetic storms and the ionization of the upper atmosphere. Professor S. Chapman opened the discussion with a brief summary of the main facts concerning storms, and proceeded to an account of his present theoretical views on their origin and causation. He regarded the only likely cause to be a neutral ionized stream of corpuscles from the sun, a suggestion first made by Lindemann in 1919. No progress in working out the effects of such a stream upon the earth had been made, however, until the recent publication of a sketch of a new theory by Chapman and Ferraro.* The main points of this theory were described. Professor E. V. Appleton continued the discussion with an account of his measures of upper-atmospheric ionization. Two distinct ionized layers are found to exist, and the ionization of the lower one is usually increased several-fold during magnetic storms. Mr. A. H. R. Goldie then proceeded to describe his recent studies on the electric current systems to which magnetic storms can be referred. He regarded magnetic storms as in the main due to an intensification of the quiet-day electric current system, the change in the system being most notable on the night side of the earth. He favoured an atmospheric dynamic theory of storms. Mr. W. M. H. Greaves next reviewed the evidence pointing to the sun, and, in particular, to corpuscular emissions from the sun, as the cause of magnetic storms. Professor J. C. McLennan spoke briefly on the help that laboratory experiments can afford in the elucidation of the

Terr. Mag. Washington, D.C., June 1931 and later issues.

difficult questions concerning atmospheric ionization, auroræ and magnetic storms. Professor A. E. Kennelly, Professor Lindemann, and Father Rowland, also contributed to the discussion.

After this discussion Dr. G. M. B. Dobson read a paper on "Recent researches on atmospheric ozone." He said that the atmosphere includes among other gases a small amount of ozone, the exact quantity being of special interest because of its connexion with weather conditions, its distribution over the world and its annual variation. Dr. Dobson next described the latest photoelectric instrument for measuring the amount of ozone. This is characterised by ease of manipulation; observations are possible on clear or cloudy days. Its object is to enable daily observations to be made regularly, and a programme has been arranged of systematic observations over northern Europe. The photoelectric instrument, having great sensitivity, allows observations to be taken either in direct sunlight or in the light of a clear zenith sky until the sun is nearly setting. Such observations enable us to deduce the height and distribution of ozone through the atmosphere. The average height is probably about 40Km., distributed between the surface and 100Km., but further observations are necessary. He next described the effect of ozone in raising the temperature of the atmosphere at great heights. This high temperature causes bending down of sound waves and gives rise to audibility of explosions at great distances. The temperatures of the upper air calculated from the absorption of sunlight by ozone and from observations of sound waves show general agreement.

Professor S. Chapman, F.R.S., then read a paper on "Atmospheric absorption of solar radiations, and some associated phenomena." He discussed the absorption of solar radiation in the upper atmosphere of the earth, taking account of the curvature of the level surface. Diagrams illustrated the degree of absorption at noon in high latitudes in winter, and in other latitudes during the hour before the sun has become visible at ground level. The results bear on the annual variation of ozone in high latitudes, the daily variation of ionization and the emission of light by excited atoms in the upper atmosphere.

On the same day a discussion of the greatest interest took place in Section E, Geography, on "Geographical problems of the earth's crust." The discussion was opened by Mr. A. R. Hinks, and was carried on by Dr. G. C. Simpson, Dr. J. H. J. Poole, Dr. H. Jeffreys, Prof. J. W. Gregory and others. The points at issue were mainly the reality of continental drift on the lines postulated by the late Dr. A. Wegener, the nature of local departures from normal gravity and the mechanism by which continental drift could possibly be effected and anomalies of gravity maintained. Especial importance was attached to a long belt of markedly deficient gravity discovered by the submarine investigations of F. A. Vening-Meinesz, which follows Wallace's line in the East Indies.

No meteorological papers were read on September 29th, which was devoted to the important discussion on "The evolution of the universe," but on September 30th Dr. G. C. Simpson described to Section A the plans for the second international polar year, 1932-3. During the first polar year in 1882-3, twelve countries sent fourteen expeditions to north polar regions and two to south polar regions. The plans for next year include the re-occupation of all these stations, and in addition the establishment of sixteen new stations. The work to be undertaken includes the investigation of the atmosphere at all levels as well as studies of terrestrial magnetism, atmospheric electricity and the aurora. The organised observations will include those which require simultaneous observations over a large area, such as the movements of air masses and the manufacture and outflow of polar air in high latitudes. All stations will be equipped with self-recording instruments, and upper air observations will be undertaken as far as possible to determine the lapse rate and the height and temperature of the stratosphere. The natural difficulties and the high cost of the new wireless transmitting meteorograph will limit the upper air investigation, however, and this will be supplemented by observations at mountain stations which rise above the level of the stagnant surface air. In spite of the present financial difficulties the International Commission which had just met at Innsbruck, after reviewing the offers of help, felt justified in going ahead with the plans. The British station will be at Fort Rae in Canada, and will consist of a party of five under the leadership of Mr. J. M. Stagg.

At 1 p.m. members of the Sub-section of Cosmical Physics and their friends met at the Hotel Rembrandt, the occasion being the customary Meteorological Luncheon, which this year was held under the auspices of the Royal Meteorological Society. A large and distinguished gathering was present, Mr. R. G. K. Lempfert, C.B.E., M.A., President of the Society, occupying the chair. In proposing the toast of "The Guests, coupled with the name of Dr. Abbot," Mr. Lempfert referred to the influence of the British Association on the work of meteorologists in the past. After Dr. Abbot had responded, "Meteorology and the allied sciences," was proposed by Sir Richard Gregory and replied to by Dr. G. C. Simpson. Finally, Sir John Russell proposed "The British Association, coupled with the name of Dr. Ferguson, Recorder to Section A," and Dr. Ferguson replied. Those present included :—

Mr. R. G. K. Lempfert, O.B.E. (in the chair); Dr. C. G. Abbot and Mrs. Abbot; Dr. E. Kidson and Mrs. Kidson; Abbé G. Lemaitre; Prof. W. de Sitter and Mrs. de Sitter; Prof. Griffith Taylor; Mr. C. Anthony; Mr. E. C. Barton; Mr. M. G.

Bennett; Mr. E. G. Bilham; Mr. E. W. Bliss and Miss E. G. Bliss; Mr. L. C. W. Bonacina; Air-Marshal Sir Robert Brooke-Popham, K.C.B., C.M.G.; Dr. C. E. P. Brooks; Mr. A. Hampton Brown; Capt. D. Brunt; Dr. L. J. Comrie; Mr. R. Corless, O.B.E.; Mr. H. W. Davis; Mr. R. M. Deeley; Dr. H. Dingle; Mr. F. Druce; Capt. F. Entwistle and Mr. W. M. H. Greaves, Secretaries of Section A, and Mrs. Greaves; Dr. A. Ferguson, Recorder of Section A, and Mrs. Ferguson; Prof. A. Fowler, F.R.S., and Mrs. Fowler; Col. E. Gold, D.S.O., F.R.S., and Mrs. Gold; Sir Richard Gregory and Lady Gregory; Dr. Ezer Griffiths, F.R.S.; Dr. Wilfred Hall; Mr. E. L. Hawke and Mrs. Hawke; Dr. J. O. Irwin; Dr. H. Jeffreys, F.R.S.; Mr. A. Pearse Jenkin, J.P.; Prof. J. Joly, F.R.S.; Dr. L. Keffler; Miss I. Lehmann; Dr. W. J. S. Lockyer; Mr. G. W. Lord; Mr. Gordon Manley; Dr. G. Merton and Mrs. Merton; Prof. E. V. Neville; the Reverend Father O'Connor, S.J.; Mr. R. S. Read; Rev. J. P. Rowland; Sir John Russell, O.B.E., F.R.S.; Mr. D. H. Sadler; Dr. B. J. F. Schönland, O.B.E.; Lady Schuster; Mr. F. J. Scrase; Sir Napier Shaw, F.R.S.; Dr. G. C. Simpson, C.B., F.R.S., and Mrs. Simpson; Mrs. H. H. Turner; Dr. K. W. Wagner; Sir Gilbert Walker, C.S.I., F.R.S.; Mr. R. A. Watson Watt; Dr. F. J. W. Whipple; Mr. R. S. Whipple and Mr. W. M. Witchell.

Among the numerous visits and excursions arranged by the local Committee were several of special interest to meteorologists. On the afternoon of September 24th a very large party visited the National Physical Laboratory, Teddington. Other excursions were: The Royal Observatory, Greenwich, on the 25th, Kew Observatory on the 28th, the Air Port of London, Croydon, on the 29th and 30th, and the Radio Research Station, Slough, on the 29th.

A party of some 30 members of Section E (Geography), visited the Meteorological Office, South Kensington, on Friday, September 25th. As the visit occupied only one hour in a crowded day, the exhibits had been designed to illustrate prominent features of some of the more obvious activities of a meteorological service, rather than to give a detailed picture. The visitors were received by Dr. G. C. Simpson, C.B., F.R.S., Director of the Meteorological Office, who gave a short account of the history of the South Kensington Office and an outline of the programme of the visit, after which parties of visitors were conducted round the various exhibits by members of the staff.

In the British Climatology Division, the methods of constructing rainfall charts was illustrated by an index map of rainfall stations and by the "charting table," designed for rapid plotting of data on a series of charts. Photographs and charts of noteworthy falls of rain and snow were also shown.

In the General Climatology Division were shown methods by which information regarding climates of different parts of the world can be rapidly obtained, varying from the latest map of Köppen's climatic regions to special bibliographies and the card index. Mr. G. A. Clarke's excellent series of cloud photographs, as well as a display of stereographic cloud photographs from aeroplanes, attracted considerable interest.

A set of "working charts," by means of which daily forecasts are made, was exhibited by the Forecast Division as well as *Daily Weather Reports* and other reports for supplying current data to the public.

The display of instruments included a modern set such as are used at telegraphic reporting stations of the Office, and for comparison a number of historic instruments, some of which were described in the *Meteorological Magazine* for September.

The Noteworthy Depression of August 8th, 1931

On August 8th last a depression, deepening considerably as it travelled, moved eastward across southern England giving heavy rain and boisterous winds in many parts of the British Isles.

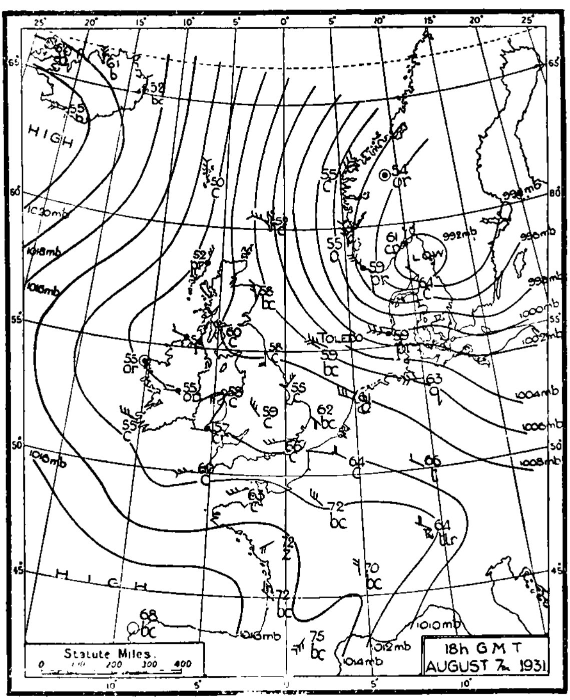

Fig. 1.

This depression was a remarkable one in view of its sudden and unexpected development and of its rapid growth. That this is so is revealed by a study of the synoptic charts. At 18h. G.M.T. on Friday, the 7th, the chart, reproduced as Fig. 1, revealed little indication of anything very untoward to come, the main features being a primary depression over Scandinavia, a secondary "kink" across southern Scotland and northern Ireland, and an anticyclone over mid-Atlantic. The 1h. chart on the 8th, however, revealed a striking change, a fully developed secondary then being centred over the Bristol Channel, the inner isobar of the secondary having a value of 1,004mb., while rain was falling over Ireland, southern Scotland, and most of Wales and southern England. The chart for 7h. on the same morning, reproduced as Fig. 2, showed a further striking development, the secondary now being centred approximately over Salisbury and the inner isobar having the value of 998mb., while rain was more or less general over the British Isles. At 13h. the depression had travelled to a position centred off Yarmouth with a further deepening of 2mb. and winds generally boisterous over the whole country, while at 18h. there was little change except for a slight eastward movement of the centre. By 1h., however, on the following morning, the centre had passed to the Netherlands.

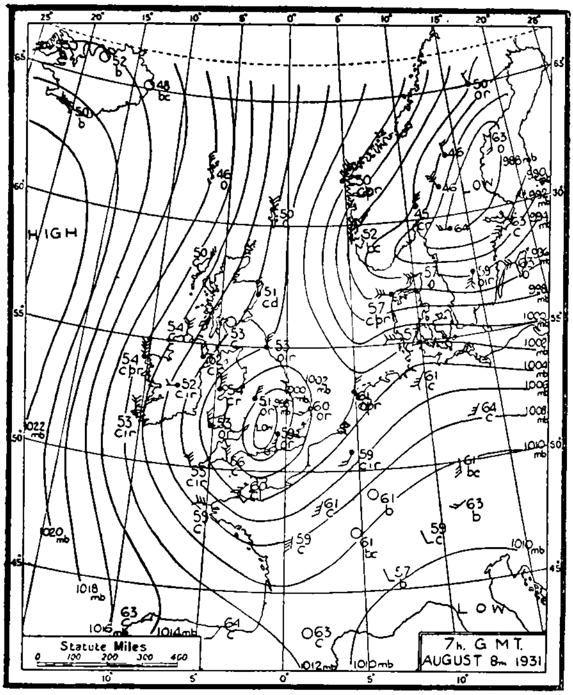

FIG. 2

Some noteworthy phenomena were associated with the passage of the disturbance. Amongst the more spectacular was a remarkable hailstorm at Hatfield on the afternoon of Saturday, the 8th, which resulted, to quote *The Daily Mirror* of the 10th, in conditions "like a scene from the Arctic regions," ice holding up traffic over a considerable distance on the Barnet bypass road. Temperature readings over the country presented abnormal features for August, the temperature at Birmingham at 13h. on the Saturday being only 50°F., while Glasgow during Saturday night experienced appreciable ground frost. It may only be a coincidence but it is to be remarked that these shivery conditions fell within Buchan's fifth cold spell, which stretches from August 6th to 11th. There were also some heavy rainfall amounts to record in connexion with the depression.* Wind conditions were generally blustery, and the Norfolk coast especially, according to newspaper reports, had a particularly boisterous experience on the Saturday night.

WILLIAM H. PICK.

*See *Meteorological Magazine*, 66, 1931, p. 185.

Memorial Tablet to the late M. A. Giblett, M.Sc.

On Monday, October 5th, 1931, the anniversary of the loss of H.M. Airshop R 101, a tablet was placed in the Library of the Meteorological Office, South Kensington, bearing the following inscription :—

IN MEMORY OF
MAURICE ALFRED GIBLETT
SUPERINTENDENT
OF THE
AIRSHIP SERVICES DIVISION
OF THE
METEOROLOGICAL OFFICE
WHO PERISHED IN THE DISASTER TO
H.M. AIRSHIP R 101
NEAR BEAUVAIS, FRANCE
ON
5TH OCTOBER, 1930

Discussions at the Meteorological Office

November 2nd, 1931.—*The mistral in the plains of the middle Rhône, between Bas-Dauphiné and Provence.* By E. Rougetet (Météorologie, Paris, 6, 1930, pp. 341-85) (in French). *Opener*—Mr. C. S. Durst, B.A.

November 16th, 1931.—*Historical note on the catch of rain-gauges.* By H. R. Puri (India Meteor. Dept. Sci. Notes, Calcutta III, No. 23, 1931). *Opener*—Mr. J. Glasspoole, Ph.D.

Correspondence

To the Editor, *The Meteorological Magazine.*

Remarkable Coloured Halos

A remarkable system of solar halos was seen at Armagh Observatory on September 4th. At 15h. 45m. G.M.T., the sky was partly covered with flocculi of alto-cumulus, and in the intervals between these patches the blue was seen through a very delicate and uniform veil of cirro-nebula. In this, a brilliant parhelion shone vertically above the sun, associated with a fragment of halo concave upwards, but tailing off to the north into one curving downwards, so that the whole resembled an elongated letter S, or an italic f. I fancy this appearance was due to a bit of the usual $22\frac{1}{2}°$ halo, asociated with a tangent arc at the point vertically above the sun. The alto-cumulus gradually dissolved, and at 17h. 25m. the sun was shining in a sky clear but for the cirro-nebula, an all but imperceptible veil; and now a magnificent circle of pure rainbow spectrum was visible at 45° from the sun. The parhelion was brighter, and was now seen to be on the circumference of a $22\frac{1}{2}°$ halo, a good deal fainter than that at 45°, and with less vivid colours. The bright patch was rather hyperbolic than circular in shape, and there were faint traces of a sun pillar extending from the sun upwards to it. The halo system lasted nearly 3 hours, only disappearing shortly before sunset.

I have seen many halos and combinations of halos, but I have never before seen anything like the large rainbow coloured halo. It was in every respect like a rainbow except in position, and the colours were, if possible, purer and clearer than those of a rainbow. Though not as bright as a primary rainbow, it was brighter than I have ever seen a secondary bow, though it was narrower, and the repetition of the colours on the violet edge was absent. The red was on the inside of the circle, whereas in a rainbow it is on the outside.

WM. F. A. ELLISON.

The Observatory, Armagh. September 7th, 1931.

St. Elmo's Fire

Mr. G. H. Brown, Parkstone Avenue, Horfield, Bristol, reports the occurrence of St. Elmo's Fire at 19h. 15m. G.M.T., on Sunday, July 12th, which he describes as follows:—"Upon looking up I saw a decided blue light not unlike the new daylight-tinted electric bulbs on the arrow of the indicating vane arm pointing true north. On closer inspection from the front gate it was still there, and several passers-by also looked up mystified. This was then 19h. 20m., and thunder occurred several times within a few minutes, and it seems that a rather severe thunderstorm which had taken place at Weston-super-Mare was nearing us. I cannot quite understand why the light was not on the very top of the vane itself, unless the copper tip of the direction pointer was selected as the better conductor, for I may mention that the metal tubing is 50ft. from the ground running up the side of the house, and is earthed, with copper bed plate."

Alto-cumulus Castellatus Clouds and Thunderstorms

I agree with Mr. Petrocokino that severe thunderstorms of the turret cloud type sometimes come with upper currents on the east side of south. For example, on the evening of July 9th, 1923, the wind was SE. at 5,000 feet and S. by E. at 18,000 feet, and on the afternoon of July 22nd, 1925, the wind was 50 m.p.h. from SSE. at 10,000 feet. On July 20th, 1929, and August 29th, 1930, there were also severe storms preceded by turret clouds, but on these occasions the upper current was slightly west of south. The preponderance of south-west upper currents is due largely to comparatively high turret clouds, often associated with moderate or slight storms, and sometimes with none at all.

Thunderstorms associated with large easterly components in the upper wind are by no means rare, especially in the early summer, and in some cases there is something of the turret cloud structure, though not necessarily alto-cumulus castellatus proper. I think the cloud structure in question requires an absence of convection from near the ground, and the necessary conditions are sometimes present at quite moderate heights (say 5,000 feet) even in the daytime, as, for example, when there is a cool shallow north-east wind from the North Sea, and a warm unstable current above it, either from east or south, or occasionally south-west. I agree that the turret cloud cumulo-nimbus differs substantially in its method of development from ordinary cumulo-nimbus, and that it ought to have some designation, but I do not much like the suggested term "Alto-cumulus nimbus." Comparatively low and heavy turret clouds have little in common with alto-cumulus.

C. K. M. DOUGLAS.

September 24th, 1931.

May and September Maximum Temperatures

Evaluation of the decadal means of maximum temperature for May and September at Greenwich Observatory since 1841 indicates that the progressive rise noted by Mr. Pick in the three sets of 20-year means (1871-1890, 1891-1910, 1911-1930) for these two months at Kew should be interpreted as a temporary fluctuation rather than as a real climatic change. The Greenwich means are as follows:—

MEAN MAXIMUM TEMPERATURE.

Period.		*May.*	*September.*	*January.*
1841-1850	......	65·6°F.	67·2°F.	41·8°F.
1851-1860	......	62·9°F.	67·7°F.	44·7°F.
1861-1870	......	65·1°F.	68·3°F.	43·0°F.
1871-1880	......	62·7°F.	67·1°F.	43·4°F.
1881-1890	......	64·3°F.	66·3°F.	42·7°F.
1891-1900	......	63·8°F.	68·1°F.	42·2°F.
1901-1910	......	62·9°F.	66·1°F.	43·9°F.
1911-1920	......	66·6°F.	67·0°F.	44·2°F.
1921-1930	......	64·8°F.	67·6°F.	46·1°F.

It is interesting to note the large range of May variation (3·9°F.) among the nine decades as compared with that of September (2·2°F.). In the matter of diurnal warmth spring apparently tends to be more inconstant than autumn not only day by day and year by year, but decade by decade. To apportion the analysis evenly through the twelve months, the Greenwich mean maximum values for January in each ten-year period are appended. In this instance the inter-decadal range of variation is still greater—4·3°F., of which as much as 3·9°F. figures in the remarkable increase shown since 1891-1900.

E. L. HAWKE.

Caenwood, Rickmansworth, Herts. October 5th, 1931.

NOTES AND QUERIES

New Meteorological Station at Tonga, Friendly Islands

Since January 1st, 1931, meteorological observations have been carried out by the Director of Agriculture at the Government Experimental Station, Nukualofa, Tonga (22°S., 175°W.). The hour of observation is 9h. Tonga time. Observations for the first four months have now been received and have already brought out a striking contrast between two successive months. February was dry, receiving only 0·41in. of rain, but March was rather rainy, the month's total amounting to 20·14in. on 25 days of which 6·72in. fell on the 24th. There were corresponding differences of temperature and humidity, as shown by the following short table:—

	Temperature			Relative Humidity
	Mean Maximum	Mean Minimum	Daily Range	9h.
	°F	°F	°F	%
February	86·8	69·0	17·8	66
March	83·2	71·7	11·5	80

Canadian Auroral Expedition

A scientific expedition has just proceeded by the Canadian National Railways to Churchill, on Hudson Bay, for the purpose of photographing the Aurora Borealis.

The expedition, which is composed of three explorers and three scientists, is equipped with a camera possessing an ultra high speed lens and with panchromatic films. Churchill has been selected because, at this time of the year, it offers the best position for observation, being situated on a direct line between the auroral pole and the magnetic pole and in the belt of maximum frequency of the aurora.

The expedition will stay in the north for six weeks and, besides photographing the aurora, will measure the height of the display by means of photography and triangulation and by making astronomical transits. The expedition also hopes to discover if the auroral phenomenon is connected with static electricity and terrestrial magnetism.

In order to obtain the complete range of colour in the aurora, a double negative back to back in the camera will be used, each negative sensitive to one-half of the spectrum. Cinematograph films will also be taken.

Heavy Rainfall in a Tropical Storm

Reports of the storms which occurred in Fiji during the period February 17th to March 2nd, 1931, show that although not unprecedented as regards force of wind, they were accompanied by the most extensive and disastrous floods ever experienced in Fiji. Over two hundred persons lost their lives, much structural damage was done and serious loss was caused to the various crops.

There appears to be some doubt whether two storm centres were concerned or whether a single storm centre hovered close to northward of the group for several days, but the main damage was caused by a period of continuous heavy rain, culminating on February 21st, on the night of which the floods on the island of Viti Levu reached their peak. No district in Viti Levu escaped serious loss, but the other islands of the group were little affected.

In the district of Colo North remarkable falls of rain were measured at the Government Station, Nadarivatu, 2,500 feet above sea level, a total of 91½ inches of rain being experienced in nine days. The daily totals were as follows:—

	in.			in.			in.
17th	1·66	...	20th	11·65	...	23rd	2·92
18th	5·94	...	21st	20·40	...	24th	4·50
19th	8·55	...	22nd	24·20	...	25th	11·70

Heavy falls were also recorded in other places, Tavua having 30 inches on the 21st and 22nd, whilst in the Ra district it was reported that "the rainfall from 17th to 26th February was approximately 50 inches, the gauge frequently overflowing."

S. T. A. Mirrlees.

The Thermal Conductivity of Snow

The *Scientific Papers of the Institute of Physical and Chemical Research, Tokyo*, vol. 12, 1929-30, contains a paper by Masao Kuroda on the "Thermal Conductivity of Snow," which is of interest to meteorologists. The readings were made by the members of the Alpine Club of Waseda University, Japan, who measured the temperature of the snow daily every three hours from March 12th to April 7th, 1928, at the surface and at depths of 5, 10 and 20cm. In the calculations only the data for fine days were employed and these were divided into two groups, I, those on which the maximum temperature did not reach 0°C., and II, those on which temperature remained near 0°C. for some time and melting occurred.

The averages of the first group were analysed harmonically at the surface and at 5cm. depth, and values of the diffusivity calculated from the first two terms of the series. These showed a rather wide dispersion but gave an average figure of 0·0086. This was checked by comparing the calculated and observed temperatures at 10 and 20cm. depth, and gave good results after allowing for the upward transfer of heat from the earth. The thermal conductivity of snow of specific gravity 0·125 was calculated as 0·000516, a rather higher value than those previously obtained in the laboratory.

The temperatures calculated from this conductivity were compared with the observed temperatures at all depths. In the morning the former were too low, in the later afternoon and evening too high, the departures being greatest at 10cm. The author accounts for this discrepancy by the convection of air through the pores in the snow; in the morning the air heated with the snow is replaced by cold air from above, hindering the downward conduction, while the air in the deeper snow does not move; later, when the surface begins to cool, cold air penetrates downwards and assists conduction. It appears that in field measurements conduction and convection cannot be separated. Since the mean temperature increases downwards, the result is a measure of conductivity higher than those found in laboratory experiments.

The diurnal variations on days accompanied by melting cannot be employed for calculating the thermal conductivity but are applied to calculate approximately the heat consumed in melting. The results agree reasonably well with the rate of lowering of the snow surface.

Reviews

Weather dominated by solar changes. By C. G. Abbot, Smiths. Misc. Coll. 85, No. 1. Hodgkins Fund and Roebling Fund, Washington, D.C.

In this paper Dr. C. G. Abbot shows that the changes of pressure and temperature at Washington following increases of solar radiation are on the whole opposite to those following decreases, suggesting a real connexion between short period solar fluctuations and terrestrial weather. The changes are complex and irregular, and differ greatly from one month to another, while the temperature effects are too large to be explained by local heating. The author thinks they may be of value in forecasting, if the changes of the solar constant can be forecast, and he accordingly investigates periodicities in the latter by a graphical method. Five periodicities are found, with lengths of 68, 45, 25, 11 and 8 months. The monthly mean temperatures at Washington are analysed for similar periodicities, and the results, with the addition of a "terrestrial" period of 18 months, are employed to construct a curve of calculated temperatures which resembles fairly well the curve of observed readings, corrected for the annual variation.

Climate and migrations. By J. C. Curry. Smiths. Ann. Rep. for 1929, Washington, D.C., pp. 423-35.

In this historical study, reprinted from "Antiquity," the racial movements in Eurasia are employed to construct a curve showing alternating periods of migration and rest. The migrations agree fairly well with the periods of drought in Eurasia according to Brooks ("Climate through the Ages"), but the author also finds in them a periodicity of about 640 years.

The thermal structure of the free atmosphere over Agra. By G. Chatterjee and N. K. Sur. Reprinted from Gerlands Beiträge zur Geophysik, Leipzig, 25, 1930, pp. 266-78.

Upper air investigation in India by means of sounding balloons, after being in abeyance for some time subsequent to the war, has been revived with great and commendable vigour during the last few years. The above paper presents a summary of the results obtained by the Agra Aerological Observatory since the year 1925. It opens with a brief but most instructive account of the instrumental methods employed, followed by tables and graphs showing monthly and seasonal mean values of temperature over Agra up to about 20 geodynamic kilometres. Further graphs show the variation of temperature at the tropopause throughout the year and indicate the various types of tropopause commonly found.

It is evident that upper air investigation at Agra is very much alive at the present time. An example of the enterprise of the staff may be given in the fact that they make their own balloons, and that the heights reached therewith now exceed those obtained by sounding balloons in England with the best balloons which can be purchased.

L. H. G. Dines.

Wanderers Wetterbuch. By Dr. Otto Myrbach. Size 6¾ × 4¾in., pp. 184, *Illus.* Leipzig, Berg. and Buch, 1931. 2 marks.

In addition to the comparatively numerous publications dealing with general meteorology, climatology, aeronautical meteorology, &c., there appears now and again some little book which appeals to the nature-loving side of man. A few years ago Mr. C. J. P. Cave published his "Clouds and weather phenomena for artists and other lovers of nature," which dealt with the colour of the sky, optical phenomena and clouds. This year we have by an official forecaster at the headquarters of the meteorological service in Vienna, a weather-book for wanderers. In Austria it is easy to understand that a wanderer is naturally in some degree a mountain climber, so that the mention of mountains on the first and last pages and throughout the work is scarcely surprising.

Presupposing no knowledge beyond that obtained in a general school education, the author builds up his structure gradually and carefully, urging the reader to read the book through from beginning to end before using it for reference purposes. Perhaps this is the reason why no index is included. There is a fairly full table of contents, but the reviewer experienced difficulty at times in re-finding some passages, *e.g.*, the paragraphs dealing with waterspouts, tornadoes, &c., which are to be found under "hail." There are also some riddles which may be due to printers' errors, but apart from such minor defects, the author has succeeded in presenting in less than 200 small pages a great deal of information in a very pleasant and readable form. He has intentionally avoided technical discussions of instruments, &c., which are not essential to the tourist, and climate is barely touched upon since he argues that mean values are of less importance to the Alpine wanderer than weather.

After a simple explanation of the meteorological elements and some principles of thermodynamics, the greater part of the book is devoted to air-masses, the formation of various kinds of cloud and precipitation, "fine" weather processes (which receive unusual though scarcely undue respect in 20 pages of this small book!), forecasting and lastly, definite examples chosen from recent years. The differences between highland and lowland conditions are emphasised and the tables accompanying the weather maps have been specially arranged to show vertical variations on different sides of the Alps and calculated temperature gradients. The author discusses the uses and also the limitations of official forecasts and stresses the duty of the leader of a party with respect to weather. Incidentally the candid manner in which he explains the forecasters' standpoint should help to foster a sympathetic understanding on the part of the reader.

The language is clear and should be easily understood by anyone with a moderate knowledge of German, while simplicity of style adds a charm to this little book which should be of particular interest and value to visitors to the Austrian Alps. It contains many good illustrations and photographs, and concludes with a nine-page weather drama in four acts described by Dr. Peter Lautner of Munich under the title of "A February storm on the Zugspitze."

L. D. SAWYER.

Deutsches Meteorologisch Jahrbuch für Bayern, 1929.

(*a*) *Die Münchener Registrierballonfahrten im Jahre*, 1929. By P. Zistler and H. Zierl.

Contains complete data, also "tephigrams."

(*b*) *Zum Mikroklima isolierter Standorte*. By K. Hummel.

Deals with measurements of temperature at various heights and exposures among vegetation.

(*c*) *Zur Methodik der Untersuchung der mechanischen Windstruktur*. By M. J. Holtzmann.

Deals mainly with the instrumental factors involved in measuring gustiness.

(*d*) *Harmonische Analyse des Luftdruckes von München und Zugspitze im Mai*, 1926. By L. Egersdörfer.

(*e*) *Die Zugspitzbahn-Versuche.* By A. Büdel.

Autographic records have been obtained from instruments fitted outside the cars on the funicular railway up the Zugspitze. There is an observatory at the top (9,724 feet), and also observing stations at the bottom and a little below the summit, and two other stations in the valley at no great distance. Aeroplane flights were also made in the neighbourhood so as to compare the conditions in the free air with those on the mountain. The paper deals mainly with the observation work, but some examples are reproduced. This work should be of great value as an investigation of mountain meteorology.

(*f*) *Schwankungen der Niederschlagsbereitschaft über West- und Mitteleuropa.* By A. Schmauss.

A large number of diagrams and charts showing the day to day variation of rainfall over Europe, averaged for period 1891 to 1910, are given. Deductions are made therefrom, of doubtful validity.

Books Received

Jaarboek, Koninklijk Nederlandsch Meteorologisch Instituut, 1929. A. Meteorologie, B. Aard-Magnetisme (Nos. 97 and 98). Utrecht, 1930.

Ergebnisse Aerologischer Beobachtungen, 1929. K. Ned. Meteor. Inst. (No. 106 A). Utrecht, 1930.

Onweders, optische verschijnselen, enz. in Nederland. Naar vrijwillige waarnemingen in 1928. Deel xlix, Amsterdam, 1930.

Obituary

We regret to learn of the death on September 25th at the age of 69 of M. Emile Schaer, founder of the Jungfraujoch Observatory and since 1898 assistant at the Geneva Observatory.

News in Brief

The retirement is announced of Mr. H. A. Hunt from the position of Commonwealth Meteorologist of Australia on February 6th, 1931. He is succeeded by Mr. William Shand Watt.

We learn from the *Morning Post* that a new type of aeroplane specially designed for flights into the stratosphere is now ready for its first ascent at the Junkers works at Dessau. It has been ordered by the Aeronautical Research Institute of Berlin, which proposes to carry out the first flight within a few weeks. It is the Institute's aim to explore and study the higher regions with the idea that future air services will use the stratosphere.

Errata

September, 1931, p. 184, fourth line from bottom of page, *for* "1·67in. at Bury St. Edmunds" *read* "1·67in. at Westley, 2 miles from Bury St. Edmunds." The rainfall in the town of Bury St. Edmunds itself was much smaller; Canon E. Hill has kindly supplied the following figures: 0·92in. at Whiting Street, 0·66in. at Southbridge House, and 0·62in. at Northgate Street.

September, 1931, p. 195, last line, *for* "with gusts of 90 m.p.h. and 72 m.p.h." *read* " with gusts of 79 m.p.h. and 72 m.p.h."

The Weather of September, 1931

Pressure was above normal over western Europe (including Switzerland), the northern North Atlantic and the extreme north-west of Africa, the greatest excess being 9·0mb. at Thorshavn. Pressure was below normal over Spitsbergen, north-east Norway, east Sweden, Russia, eastern Germany and south-east Europe and Madeira, the greatest deficit being 6·1mb. at Moscow. Temperature was below normal over the whole of western Europe—as much as 6·5°F. below normal at Zurich—but above normal at Spitsbergen. The rainfall distribution was irregular, in excess at Spitsbergen and in eastern Svealand, Sweden, deficient in northern Norway, most of Sweden and in Switzerland.

The weather of September over the British Isles was generally cold and dull, but after the heavy local rain at the beginning mainly dry. The opening days were very unsettled. A complex depression off south-west Ireland moved slowly eastward across England giving heavy rain in many places, 4·97in. at Kildale (Yorks.) and 3·11in. at Pickering (Yorks.) on the 4th, and 3·20in. at Dalgany (co. Wicklow), and 2·43in. at Mansfield (Notts.) on the 3rd were among the heavier falls. Floods occurred locally. Thunderstorms were widespread on the 2nd and 3rd and local on the 4th, 5th and 7th. Temperature was high at the beginning of the month, especially in north England and the Midlands, where it rose to 73°F. at Huddersfield on the 1st. In the rear of the depression cold northerly winds, approaching gale force locally at times, prevailed over the British Isles and day temperatures were low; one of the lowest maxima reported was 49°F. at Leafield on the 5th. Sunshine records were good in south-east England on the 3rd, and in Ireland on the 5th. Thereafter the character of the month completely changed, quiet anticyclonic weather prevailing with only occasional short breaks. On the 6th an anticyclone situated westward of Ireland with a tongue of high pressure extending over France moved a little eastwards. A period of cool, mainly fair weather ensued apart from scattered showers. Ground frost occurred generally and sunshine records were good, the 6th, 7th and 8th were very fine days in Ireland and north-west England. This distribution persisted with little change until the evening of the 10th, when a secondary depression south of Iceland moved south-east and gave rain locally on the 11th and 12th. Thunderstorms occurred in the west on the 10th. About the 13th an anticyclone centred near the Azores moved north-east over the British Isles and warmer but mainly cloudy conditions with light south-west to west winds prevailed for some days, with much mist or fog and local drizzle. Temperature rose above 70°F. at many places on the 15th, 16th and 18th, and reached 72°F. at York and Hull on the 15th. Good sunshine records were obtained along the south coast on the 16th. Although the anticyclone persisted, a change to cooler conditions occurred about the 20th, when the winds became northerly. The weather for the next two or three days was sunny and bright but cool; sunshine records of over 10hrs. were registered at many places on the 20th, 22nd and 23rd; Valentia (co. Cork) had 11·0hrs. on the 20th, 10·7hrs. on the 22nd and again on the 23rd. Slight rain occurred in eastern England on the 22nd or 23rd. After this the weather became increasingly overcast, the anticyclone diminished in intensity and moved eastwards. It was followed by a depression from the Atlantic which brought rain to the west on the 29th and to other districts on the 30h, with warmer conditions in the south. Temperature was below normal for the month, the mean being as much as 2·9°F. below normal at Kew. The distribution of bright sunshine was as follows:—

	Total (hrs.)	Diff. from normal (hrs.)		Total (hrs.)	Diff. from normal (hrs.)
Stornoway	93	— 22	Liverpool	93	—35
Aberdeen	110	— 14	Ross-on-Wye	95	—41
Dublin	97	— 42	Falmouth	131	—32
Birr Castle	111	— 15	Gorleston	127	—35
Valentia	127	— 6	Kew	117	—28

The special message from Brazil states that the rainfall was irregular in the northern regions with an average 0·47in. above normal and generally scarce in the central and southern regions with averages 0·35in. and 0·87in. below normal respectively. The crops were generally in good condition, especially the cane and cotton crops. The coffee blossom was affected in some places by strong winds. Four anticyclones crossed the country. At Rio de Janeiro pressure was 1·3mb. above normal and temperature 1·3°F. below normal.

Miscellaneous notes on weather abroad culled from various sources.

High winds were experienced along the Atlantic and Channel coasts of France on the 6th and 7th, and cold weather accompanied by heavy snowfall was reported from the Alps and the Auvergne. On the 7th the snow had descended to a level of 3,000ft. in the Alps. Heavy snow fell in upper Bavaria and in the Taunus hills a few miles to the north-west of Frankfurt on the 22nd and 23rd. This is the first time snow has been recorded in September in Munich since 1830 and near Frankfurt since 1859. Cold weather was also experienced in France, and snow was recorded in the central and southern districts about the 24th. (*The Times*, September 7th-8th, 24th-26th.)

The Chinese floods continued throughout September. At Hankow the river was 51ft. above bund level on the 4th, but the floods were gradually subsiding, the river being down to 48ft. on the 22nd when some streets were nearly dry. A small typhoon struck Hongkong on the 12th doing much damage to the fishing fleets—200 Chinese were drowned. Floods were still reported from several districts of Burma on the 8th, but in others the monsoon partially failed. A typhoon in Japan on the night of the 26th caused the heaviest rainfall recorded in Tokyo for 17 years (*The Times*, September 5th-28th).

Several miles of the Canadian Pacific main railway line have been swept away by the flooding of the Columbia river in the Rocky Mountains. A heat wave, unusually severe for September, with temperatures of over 90°F., passed over central and eastern Canada round about the 9th; a maximum temperature of 100°F. was recorded at Ottawa on the 11th. At the same time in Alberta the temperature was below freezing point and snow fell on the 9th. Two hundred people were reported on the 4th to have been drowned by the floods in Porto Rico. A hurricane struck Belize, British Honduras, at 11.30 a.m. on the 10th and lasted 4 hours, during which the velocity of the wind reached 90 m.p.h. After this there was dead calm for half-an-hour with a very low barometer and high temperature. Then came the second blast, which lasted 5 hours and during which the wind reached 120 m.p.h. An inrush of the sea followed which inundated the town in places to a depth of 16ft. The number of deaths was estimated at 1,000 and most of the town was destroyed. A much less severe hurricane passed over Jamaica on the 12th, destroying many banana trees. A hurricane passed over Santa Rosalie, lower California, on the 12th and 13th, killing some 50 people, and a hurricane also swept Vera Cruz on the 16th wrecking a number of small ships in the harbour. Temperature was considerably above the normal over the United States during the month, except along the Pacific Coast, where it was about normal, while rainfall was generally deficient at the beginning and end of the month though in excess locally in the middle. (*The Times*, September 4th-22nd, *Toronto Weather Map*, September 12th, and *Washington, D.C., U.S., Dept. Agric., Weekly Weather and Crop Bulletin*.)

Rainfall, September, 1931—General Distribution

England and Wales	123	per cent of the average 1881-1915.
Scotland	55	
Ireland	101	
British Isles	102	

Rainfall: September, 1931: England and Wales

Co.	Station	In.	Per-cent of Av.	Co.	Station	In.	Per-cent of Av.
Lond .	Camden Square.........	2·70	148	*Leics* .	Belvoir Castle...........	2·69	144
Sur .	Reigate, Alvington.....	2·09	100	*Rut* .	Ridlington...............	3·72	194
Kent .	Tenterden, Ashenden...	2·25	105	*Linc* .	Boston, Skirbeck........	2·67	152
,, .	Folkestone, Boro. San..	1·32	...	,, .	Cranwell Aerodrome...	2·58	145
,, .	Margate, Cliftonville...	1·16	59	,, .	Skegness, Marine Gdns	2·92	161
,, .	Sevenoaks, Speldhurst	2·27	...	,, .	Louth, Westgate........	1·82	90
Sus .	Patching Farm.........	2·05	85	,, .	Brigg, Wrawby St.....	2·68	...
,, .	Brighton, Old Steyne..	2·02	97	*Notts* .	Worksop, Hodsock.....	3·07	202
,, .	Heathfield, Barklye....	2·19	89	*Derby* .	Derby, L. M. & S. Rly.	2·09	127
Hants .	Ventnor, Roy. Nat. Hos.	2·20	89	,, .	Buxton, Devon Hos....	4·02	124
,, .	Fordingbridge, Oaklnds	1·92	89	*Ches* .	Runcorn, Weston Pt...	3·41	128
,, .	Ovington Rectory.......	2·48	108	,, .	Nantwich, Dorfold Hall	5·34	...
,, .	Sherborne St. John.....	1·51	74	*Lancs* .	Manchester, Whit. Pk.	3·08	129
Berks .	Wellington College.....	2·02	110	,, .	Stonyhurst College.....	2·99	78
,, .	Newbury, Greenham...	2·17	107	,, .	Southport, Hesketh Pk	3·58	138
Herts .	Welwyn Garden City...	2·38	...	,, .	Lancaster, Strathspey	3·23	...
Bucks .	H. Wycombe, Flackwell	2·08	...	*Yorks* .	Wath-upon-Dearne.....	3·88	246
Oxf . .	Oxford, Mag. College..	2·62	156	,, .	Bradford, Lister Pk....	3·81	184
Nor .	Pitsford, Sedgebrook...	3·73	207	,, .	Oughtershaw Hall......	2·82	...
,, .	Oundle....................	2·37	...	,, .	Wetherby, Ribston H.	4·46	276
Beds .	Woburn, Crawley Mill	2·44	136	,, .	Hull, Pearson Park.....	3·50	204
Cam .	Cambridge, Bot. Gdns.	2·87	178	,, .	Holme-on-Spalding.....	2·65	...
Essex .	Chelmsford, CountyLab	1·72	100	,, .	West Witton, Ivy Ho.	3·82	178
,, .	Lexden Hill House....	1·55	...	,, .	Felixkirk, Mt. St. John	4·54	250
Suff .	Hawkedon Rectory.....	2·38	123	,, .	Pickering, Hungate....	5·35	280
,, .	Haughley House........	1·97	...	,, .	Scarborough.............	4·04	226
Norf .	Norwich, Eaton...... ...	2·36	110	,, .	Middlesbrough..........	4·62	278
,, .	Wells, Holkham Hall	3·73	196	,, .	Baldersdale, Hury Res.	1·93	...
,, .	Little Dunham..........	2·32	101	*Durh* .	Ushaw College..........	3·61	180
Wilts .	Devizes, Highclere......	2·65	130	*Nor* .	Newcastle, Town Moor	2·03	100
,, .	Bishops Cannings.......	2·20	100	,, .	Bellingham, Highgreen	1·32	55
Dor .	Evershot, Melbury Ho.	1·90	71	,, .	Lilburn Tower Gdns....	2·58	109
,, .	Creech Grange..........	2·07	75	*Cumb* .	Geltsdale.................	1·50	...
,, .	Shaftesbury, Abbey Ho.	1·72	71	,, .	Carlisle, Scaleby Hall	1·43	52
Devon .	Plymouth, The Hoe....	1·64	64	,, .	Borrowdale, Seathwaite	7·95	80
,, .	Polapit Tamar..........	...	...	,, .	Borrowdale, Rosthwaite	3·53	...
,, .	Holne, Church Pk. Cott.	1·82	51	,, .	Keswick, High Hill.....	2·16	...
,, .	Cullompton	1·36	60	*West* .	Appleby, Castle Bank..	1·32	52
,, .	Sidmouth, Sidmount...	1·56	68	*Glam* .	Cardiff, Ely P. Stn.....	1·93	62
,, .	Filleigh, Castle Hill....	2·48	...	,, .	Treherbert, Tynywaun	3·46	...
,, .	Barnstaple. N. Dev. Ath	1·94	72	*Carm* .	Carmarthen Friary.....	2·92	84
,, .	Dartm'r, Cranmere Pool	3·80	...	*Pemb* .	Haverfordwest, School	4·43	125
Corn .	Redruth, Trewirgie.....	3·48	111	*Card* .	Aberystwyth............	3·79	...
,, .	Penzance, Morrab Gdn.	3·05	104	,, .	Cardigan, County Sch.	3·14	...
,, .	St. Austell, Trevarna...	3·23	101	*Brec* .	Crickhowell, Talymaes	3·20	...
Soms .	Chewton Mendip........	1·48	48	*Rad* .	BirmW. W. Tyrmynydd	2·87	74
,, .	Long Ashton............	2·95	123	*Mont* .	Lake Vyrnwy...........	3·21	91
,, .	Street, Millfield	1·54	68	*Denb* .	Llangynhafal............	5·46	246
Glos. .	Cirencester, Gwynfa....	2·19	100	*Mer* .	Dolgelly, Bryntirion...	4·72	111
Here .	Ross, Birchlea...........	1·86	97	*Carn* .	Llandudno...............	3·92	172
,, .	Ledbury, Underdown..	2·02	106	,, .	Snowdon, L. Llydaw 9	10·15	...
Salop .	Church Stretton.........	2·30	113	*Ang* .	Holyhead, Salt Island	3·08	115
,, .	Shifnal, Hatton Grange	2·38	123	,, .	Lligwy....................	2·98	108
Worc .	Ombersley, Holt Lock	2·36	133	*Isle of Man*			
,, . .	Blockley..................	2·35	...		Douglas, Boro' Cem....	4·14	127
War .	Birminghm, Edgbaston	2·41	135	*Guernsey*			
Leics .	Thornton Reservoir....	2·36	130		St. PeterP't. GrangeRd.	2·41	93

Rainfall : September, 1931 : Scotland and Ireland

Co.	Station	In.	Per-cent of Av.	Co.	Station	In.	Per cent of Av.
Wigt .	Pt. William, Monreith	3·60	123	*Suth* .	Melvich	1·13	...
,, .	New Luce School	2·55	71	,, .	Loch More, Achfary	3·65	63
Kirk .	Carsphairn, Shiel	2·19	41	*Caith* .	Wick	·94	38
Dumf.	Dumfries, Crichton, R.I	1·49	...	*Ork* .	Pomona, Deerness	·81	28
,, .	Eskdalemuir Obs.	1·46	39	*Shet* .	Lerwick	1·11	37
Roxb .	Branxholm	1·79	80	*Cork* .	Caheragh Rectory	1·52	...
Selk .	Ettrick Manse	1·73	48	,, .	Dunmanway Rectory	1·31	32
Peeb .	West Linton	1·34	...	,, .	Ballinacurra	1·50	59
Berk .	Marchmont House	1·87	78	,, .	Glanmire, Lota Lo.	1·16	41
Hadd .	North Berwick Res.	1·34	64	*Kerry*.	Valentia Obsy.	2·61	63
Midl .	Edinburgh, Roy. Obs.	1·98	105	,, .	Gearahameen	5·20	...
Lan .	Auchtyfardle	1·04	...	,, .	Killarney Asylum	2·56	67
Ayr .	Kilmarnock, Agric. C.	...	...	,, .	Darrynane Abbey	2·52	71
,, .	Girvan, Pinmore	1·73	45	*Wat* .	Waterford, Brook Lo.	3·35	121
Renf .	Glasgow, Queen's Pk.	1·35	49	*Tip* .	Nenagh, Cas. Lough	3·13	111
,, .	Greenock, Prospect H.	1·64	35	,, .	Roscrea, Timoney Park	2·20	...
Bute .	Rothesay, Ardencraig.	2·51	62	,, .	Cashel, Ballinamona	2·68	109
,, .	Dougarie Lodge	2·06		*Lim* .	Foynes, Coolnanes	1·78	62
Arg .	Ardgour House	3·06	...	,, .	Castleconnel Rec.	1·82	...
,, .	Manse of Glenorchy	...	...	*Clare* .	Inagh, Mount Callan	3·80	...
,, .	Oban	1·85	42	,, .	Broadford, Hurdlest'n.	2·24	...
,, .	Poltalloch	2·15	47	*Wexf*.	Gorey, Courtown Ho.	4·70	190
,, .	Inveraray Castle	2·19	34	*Kilk* .	Kilkenny Castle	2·33	101
,, .	Islay, Eallabus	2·76	66	*Wic* .	Rathnew, Clonmannon	5·74	...
,, .	Mull, Benmore	...	..	*Carl* .	Hacketstown Rectory	2·96	106
,, .	Tiree	2·30	...	*Leix* .	Blandsfort House	4·36	160
Kinr .	Loch Leven Sluice	1·59	...	,, .	Mountmellick	2·93	...
Perth .	Loch Dhu	2·50	44	*Off'ly* .	Birr Castle	2·50	109
,, .	Balquhidder, Stronvar	...	...	*Kild'r*.	Monasterevin	3·15	...
,, .	Crieff, Strathearn Hyd.	1·39	49	*Dubl* .	Dublin, FitzWm. Sq.	4·84	252
,, .	Blair Castle Gardens	1·27	54	,, .	Balbriggan, Ardgillan.	3·95	194
Angus.	Kettins School.	1·24	62	*Me'th* .	Beauparc, St. Cloud	3·28	...
,, .	Dundee, E. Necropolis	1·04	50	,, .	Kells, Headfort	3·52	132
,, .	Pearsie House	1·06	...	*W.M* .	Moate, Coolatore	2·31	...
,, .	Montrose, Sunnyside	1·74	53	,, .	Mullingar, Belvedere	3·74	140
Aber .	Braemar, Bank	1·22	49	*Long* .	Castle Forbes Gdns.	2·44	85
,, .	Logie Coldstone Sch.	1·60	69	*Gal* .	Ballynahinch Castle	3·91	82
,, .	Aberdeen, King's Coll.	·89	40	,, .	Galway, Grammar Sch.	1·88	...
,, .	Fyvie Castle	1·78	68	*Mayo* .	Mallaranny	5·23	...
Moray.	Gordon Castle	1·63	65	,, .	Westport House	2·75	77
,, .	Grantown-on-Spey	1·69	68	,, .	Delphi Lodge	8·31	109
Nairn.	Nairn, Delnies	1·27	58	*Sligo* .	Markree Obsy	2·70	81
Invs .	Ben Alder Lodge	1·85	...	*Cav'n*.	Belturbet, Cloverhill	1·84	74
,, .	Kingussie, The Birches	1·10	...	*Ferm* .	Enniskillen, Portora	3·31	...
,, .	Loch Quoich, Loan	1·27	...	*Arm* .	Armagh Obsy	1·96	80
,, .	Glenquoich	2·63	30	*Down*.	Fofanny Reservoir	5·13	...
,, .	Inverness, Culduthel R.	1·20	...	,, .	Seaforde	3·87	141
,, .	Arisaig, Faire-na-Squir	1·32	...	,, .	Donaghadee, C. Stn.	2·32	97
,, .	Fort William	1·58	...	,, .	Banbridge, Milltown	2·07	...
,, .	Skye, Dunvegan	1·80	...	*Antr* .	Belfast, Cavehill Rd.	2·93	...
R & C.	Alness, Ardross Cas.	1·50	...	,, .	Glenarm Castle	2·15	...
,, .	Ullapool	1·15	31	,, .	Ballymena, Harryville	2·30	74
,, .	Torridon, Bendamph	...	...	*Lon* .	Londonderry, Creggan	3·27	99
,, .	Achnashellach	1·57	..	*Tyr* .	Omagh, Edenfel	1·87	61
,, .	Stornoway	1·66	...	*D.n* .	Malin Head	3·01	...
Suth .	Lairg	1·03	59	,, .	Dunfanaghy	2·69	...
,, .	Tongue	1·78	56	,, .	Killybegs, Rockmount	3.11	68

Climatological Table for the British Empire, April, 1931.

STATIONS	PRESSURE: Mean of Day M.S.L. (mb.)	PRESSURE: Diff. from Normal (mb.)	TEMPERATURE: Absolute Max. (° F.)	TEMPERATURE: Absolute Min. (° F.)	TEMPERATURE: Mean Values Max. (° F.)	TEMPERATURE: Mean Values Min. (° F.)	TEMPERATURE: Mean Values ½ max. and min. (° F.)	TEMPERATURE: Mean Values Diff. from Normal (° F)	TEMPERATURE: Mean Wet Bulb (° F.)	Relative Humidity (%)	Mean Cloud Am'nt (0—10)	PRECIPITATION: Am'nt (in.)	PRECIPITATION: Diff. from Normal (in.)	PRECIPITATION: Days	BRIGHT SUNSHINE: Hours per day	BRIGHT SUNSHINE: Percentage of possible
London, Kew Obsy.	1011·8	— 2·6	62	33	52·1	40·6	46·3	— 1·0	42·1	84	7·9	3·66	+ 2·21	16	3·8	27
Gibraltar	1013·8	— 2·7	78	47	69·3	53·2	61·3	+ 0·3	53·3	85	4·3	5·48	+ 2·80	11	..	..
Malta	1012·9	— 0·5	73	47	64·3	54·9	59·6	— 1·3	55·4	78	5·6	0·09	— 0·77	4	8·3	63
St. Helena	1014·2	+ 0·9	71	58	67·9	60·6	64·3	— 1·0	61·9	93	9·3	4·37	..	26	..	..
Sierra Leone	1009·2	— 1·6	94	70	89·3	73·9	81·6	— 0·8	76·9	75	5·2	1·94	— 2·12	5	..	..
Lagos, Nigeria	1009·8	0·0	92	71	88·9	77·5	83·2	+ 0·7	78·8	80	8·5	7·16	+ 1·41	14	..	..
Kaduna, Nigeria	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..
Zomba, Nyasaland	1012·5	0·0	82	54	76·4	62·9	69·7	+ 0·4	..	77	6·2	6·16	+ 2·50	11	..	..
Salisbury, Rhodesia	1012·6	+ 0·1	86	45	77·6	55·9	66·7	+ 1·0	58·3	65	4·0	0·52	— 0·47	4	8·3	71
Cape Town	1018·5	+ 2·1	84	44	70·0	53·9	61·9	— 1·3	54·6	83	5·2	3·83	+ 1·96	11	..	..
Johannesburg	1017·6	+ 0·3	78	34	67·4	49·2	58·3	— 1·7	50·3	69	3·3	3·92	+ 2·18	11	8·3	72
Mauritius	1015·6	+ 1·6	85	66	82·4	71·2	76·8	+ 1·0	73·4	77	5·4	7·15	+ 2·68	15	6·8	59
Calcutta, Alipore Obsy.	1006·1	— 0·2	103	68	97·2	78·6	87·9	+ 2·3	78·5	81	4·2	1·08	— 1·10	1*	..	..
Bombay	1008·7	— 0·1	94	73	91·1	78·0	84·5	+ 1·4	77·1	75	1·7	0·01	— 0·04	0*	..	..
Madras	1008·4	0·0	98	74	92·7	78·6	85·7	+ 0·4	78·7	75	5·1	1·51	+ 0·88	2*	..	..
Colombo, Ceylon	1009·9	+ 1·2	91	73	88·6	75·8	82·2	— 0·5	78·6	78	7·5	9·40	— 0·33	22	7·7	63
Singapore	1009·4	+ 0·5	94	72	89·0	75·7	82·3	+ 0·6	78·6	80	6·2	6·80	— 0·84	19	6·0	49
Hongkong	1012·5	— 0·1	86	59	75·0	67·8	71·4	+ 0·6	68·7	87	9·3	8·93	+ 3·62	15	2·6	21
Sandakan	..	..	92	74	89·8	76·0	82·9	+ 0·7	78·0	79	..	1·90	— 2·59	4	..	..
Sydney, N.S.W.	1018·7	+ 0·3	81	49	70·4	58·4	64·4	— 0·3	60·1	81	6·6	7·24	+ 1·72	18	5·4	48
Melbourne	1020·9	+ 1·4	77	43	65·7	48·2	56·9	— 2·6	52·7	81	6·3	2·82	+ 0·65	11	5·6	50
Adelaide	1020·6	+ 0·7	91	47	73·5	52·6	63·1	— 0·8	54·7	51	4·4	0·90	— 0·83	11	7·6	68
Perth, W. Australia	1017·2	— 1·2	89	42	74·4	57·1	65·7	— 1·1	59·0	65	5·0	3·96	+ 2·31	10	7·2	64
Coolgardie	1017·5	— 1·1	93	42	76·1	52·5	64·3	— 0·7	55·4	59	4·5	0·48	— 0·48	7	..	..
Brisbane	1016·5	— 1·1	90	56	78·5	60·9	69·7	— 0·6	63·6	69	4·1	3·61	+ 0·07	8	7·7	67
Hobart, Tasmania	1019·8	+ 5·0	72	38	61·4	47·1	54·3	— 0·9	49·4	75	5·8	1·80	— 0·05	10	5·2	48
Wellington, N.Z.	1018·7	+ 0·6	66	41	59·4	50·0	54·7	— 2·4	52·0	79	7·5	5·59	+ 1·71	14	5·0	45
Suva, Fiji	1011·4	+ 0·8	89	72	84·7	74·7	79·7	+ 1·1	76·1	83	6·7	8·33	— 3·88	21	6·1	52
Apia, Samoa	1010·0	+ 0·1	89	72	86·3	74·1	80·2	+ 1·3	77·5	77	5·1	15·94	+ 5·79	13	6·8	58
Kingston, Jamaica	1012·2	— 1·9	91	70	88·2	73·2	80·7	+ 2·3	72·1	79	3·4	0·85	— 0·39	6	5·7	46
Grenada, W.I.	1013·6	+ 1·1	92	71	87·7	73·8	80·7	+ 1·8	73·7	75	3·9	2·49	+ 0·33	15	..	..
Toronto	1016·4	+ 0·3	78	28	53·5	36·1	44·8	+ 2·7	38·3	64	4·7	1·90	— 0·39	8	6·6	49
Winnipeg	1017·0	+ 0·3	75	11	52·4	31·0	41·7	+ 4·0	..	..	4·1	0·34	— 1·06	5	..	..
St. John, N.B.	1014·6	+ 1·2	65	26	49·6	34·6	42·1	+ 3·1	37·5	69	5·7	3·89	+ 0·38	12	5·4	40
Victoria, B.C.	1017·6	+ 0·1	75	37	58·3	44·4	51·3	+ 3·4	46·7	70	4·4	1·11	— 0·41	12	7·8	57

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

facing p. 225

Dines Anemobiagraph, Magazine Point, Lagos. Nigeria.

M.O. 340.

The Meteorological Magazine

Air Ministry :: Meteorological Office

Vol. 66

Nov., 1931

No. 790

LONDON: PUBLISHED BY HIS MAJESTY'S STATIONERY OFFICE

To be purchased directly from H.M. STATIONERY OFFICE at the following addresses: ADASTRAL HOUSE, KINGSWAY, LONDON, W.C.2; 120, GEORGE STREET, EDINBURGH; YORK STREET, MANCHESTER; 1, ST. ANDREW'S CRESCENT, CARDIFF; 15, DONEGALL SQUARE WEST, BELFAST; or through any Bookseller.

Erection of Dines Anemobiagraph at Magazine Point, Lagos, Nigeria

By D. E. SMITH, M.A.

The completion of the installation of a 45 ft. Dines Anemobiagraph at Magazine Point, Lagos, on June 15th marked an epoch in the meteorological history of Nigeria if not of west Africa. The meteorological service in Nigeria is under the Survey Department, and a site for the instrument was fixed about ¼ mile from the Survey Office with an exposure which if not almost unique is certainly rather unusual. Lagos is situated on an island and is connected to the mainland by Carter Bridge and Denton Bridge, which is the highway to the north. As shown in the sketch map six creeks converge on the anemobiagraph site. These are Ebute Metta Creek, Badagri Creek, Porto-Novo Creek, Light-house Creek, Five Cowrie Creek, and the main channel to the Bight of Benin. To the reader who is unacquainted with the topography of Lagos and its environs it would appear that the site chosen was the worst possible. Wind would blow up these channels and give wind direction and force at Magazine Point which, if not entirely erroneous, would certainly tend to give a false idea of the true wind. Unfortunately, however, Lagos might be appropriately called the "city of creeks," and only on the north side of town would there have been a site entirely free from the

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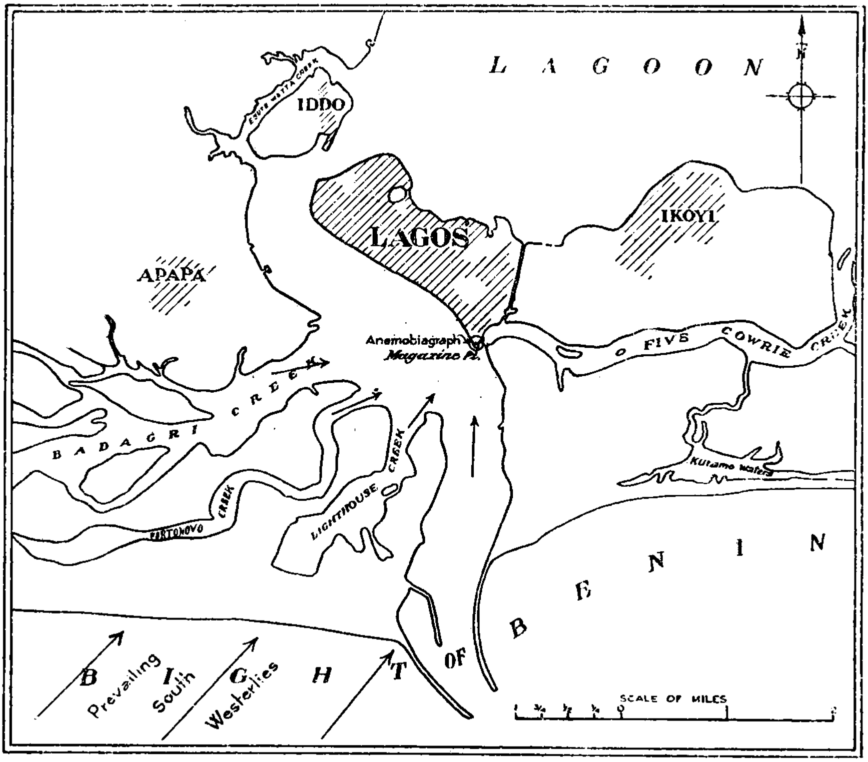
influence of creek wind currents, and then the site would have been inconveniently distant from the Survey Offices.

It appears to me in view of the recent anemograms that the present site is really quite a good one. It seemed at first that the velocity recorded by the instrument was rather lower than it ought to have been. This was deduced from the rather rough consideration of the various Beaufort numbers and the equivalent speeds in m.p.h. as given in the Observers' Handbook. It was thought that a better idea of the wind velocity could be got from pilot balloon observations. The velocity of the wind at 500ft. was found to be practically identical with the mean



speed recorded by the anemometer. That is to say if one stood at ground level there appeared from consideration of Beaufort Scale to be a wind velocity of say 20 m.p.h., but the anemobiagraph and pilot balloon observation agreed in giving the velocity as 12 m.p.h. The apparent gustiness at ground level, I deduce, must be due either to semi-vertical currents or to another reason which I am inclined to think is nearer the truth. The height of the ground level both at Lagos and on the surrounding islands is approximately 10ft. to 15ft. On the various small peninsulas which border the creeks I have mentioned above, there are mangrove trees of say 20ft. in height. My theory is that the south-westerly wind (the prevailing wind at this time of the year) comes off the Bight of Benin and gets concentrated into the various channels south-west of Lagos, but this concentration is active only in the first 30ft. layer of the atmosphere, and thereafter the wind adopts its true direction and force. It will be interesting to get the opinion of other observers at stations with anemobiagraphs in similar environment.

A critical reader may say that the low velocity recorded by the anemobiagraph is due to faulty tubing between the head of the instrument and the base, but the tubing has been carefully examined and found to be in apparently good condition.

Some Recent Studies of the Upper Air

(1) *Reports of the Greenland Expeditions of the University of Michigan* (1926-31). William Herbert Hobbs, Director. Part I. Aërology. Expeditions of 1926 and 1927-29. S. P. Fergusson, Editor. Size $10\frac{3}{4} \times 8$, pp. x + 259, *Illus.* Ann Arbor, University of Michigan Press, 1931.

(2) *India Meteorological Department. Scientific Notes*, Vol. 1, No. 7, Normal monthly upper winds over eight stations in India. Vol. 1, No. 8, Monthly normal isobars and wind-roses at 0·5, 1, 2 and 3 Km. above sea-level over India and neighbourhood. Vol. 3, No. 21, Upper air circulation over India and its neighbourhood up to the cirrus level during the winter and the monsoon. By H. C. Banerjee and K. R. Ramanathan. Calcutta, 1930-31.

(3) *Miscellaneous publications of the Royal Alfred Observatory*, No. 9. Pilot balloon observations at Mauritius from July, 1927—June, 1928. By N. R. McCurdy, pp. 6, *Illus.* Mauritius, 1931.

(1) Professor W. H. Hobbs regards the Greenland ice sheet as the northern wind pole of the earth, and accordingly as a vital factor in the weather of the North Atlantic Ocean. To study the meteorological conditions of this important region he has led three expeditions to Greenland between 1926 and 1929, well equipped for upper air as well as surface investigations. In the present volume he contributes a long introduction of 37 pages, in which he shows how the upper air results confirm the theory of a " glacial anticyclone " over Greenland, with outflowing winds near the surface changing to inflowing winds at a higher level. The observations were obtained not only on the west coast, but also at several points on the ice itself; but the most favourable site found was on Mount Evans, in latitude 66° 51′N. on a rounded summit at an altitude of 1,294 feet, and only 25 miles from the western margin of the inland ice. At this station practically all the strong winds (sometimes reach-

ing 120 miles per hour) " come from the south-easterly quarters and blow down off the inland ice lying to the eastward . . . The domination by the glacial anticyclone is most marked for the winter season and shows greatest variation in the month of May." The surface winds and those at a height of 393 metres above the station (750m. above tide) are shown in a series of seasonal wind roses; the latter height was selected to show the lowermost winds free of local irregularities due to topography.

The changes of wind direction with height are shown in another series of diagrams month by month. In summer the winds are south-west only between 2,000 and 4,000 metres and north-westerly above 4,000 metres. In September and October the winds remain south-easterly at all heights, while from November throughout the winter they become south-westerly at a small height and remain almost entirely in that quadrant to the highest levels reached. The general change from south-easterly winds to winds with a component from west shows that the air-flow from the ice is supplied by in-blowing winds at a moderate elevation. The outbreaks of air from the glacial anticyclone are regarded as " strophic," and an interesting table displays the connexion between individual strophs or bursts of air and the subsequent development of depressions in the North Atlantic. The stroph of January 14th, 1928, with a south-east wind of 120 miles per hour, followed four days later by some of the worst weather ever experienced by Atlantic liners, is especially interesting.

The observations on the western margin of the ice-sheet were supplemented by a series of ascents carried out by the Norwegian Meteorological Institute at Mackenzie Bay on the east coast of Greenland from June 18th to August 10th, 1927. Apart from a very shallow and weak current from south-east, reaching only to 500 metres, these show prevailing winds from north-west extending from 1,000 to 9,000 metres, above which they become south-westerly. An in-blowing south-easterly wind is frequently found, most often near 4,000 metres, but the height is so variable that this wind does not appear on the graph of resultant winds. The reviewer thinks however that the importance of this easterly component is somewhat over-estimated, for it occurs in only 13 of the 26 ascents which reached 5 Km., and in some of these it is only a few hundred metres thick and is overlain as well as underlain by westerly winds. It does not compare in volume with the westerly in-blowing winds of the west coast, and it seems probable that the actual circulation at high levels is a combination of the in-blowing winds required to maintain the glacial anticyclone with the westerly winds of the general atmospheric circulation appropriate to these latitudes.

The greater part of the volume consists of diagrams and tables presenting the results of the individual ascents (including two sounding balloons with meteorographs), and the observations of clouds, published for synoptic purposes. There is also a very fine atlas of cloud forms. The whole volume is profusely illustrated, while the printing and general appearance are excellent.

(2) These three publications of the India Meteorological Department form a valuable addition to our knowledge of the upper winds over India. No. 7 gives the resultant direction and velocity in each month, in tabular and diagrammatic form, for periods ending 1925 at nine stations (of which Bombay and Poona are grouped together) ranging from Lahore in 31° 34′N. to Bangalore in 12° 58′N. The results were obtained by the tail method, generally in the morning, when turbulence is slight but katabatic effects may occur.

In No. 8 the results of upper air observations from a number of stations in India and surrounding districts (including Iraq and Kamaran Is. in the Red Sea) are plotted month by month in the form of wind roses at levels of 0·5, 1, 2 and 3 Km. On the same charts are plotted isobars constructed from monthly normals of pressure and temperature at surface stations, employing a lapse-rate of temperature with height of 11°F. per Km., except from June to October over the sea, when higher lapse rates were assumed for the first half kilometre. In general the wind roses fit the calculated isobars with remarkable fidelity, which is rather surprising considering the uncertainties of this form of extrapolation.

The changes in the pressure distribution with height are most rapid in winter, when the thermal gradient from south to north is steepest. In January there is an almost complete reversal between the surface, with high pressure in the north and low in the south, and 3 Km., with low pressure in the north-west and high in the south. The insertion of a closed high over Arabia seems rather problematical, however, considering the paucity of data for that region. In July, on the other hand, while the intense low over north-west India weakens in intensity and shifts to the northern Arabian Sea between the surface and 3 Km., the high pressure south of India retains its position. Thus, there is a marked reversal of the prevailing wind direction at 3 Km. from east in winter to west in summer. This painstaking publication should thoroughly fulfil the purpose of assisting aviation in India.

No. 21 extends the results described in the preceding paper up to a height of 10 Km. Wind roses are drawn for 13 stations at heights of 4, 6, 8 and 10 Km. for the two periods December-January and July-August. The winds are classified into seven groups according to force, ranging from below 5 to above 60 m./s., and approximate isobars have been sketched in, based on pressures and temperatures over Agra obtained from sounding balloon ascents and pressure gradients calculated from the monthly mean winds. In addition, charts of the cirrus movement are shown with stream lines but no isobars.

The charts at 4 Km. are of especial interest for comparison with those constructed by Teisserenc de Bort from surface observations only. In January the latter shows a very weak gradient from south to north over India (only 4mb. between 18° and 30°N.), and a small closed high pressure isobar of 474mm. (632mb.) over the west coast in 14°N. The new Indian charts show a much steeper gradient (nearly 7mb. in the same distance), the isobars being crowded together owing to the effect of the Himalayas, which still persists at this level, while the greater part of peninsular India is occupied by a broad belt of pressure above 628mb. extending from west to east. Teisserenc de Bort's chart for July bears very little relation to the Indian chart at 4 Km. for July and August, which shows a closed low pressure area over the Peninsula. The paper ends with two charts showing the approximate limiting heights of winds with a westerly component in winter and summer.

(3) The series of pilot balloon observations from Mauritius is a continuation of those for 1925-6 previously published. The individual ascents are tabulated and illustrated graphically, and in addition wind roses are given for the two half-years May to October and November to April, and vector means for shorter periods. The results show that the surface layer of light to moderate east to south-east winds is overlain by very light southerly or variable winds extending from 1,500 metres to 3 Km. in winter and 5 Km. in summer. Above this is a layer of moderate to strong westerly winds.

It will be seen that the various publications mentioned above provide the means for confirmation or rectification of the existing charts of isobars in the upper air in three widely separated regions. Teisserenc de Bort made his calculations in 1893, when our observational knowledge of the upper air was rudimentary, and on the whole they have stood the test of time remarkably well. The period is approaching, however, when the accumulation of data from ascents of pilot balloons and sounding balloons will demand a re-examination of the whole problem of the atmospheric circulation in three dimensions. An important contribution to this end has recently been made by A. Wagner,* but this summary, admirable as it is, remains a summary, and contains very little attempt at generalisation. Incidentally, so fast does our knowledge grow nowadays that neither the Greenland nor the Indian results described above appear in Wagner's collection.

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* Handbuch der Klimatologie, Bd. I, Teil F. Klimatologie der freien Atmosphäre, von A. Wagner, Berlin, 1931.

Barometric Characteristic in the Tropics

Flight-Lieutenant Batty, in a recent paper,* discusses the possibility of using the barometric characteristic and tendency for forecast purposes in the tropics. The barograph used was a small one with a weekly clock recording in natural scale of inches of mercury.

A barograph has been in use in Salisbury for two and a-half years, with a time scale of 1·5 centimetres to the hour and a magnification of five times the mercury scale. This instrument was specially made by Messrs. Negretti & Zambra and has proved very sensitive and accurate in use. The instrument is very sensitive to minor changes of pressure and responds to gusts during high winds; it was, therefore, necessary to adopt an arbitrary criterion to discriminate between the characteristics. The characteristic classes were taken from the Meteorological Office large pocket register, form 2003—page 23. Unsteady motion was defined as irregularities extending at least 0·005 (mercury) inches on either side of the mean line and curved traces show a curvature of at least 0·01 inches deviation from the straight line. The characteristic was determined for the three hours before the morning observation—8.30 a.m., South African Standard time, which is four minutes slow by local time. The results were as follows:—

Characteristic	0 Rising then falling	1 Rising then steady	2 Unsteady	3 Steady or rising	4 Falling or steady then rising
Per cent.—Salisbury ...	4	18	20	52	6
(Batty) Quetta	—	—	25	46	29

The occurrence of 0 and 1 is obviously due to the hours selected and the period 4 to 7 a.m. was, therefore, tried:—

Characteristic	0 Rising then falling	1 Rising then steady	2 Unsteady	3 Steady or rising	4 Falling or steady then rising
Per cent.—Salisbury ...	—	—	25	42	33
(Batty) Quetta	—	—	25	46	29

The agreement is remarkably close.

Batty found that the "unsteady" characteristic preceded 50 per cent. of the days of unsettled weather, and that 80 per cent. of the occurrences of this characteristic were followed by unsettled weather. In Salisbury the respective figures were 45 per cent. and 55 per cent. These figures are not strictly comparable as the weather is not so closely observed in Salisbury and rain days only have been taken. Since October, 1930, more detailed observations have been made, and for the six months—October to March—the percentages were 57 and 78 respectively.

*India Meteor. Dept., Sci. Notes, Calcutta, Vol. III, No. 24.

It appears, therefore, that very similar conditions apply in Southern Rhodesia.

Weather forecasting in Southern Rhodesia, in the absence of cyclonic disturbances, is based on the general pressure fluctuations from day to day and the deviation from normal pressure. The latter maps have been classified into types by Mr. C. L. Robertson and, with the aid of past experience, fair general forecasts for 24 and 48 hours are issued. The method is quite empirical, and several noteworthy failures have proved that the weather is not entirely dependent on the general pressure distribution.

Investigations have, therefore, been extended to other factors, and it is found that absolute humidity plays a notable part. Quite half the rainfall, however, is associated with travelling disturbances, which can be readily traced on maps showing the hour at which rain commenced at about 200 stations. Autographic instruments at Salisbury show these disturbances very well. The general appearance on the weather map is in accord with that of cold fronts except that the winds converge from both sides, in entire disregard of the isobars, and wind swings of 90° to 180° are usual.

During periods of unsettled weather, the normal barograph trace at Salisbury is disturbed by irregular humps and hollows which last for several hours, and are of the order of a millibar on the average. That these disturbances are associated with rain is shown by an examination of the weather maps between December 14th, 1930, and March 31st, 1931. In 108 days, there were 71 rain days (rain days are taken as days when 10 per cent. or more of the stations reported rain). On 47 days irregularities were noted on the Salisbury barograph, and 40 of these coincided with rain days; five of the remaining seven were on days when isolated showers were reported. The present distribution of barometers, 10 in an area about 7° square, is quite inadequate to show these irregularities, and the great differences in altitude between the barometers—3,000ft.—and the absence of reliable levels makes the problem exceedingly difficult. The fact that these irregularities are associated with rain and frontal phenomena invites the conclusion that they are "secondaries," and it is hoped that a suitable distribution of barometric stations will show them on the weather map.

There is a slight connexion between the occurrence of the unsteady characteristic and the irregularities in the barograms. In 108 days, 41 recorded the unsteady characteristic; 47, irregularities, and on 31 occasions the latter preceded or fell on the same day as the former. This connexion is not close enough to associate the characteristic with the irregularities, and some other explanation of the former must be sought.

NOEL P. SELLICK.

Discussions at the Meteorological Office

November 30th, 1931.—*Contribution to the aerology of the Indian monsoon.* By A. Wagner. (Beitr. Geophysik, Leipzig, 30, 1931, pp. 196-238) (in German). *Opener*—Mr. S. P. Peters, B.Sc.

December 14th, 1931.—(1) *Discussion of the results of sounding balloon ascents at Agra during the period July*, 1925, *to March*, 1928, *and some allied questions.* By K. R. Ramanathan (Ind. Meteor. Mem., Calcutta, 1930, pp. 163-193); and (2) *Distribution of temperature in the lower stratosphere.* By P. R. Krishna Ras (Ind. Meteor. Dept., Sci. Notes, Calcutta I, No. 10, 1930). *Opener*—Mr. L. H. G. Dines, M.A.

Correspondence

To the Editor, *The Meteorological Magazine.*

Electric Storm at Clunes

About 2 p.m. on October 2nd there was a sudden electric storm here accompanied by heavy rain. The electricity fused all the telephones in the place, including the Post Office.

At my keeper's and forester's houses, where they have the telephone, exactly the same thing happened. Two or three shots went off at the door like gun shots, to be followed a second or two later by a flash of lightning and a clap of thunder. Two or three trees were struck in the old forest, but all was apparently done by the rainstorm. The telephone instruments all fused. My electric light cables were also affected, although protected by an overhead lightning wire. Two fuses went, one in the castle and the other in the butler's house, although the dynamo was not working at the time. (I have no batteries and run direct.) My forester was mending one of the telephone wires at the time and got a shock though he hastily dropped the wire. The curious thing is that this storm seems to have preceded and not to have been simultaneous with the flash of lightning. Exactly the same thing occurred again at 4 p.m., though the damage seems to have been all done at 2 p.m.

I was at Spean Bridge at 2 p.m. and heard two peals of thunder away in this direction. At 4 p.m. I was in Fort William and have no recollection of hearing any thunder at all, though of course there was heavy rain. So it must have been very local. In fact, I can hear of no thunder or lightning anywhere else in this district, though most people heard the thunder in this direction.

It took a man a day and a half to put the telephones right, and I believe the Post Office wires were affected right up to Inverness and in all other directions.

D. W. Cameron of Lochiel.

Clunes, Spean Bridge, Inverness. October 19*th*, 1931.

Atmospheric Pollution

The following extract from a letter dated October 27th, 1931, to the Director of the Meteorological Office from Colonel, The Master of Sempill will be of general interest :—" I thought you might possibly be interested to know of certain things that I have noticed during the past week while this anticyclone has been over the country.

Yesterday I noticed that the smoke over Manchester, Sheffield, Huddersfield, Leeds and suchlike places went up at least to 6,000 feet, and in some cases slightly higher, about 8,500 feet.

On Sunday, October 18th, I had to fly from Liverpool to Southampton, and on account of the smoke kept well to the west, in fact passed down at about 2,000 feet above the tops of the Welsh hills. When I came to the lee side of Birmingham (there was a north-easterly wind on that day), I ran into very thick weather caused by smoke from Birmingham and district, and the visibility dropped to a few hundred yards and maintained itself in this condition for some ten to fifteen miles. I experienced slight rain, and when I came out of this smoke bank, although still 2,000 feet over the top of the Welsh mountains, the machine was absolutely filthy, and it was necessary to wipe the soot-laden moisture off the windscreen to get normal visibility.

On the night of Friday, the 23rd, the machine was out in the open in the extreme south of Cornwall, and the wind was then from the NE. During the late afternoon and evening there was slight rain, and in the morning the whole machine was found to be covered with soot."

Steaming Water

Steaming water is seen in the lanes between ice floes and over rivers and lakes on mornings after a night of radiation. The vapours which give rise to it are attributed to the mixing of warmer moist air with colder air above. The air is therefore essentially unstable in a layer near the water surface.

I have often seen wisps and swirls in these vapours which appeared to be an attempt at the formation of such a pattern as would be expected in an unstable fluid.* One morning recently, however, while crossing a bridge over the river Ouse I saw a quite definite pattern of convectional streaks such as have been produced in a laboratory by Terada.† The streaks of vapour were about one or two feet apart, and it was quite obvious from the drift of vapour that there was a current of air flowing in the direction of their length.

C. S. DURST.

*See *Meteorological Magazine*, 60, 1925, p. 1.

†Some experiments of periodic columnar forms of vortices caused by convection, *Tokyo, Rep. Aeron. Res. Inst., Vol. III*, No. I, 1928.

Parhelion in "False Cirrus"

A parhelion was observed yesterday, October 7th, in an anvil of "false cirrus" at 14h. 25m. on the eastern side of the sun. There was no trace of the halo of 22° visible. The phenomenon became obscured at 14h. 35m. by lower cloud, and had by this time become much fainter owing to a thicker portion of the anvil having spread upwards into the vicinity of the parhelion. The parhelion was brightly coloured at 14h. 30m. Although "false cirrus" was frequently in the vicinity of the sun during other parts of the day, I did not observe any other optical phenomena. Apparently a thin layer of this cloud is the ideal for the production of halo phenomena, since the above was only observed in such.

Weather conditions were of a showery type and thunder occurred about 12h. 15m. The wind was westerly and very strong about midday and early afternoon.

A. E. Moon.

39. *Clive Avenue, Hastings. October 8th,* 1931.

Corona in Cirrus Cloud

This unusual phenomenon was observed at this station at 14h. 20m. on October 14th.

The corona was some 5° in diameter, well defined in very fine cirrus cloud and had the usual sequence of colours.

The sky at the time was 7/10ths clouded, consisting of 2/10ths strato-cumulus cumulo-genitus and the remainder being the afore-mentioned fine cirrus. The corona perisisted for some time and later small patches of cirro-cumulus were observed approaching from northwards.

This phenomenon is probably such an occurrence as is mentioned in the notes on clouds in the Meteorological Glossary, p. 43.

W. I. Jones.

Salt Island, Holyhead. October 15th, 1931.

NOTES AND QUERIES

Train Struck by Tornado

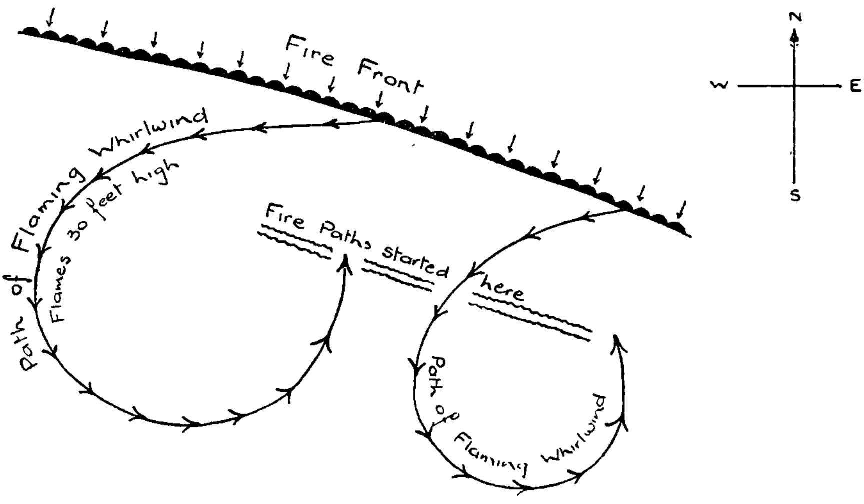
We learn from the *Monthly Weather Review* for May, 1931, that a tornado struck the express train "Empire Builder" when it was travelling at nearly 60 miles per hour east of Moorhead, Minn. The engine and tender remained on the rails intact, but five coaches were torn loose from the engine and lifted bodily from the rails, one being hurled 80 feet away. The remaining eight coaches were probably pulled from the rails. Fortunately the heavy steel coaches were strong enough to resist the crash and only one passenger was killed, but 57 were injured. One other life was lost, a farm youth being crushed beneath the ruins of a house. At one point on the storm's path the roof of a barn was carried through the air for 200 yards.

Bush Fires and Whirlwinds

The following observations in connexion with bush and grass fires, and whirlwinds, were made some time ago and may be of interest.

The first case happened in Southern Rhodesia, in the bush country located between Bulawayo and a small village to the north called the Lonely Mine, during August, 1929. A big bush fire was raging at the time and there was a NNE. wind blowing at about 25 m.p.h. The farmers in the district went out with their natives to points a couple of miles ahead of the fire and started to burn fire-paths, keeping the fires they had made well under control to windward.

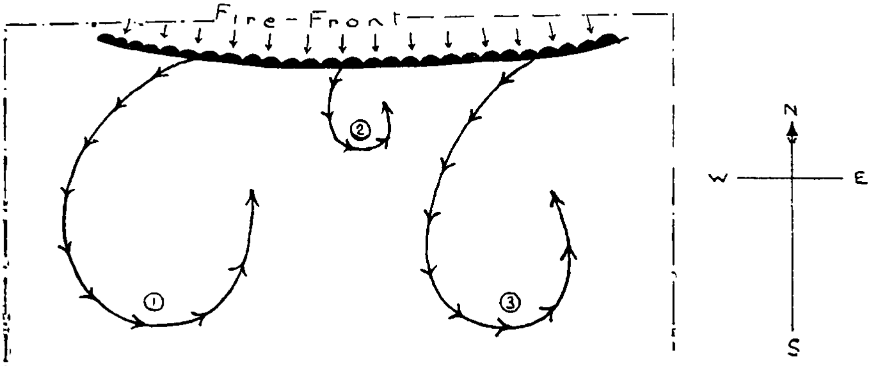
It was at this time that the strange effect of whirlwinds was observed.



RHODESIAN BUSH FIRE,

A whirlwind would start up and carry a column of fire and smoke, first across wind, then do a left-hand circuit and make straight back towards the advancing fire, against wind. The flames were about 30 feet high, but smoke and burnt grass were carried upwards to over 2,000 feet.

The second case in point and in which exactly the same observations were made took place at the South African Air Force Aerodrome, Pretoria, during June last year. The machine-gun target is located on the north side of the aerodrome, and on this particular day tracer bullets set fire to the grass, and as there was a strong breeze blowing from the north the fire soon spread across the whole field. Every available man was turned out to try and stop the fire spreading across the whole area, and this could have been done had it not been for the strange behaviour of a lot of small whirlwinds, which, in several instances carried the fire right round the fire-fighters, in a circle, and naturally



AERODROME FIRE CAUSED BY TRACER BULLETS.

the men had to run for their lives as the flames were four to six feet high. The debris in this case was carried up about 150 to 200 feet.

It was noticed that in each case the whirlwind went first towards the west, that was cross-wind, then right round south and back towards the fire, actually against the strong prevailing wind.

F. C. ELLIOT WILSON.

Course of Training for Observers

A course of training for meteorological observers was held at the Meteorological Office, South Kensington, on October 6th and 7th, 1931. Sixteen observers attended. Of these, eight were from health resorts and eight from crop weather stations.

A short discussion of British climatology was given on the morning of the second day, illustrated by specially prepared slides, and in the afternoon a visit was paid to Kew Observatory.

Meteorology and Agriculture

The annual paper-reading Conference organised by the Agricultural Meteorological Committee was held at the Meteorological Office on October 8th and 9th under the chairmanship of Sir Napier Shaw, F.R.S. Following an account on the first morning by Mr. E. G. Bilham, B.Sc., of some recent instrumental and statistical developments in the Meteorological Office, nine papers were read dealing with the influence of weather on soil and on plant parasites and the action of light on disease organisms in plants and in milk. Dr. E. M. Crowther, who spoke about soil, made interesting observations on the differences of outlook in regard to soil classification in Russia and this country. In Russia a broad outlook is induced by the fact that there are vast climatic zones with strong contrasts and equally vast soil formations. Soil science in such a field of study would naturally develop on very different lines from those likely to be followed in the British Isles, where the whole range of geological formation from the oldest igneous rocks in the west to the latest deposits in the eastern lowlands are crowded together, with moderate climatic contrasts distributed to a great extent selectively so that the older formations tend to have the wetter and more oceanic climate and the recent deposits the maximum degree of dryness and continentality which such a small land area can furnish. The lecturer held that these considerations were mainly responsible for the difficulty at first experienced in this country of assimilating Russian ideas. He then went on to consider among other matters the action of weather on the chemical constituents of various types of soil. The paper may be regarded as an extension of Dr. Ogg's "Soils and Weather," which introduced the subject to the Conference in 1930. Of the remaining papers, each of obvious importance and interest, that by Mr. A. Beaumont on the relation of weather to the appearance and progress of potato blight may be noticed particularly for the very definite meteorological relationship established. The element of prime importance in this case is humidity. Wet weather was found to vary in its effects in accordance with the type of synoptic weather chart with which it was associated, even very wet spells being comparatively unfavourable for development of the trouble when associated with fast morning depressions giving rise to intervals of strong sunshine and dry wind when passing away to the east or north-east.

Mr. L. Iorwerth Jones, when studying crop yields under climatic contrasts furnished by neighbouring localities at very different heights above sea level near Aberystwyth, obtained surprising results when interchanging samples of soil between the different stations. In one case grass would not even germinate when the soil that suited it well at a low level was transferred to a high level.

The only other paper that calls for special mention because of its meteorological interest was by Dr. T. Wallace, who described how, at Long Ashton, heavy rain had been shown to wash various substances from the leaves of fruit trees, the result in some species being obvious symptoms of lack of nitrogen and even subsequent frost damage. The application of water in the laboratory in accordance with a fixed routine to the leaves of various fruit trees was carried out in order to determine which species were most liable to loss from this source.

As a whole, papers read at this Conference tended to emphasise the especial importance of relative humidity in agricultural meteorology, as was pointed out by the Chairman in his concluding remarks.

E. V. NEWNHAM.

Toy Balloon Race

Mr. R. Parker Smith sends word of a toy balloon race which was held at the Perse School, Cambridge, on June 25th, 1931. The recovered balloons were all found at places lying to the south-west of Cambridge—amongst others three were found near Hitchin, three near Hemel Hempstead, two near Amersham, one near Stratfield Turgis, and one, the furthest, near Southampton, a distance of 110 miles. The tracks followed by the recovered balloons were thus in general accordance with the results of pilot balloon observations made in east and south-east England that afternoon, the wind up to 5,000ft. being north-easterly or east-north-easterly towards the south coast and usually not exceeding 15 m.p.h.

Reviews

The Climate of Japan. By T. Okada. Size 12 × 9in., pp. 4 + 328 + 10, *Illus.* Tokyo, Central Meteorological Observatory, 1931.

Japan is meteorologically one of the most interesting countries in the world, with alternating monsoons, a long chain of islands extending from sub-arctic to sub-tropical latitudes, a high mountain range in Japan proper giving a remarkable contrast of seasons on opposite coasts, and an eternal conflict between the continental power of Siberia and the oceanic influence of the Pacific. Thanks to the large number of observatories which have been erected since 1893, when the late Dr. K. Nakamura's "Climate of Japan" appeared, abundant material is now available for the study of these questions, and Dr. Okada has presented us with a work which is magnificently complete in every detail.

The book is divided into four parts, climatography, climatology, tables and charts. Climatography is descriptive; after a general introduction we have brief climatic sketches of 17 regions, from Sakhalin to Formosa and the Bonin Islands to Korea. These contain a number of small tables giving monthly temperature, precipitation and sometimes humidity and sunshine for representative stations, the positions of which are in most cases shown on small inset maps—a very useful feature.

Climatology includes the scientific study of the distribution of the various elements over the Japanese islands and Korea; for example, under the heading "air temperature," not only is the distribution and the diurnal and annual variation described but formulæ are given showing the relation of daily range and of mean January and July temperatures to latitude, longitude, "continentality" and cloudiness. Continentality is calculated as the percentage of land in a circle of 20 Km. radius round the station. Other chapters deal with the absolute and relative humidity, pressure, wind direction and velocity, cloudiness, clear and cloudy days, sunshine, first and last hoar frost, first ice, evaporation, rainfall and snowfall. The thorough nature of the discussion may be illustrated by the chapter on wind direction; the average hourly directions and velocities are converted into vectors which are then analysed harmonically into diurnal, semi-diurnal and tri-diurnal ellipses. The results are summed up as follows: "Consulting with the topographical maps we find that the major axis of the diurnal wind ellipse coincides with the general trend of the valley in which the observing station lies."

The "Climatic tables" are very complete, including 162 stations; they embrace monthly tables for all customary elements as well as some which are not usual, such as mean daily variability of temperature, maximum wind velocity, minimum relative humidity, maximum precipitation in one hour, evaporation, and dates of first and last ice, the latter from observations in the evaporation gauges. There are also, for a selection of stations, tables of five-day means for pressure, temperature, vapour pressure, relative humidity, rainfall and wind direction, and hourly means for each month of these elements as well as cloud amount and sunshine. The data are shown also in the form of diagrams and an excellent series of coloured charts.

The text is written in English, which though occasionally quaint is remarkably good considering that it is for the author a foreign language. Misprints are rare, and the majority are corrected in an erratum slip, though a reference to the National Physical Laboratory at "Tedenton" has escaped the proof-reader. The whole work is most neatly and tastefully produced.

C. E. P. Brooks.

The Flood Rains of 11*th March*, 1924, *in Hawke's Bay*. By Dr. E. Kidson. (Wellington, N.Z., J. Sci. Tech. xii, No. 1, 1930, pp. 53-60).

The rains of March 11th, 1924, in Hawke's Bay, are worthy of comment because of the severity "which has probably never been equalled in any part of New Zealand since the advent of the white man." Hawke's Bay is on the east coast of North Island and the heavy rain fell over an area where the average annual rainfall is about 45 inches a year (*i.e.*, equal to that of Falmouth). At Rissington, some 8 miles inland (altitude 420ft.), 20.14in. fell in 10 hours between 7.30 a.m. and 5.30 p.m. on the 11th. At 9 a.m. on the 11th 2.99in. was recorded, and at 11.45 a.m. "we thought we had better ease the gauge a bit, so took 9in. out of the bottle!" So far as can be ascertained from the rainfall records 10in. fell over 450 sq. miles; 15in. over 175 sq. miles and 20 in. over 30 sq. miles. The bulk of the rain fell in 14 hours between 4 a.m. and 6 p.m. on the 11th. This is far more striking than any heavy rain which has occurred in the British Isles. Perhaps the most remarkable storms of this country are those of August 26th-27th, 1912, in East Anglia and of June 28th, 1917, near Bruton in Somersetshire, but these only gave from 6 to 8 inches in 20 hours over 550 sq. miles and more than 9 inches in 16 hours over 2 sq. miles respectively.

The rains of March 11th, 1924, were associated with the passage of a deep cyclonic depression across the Auckland Peninsula. The reports of continuous thunder lasting many hours suggests that the air was in an unusually unstable condition. A large mass of warm air from the north was apparently trapped in Hawke's Bay between the sea and the mountains, which rise to over 3,000ft., and became surrounded finally by cold air, including cold air brought up the western sides of the mountains.

This illustrates an important difference in the climates of New Zealand and the British Isles. While the rainfall of New Zealand is generally heavier than that of the British Isles, the number of rain-days is on the whole appreciably fewer. Thus, the average number of rain-days near Hawke's Bay is about 140 compared with 200 at Falmouth.

J. GLASSPOOLE.

Books Received

Deutsches Meteorologisches Jahrbuch für 1928. Freistaat Sachsen. Edited by Prof. Dr. E. Alt, Jahrgang, xlvi, Dresden, 1930.

In addition to the usual very complete presentation of the year's data in tables and charts, this volume contains an interesting dissertation by Karl Knopf, entitled "Das Erzgebirge als Klimafaktor," well illustrated by charts.

Den Genomträngande Kosmiska Strälningen. By F. Lindholm. (Reprinted from Sv. Fysikersam. publ. Kosmos band 8, 1930, pp. 97-135.)

Die atmosphärische Trübungsdichte aus Sonnenstrahlungsmessungen in einzelnen kurzwelligen Spektralbereichen. By F. Lindholm. (Reprinted from Strahlentherapie, Berlin and Vienna, 39, 1931, pp. 369-75.)

Obituary

Dr. Alfred Wolfer.—We regret to record the death at Zurich on October 8th, 1931, of Alfred Wolfer, well known to all meteorologists for his work in the measurement and recording of sunspots. Wolfer was born on January 27th, 1854, at Schönenberg near Zurich. In 1894 he was appointed Director of Zurich Astronomical Observatory in succession to R. Wolf, and he continued to occupy that post until he retired in 1926. In 1901 he was awarded the degree of Doctor of Philosophy at Basel.

Most of Wolfer's work appeared in the long series of *Astronomische Mitteilungen,* which he edited, and in the quarterly tables of sunspot relative numbers which appeared in the *Meteorologische Zeitschrift* and later also in *Terrestrial Magnetism.* The latter also contained in 1925 a revision of the table of relative numbers from 1749 onwards first compiled by Wolf. These basic data have played a very large part in studies of the relation between solar conditions and the phenomena of meteorology and terrestrial magnetism, so that Wolfer, though not himself a meteorologist, has contributed greatly to meteorological knowledge.

News in Brief

Mr. E. P. Burd, of Okehampton, sends the following note taken from the Corporation records: "4th July, 1675. From this tyme to the beginning of October following we had little or no rain : for that the like hath not been knowne by any one living here."

Dr. Victor F. Hess, professor of experimental physics at Graz University has been chosen Chief of the newly established station for the investigation of penetrating radiation on the Hafelekar near Innsbruck.

The retirement of Professor A. McAdie.—We learn that after sabbatical leave for the first semester of the coming academic year, Alexander McAdie, Abbot Laurence Rotch Professor of meteorology, Harvard University and Director of Blue Hill Observatory, will become Professor Emeritus.

We learn that Prof. E. Mathias has retired from the posts of Director of the Puy de Dôme Observatory and Professor in the Faculty of Science at Clermont-Ferrand.

Mr. C. A. Bracey retired from the staff of the Meteorological Office on November 2nd after just over 52 years' service. At a well-attended meeting the Director, on behalf of the Staff Council, presented him with Groves' Dictionary of Music and a pair of binoculars, in appreciation of his services.

Mr. Bracey joined the Office in 1879 and was posted to the autogaphic records section, where he was for some time engaged in the production of the engraved plates published in the *Quarterly Weather Report*. In 1884 he was transferred to the Land Branch, which subsequently became the British Climatology Division, where he was the clerk in charge of the section responsible for the production of the *Monthly Weather Report*. Figures seemed to fascinate him and he was responsible for preparing several labour-saving tables which are still in daily use. These were largely produced during his long daily train journey to and from the Office. He prepared a list of the greatest daily falls of rain at some 116 stations in the British Isles from the date of commencement of the station up to 1915. These statistics are preserved in two volumes in the Library of the Office. He also compiled a detailed summary of the daily rainfall observations at Brixton from 1871-1910.

On the social side he was chairman of the Office Cycling Club for many years, right up to his retirement. He was always the first to help a less fortunate colleague.

The Weather for October, 1931

Pressure was above normal over northern Africa, southern and central Europe to southern Scandinavia, the British Isles and the Faroes, and also over southern Greenland, the greatest excess being 9·6mb. at Scilly Isles. Pressure was below normal over Russia, northern Scandinavia, Spitsbergen, Iceland, and the greater part of the northern North Atlantic, the greatest deficit being 10·8mb. at Vardo. Temperature was above normal in Spitsbergen and northern Scandinavia and below normal in southern Scandinavia and central and southern Europe, while rainfall was deficient over nearly the whole of Europe; in north-west Norrland (Sweden), however, it was 50 per cent. above normal.

The weather of October in the British Isles was dry. The first fortnight of the month was mild, but from the 20th onwards the weather was cold with severe night frosts. Sunshine was considerably above normal in a belt extending roughly from Dublin to Lincolnshire and Essex. For the first 12 days the weather was unsettled and mild, with depressions moving east or north-east across Iceland giving S-SW. winds generally over the British Isles—these reached gale force at times in the north. Some heavy rain fell locally in the west and north, among the biggest measurements being 2·02in. at Oakley (Merioneth) on the 1st, 1·0in. at Blacksod Point (co. Mayo) on the 5th, and 2·26in. at Rosthwaite (Cumberland) on the 9th. In the south and east the amounts measured were small and the rainfall less frequent than in the north and west. On the 3rd a wedge of high pressure crossed the British Isles between two depressions giving a sunny day; much sunshine was also reported on the 10th and 11th, 9·7hrs. at Portsmouth on the 3rd, 10·4hrs. at Rhayader on the 10th, and 9·7hrs. at Cardiff on the 11th, were among the larger amounts. Thunderstorms occurred in the Orkneys on the 2nd, and locally in England on the 7th. There was much mist and fog locally on the 11th and 12th. On the 13th an anticyclone moved north-east over the British Isles from the Azores. Day temperature fell somewhat and night temperatures considerably, but sunshine records were good generally on the 15th and 16th and locally on the 17th. 9·8hrs. were recorded at Cockle Park on the 15th, 9·3hrs. at Dundee on the 16th. Mist and fog were again experienced locally on the 15th and 19th. A change to much colder weather occurred about the 20th, when a depression over northern Norway extended southwards and northerly winds swept across the British Isles. From then onwards a succession of anticyclones passed across the kingdom and cold sunny weather prevailed. On several days maxima were generally below 50°F.; 40°F. was the maximum at Inverness, Fort Augustus and Nairn on the 29th, and at Edinburgh on the 30th, while screen minima fell to 15°F. at Rhayader on the 26th and to 16°F. at Dalwhinnie on the 25th, and grass minima to 7°F. at Rhayader on the 25th and 26th, and to 10°F. at Greenwich on the 28th. At Ross-on-Wye the minimum temperatures for the 27th were the lowest on record for October for at least 70 years. Snow was reported from numerous places in north Scotland on the 20th, 21st, 24th, 25th and 30th, and also at a few places in north England on the 24th. A trough of low pressure moved across the British Isles and gave rain generally on the 29th, 1·35in. fell at Festiniog (Merioneth), and 1·07in. at Stonyhurst. This was followed by a ridge of high pressure in the rear of which south-westerly winds brought warmer weather to the country for the last day. The total rainfall for the month was below normal over the whole country and was as little as 10 per cent. of the normal at Brighton. Absolute droughts (a period of at least 15 consecutive days, to none of which is credited ·01in. of rain or more) were recorded at many places in southern England, the southern Midlands and southern Wales. At Street, Somerset, the absolute drought ended on the 27th. The distribution of bright sunshine was as follows:—

	Total (hrs.)	Diff. from normal (hrs.)		Total (hrs.)	Diff. from normal (hrs.)
Stornoway	69	— 17	Liverpool	126	+40
Aberdeen	104	+ 9	Ross-on-Wye	109	+17
Dublin	123	+ 19	Falmouth	123	+ 7
Birr Castle	101	+ 3	Gorleston	127	+18
Valentia	102	+ 1	Kew	90	— 2

The special message from Brazil states that the rainfall in the northern and central regions was irregular with 0·04in. and 0·59in. above normal respectively and in the southern regions generally scarce with 0·59in. below normal. Sugar and cotton crops were in good condition in the north-east but in the centre and south the coffee blossoms were affected by the strong winds during the last ten days. Seven anticyclones passed across the country. At Rio de Janeiro, pressure was 1·4mb. above normal and temperature 0·2°F. above normal.

Miscellaneous notes on weather abroad culled from various sources.

Three inches of rain fell in Funchal, Madeira, on the 2nd and many streets were flooded for a short time. Severe weather was experienced in south-east Europe early in the month. Basements of houses fronting the Neva in Leningrad were flooded early on the 20th, when the river level rose suddenly owing to a storm over the Baltic. After a long drought during which the use of water was severely restricted in Madrid, rain fell in Spain about the 22nd (*The Times*, October 5th-23rd, 1931).

The monsoon lasted longer than usual this year in Bombay, where the rainfall was considerably above the average. A typhoon swept along the Pacific coasts of Japan on the night of the 12th. As a result of heavy rains which flooded the Vizagapatam district, a number of heavy boulders, displaced by the rains, fell on the Ghat road between Itikwalasa and Jeypore, and crushed to death 30 people. Other landslips have completely blocked communications in many districts (*The Times*, October 13th-21st, 1931).

Great damage was done by frost to some of the best vineyards in South Australia during the first part of the month. Useful rains fell in the northern and central districts of Queensland on the 24th and 25th (*The Times*, October 13th-26th, 1931).

Stormy weather on the Atlantic interfered with shipping towards the end of the month (*The Times*, October 27th, 1931).

Temperature in the United States was much above the normal during the early and last parts of the month but about normal in the middle, while rainfall was mainly below normal during the month (*Washington, D.C., U.S. Dept. Agric. Weekly Weather and Crop Bulletin*). October, 1931, in Maine was one of the clearest and sunniest months in many years. A heavy rainstorm on the 16th and a thunderstorm accompanied by torrential rain and hail on the 25th, however, brought the rain fall total above the normal (E. C. Austin, Auburn, Maine).

Rainfall, October, 1931—General Distribution

England and Wales	32	per cent of the average 1881-1915.
Scotland	82	
Ireland	56	
British Isles	49	

Rainfall: October, 1931: England and Wales

Co.	Station	In.	Per-cent of Av.	Co.	Station	In.	Per-cent of Av.
Lond .	Camden Square	·66	25	*Leics* .	Belvoir Castle	·54	20
Sur .	Reigate, Alvington	·62	19	*Rut* .	Ridlington	·63	22
Kent .	Tenterden, Ashenden	·63	18	*Linc* .	Boston, Skirbeck	·65	24
,, .	Folkestone, Boro. San.	1·03	...	,, .	Cranwell Aerodrome	·54	19
,, .	Margate, Cliftonville	·53	18	,, .	Skegness, Marine Gdns	·94	34
,, .	Sevenoaks, Speldhurst	·80	...	,, .	Louth, Westgate	·82	25
Sus .	Patching Farm	·55	14	,, .	Brigg, Wrawby St.	1·12	...
,, .	Brighton, Old Steyne	·37	10	*Notts* .	Worksop, Hodsock	·70	27
,, .	Heathfield, Barklye	·92	22	*Derby* .	Derby, L. M. & S. Rly.	·61	23
Hants .	Ventnor, Roy. Nat. Hos.	·76	19	,, .	Buxton, Devon Hos.	2·27	46
,, .	Fordingbridge, Oaklnds	·76	18	*Ches* .	Runcorn, Weston Pt.	1·60	47
,, .	Ovington Rectory	·75	19	,, .	Nantwich, Dorfold Hall	1·10	...
,, .	Sherborne St. John	·77	22	*Lancs* .	Manchester, Whit. Pk.	1·66	50
Berks .	Wellington College	·53	16	,, .	Stonyhurst College	3·45	77
,, .	Newbury, Greenham	·49	14	,, .	Southport, Hesketh Pk	2·41	68
Herts .	Welwyn Garden City	·65	...	,, .	Lancaster, Strathspey	3·65	...
Bucks .	H. Wycombe, Flackwell	·81	...	*Yorks* .	Wath-upon-Dearne	·69	25
Oxf .	Oxford, Mag. College	·71	25	,, .	Bradford, Lister Pk.	1·26	36
Nor .	Pitsford, Sedgebrook	·48	18	,, .	Oughtershaw Hall	4·04	...
,, .	Oundle	·47	...	,, .	Wetherby, Ribston H.	1·04	35
Beds .	Woburn, Crawley Mill	·64	24	,, .	Hull, Pearson Park	1·22	41
Cam .	Cambridge, Bot. Gdns.	·49	21	,, .	Holme-on-Spalding	1·41	...
Essex .	Chelmsford, County Lab	·61	25	,, .	West Witton, Ivy Ho.	1·53	41
,, .	Lexden Hill House	·62	...	,, .	Felixkirk, Mt. St. John	1·25	43
Suff .	Hawkedon Rectory	·85	31	,, .	Pickering, Hungate	1·43	47
,, .	Haughley House	·62	...	,, .	Scarborough	2·02	65
Norf .	Norwich, Eaton	1·03	33	,, .	Middlesbrough	1·21	40
,, .	Wells, Holkham Hall	1·11	40	,, .	Baldersdale, Hury Res.	1·78	...
,, .	Little Dunham	1·61	52	*Durh* .	Ushaw College	1·30	38
Wilts .	Devizes, Highclere	1·08	35	*Nor* .	Newcastle, Town Moor	1·09	34
,, .	Bishops Cannings	·73	22	,, .	Bellingham, Highgreen	2·02	51
Dor .	Evershot, Melbury Ho.	·69	15	,, .	Lilburn Tower Gdns.	1·06	29
,, .	Creech Grange	·88	17	*Cumb* .	Geltsdale	3·57	...
,, .	Shaftesbury, Abbey Ho.	·53	14	,, .	Carlisle, Scaleby Hall	2·96	89
Devon .	Plymouth, The Hoe	·67	17	,, .	Borrowdale, Seathwaite	9·75	81
,, .	Polapit Tamar	...	...	,, .	Borrowdale, Rosthwaite	9·32	...
,, .	Holne, Church Pk. Cott.	1·26	19	,, .	Keswick, High Hill	3·60	...
,, .	Cullompton	·62	15	*West* .	Appleby, Castle Bank	2·78	80
,, .	Sidmouth, Sidmount	·48	13	*Glam* .	Cardiff, Ely P. Stn.	·68	14
,, .	Filleigh, Castle Hill	1·17	...	,, .	Treherbert, Tynywaun	3·33	...
,, .	Barnstaple. N. Dev. Ath	1·03	23	*Carm* .	Carmarthen Friary	2·14	37
,, .	Dartm'r, Cranmere Pool	2·20	...	*Pemb* .	Haverfordwest, School	2·25	42
Corn .	Redruth, Trewirgie	1·20	23	*Card* .	Aberystwyth	...	...
,, .	Penzance. Morrab Gdn.	1·07	23	,, .	Cardigan, County Sch.	1·81	...
,, .	St. Austell, Trevarna	1·15	22	*Brec* .	Crickhowell. Talymaes	1·40	...
Soms .	Chewton Mendip	1·73	36	*Rad* .	Birm W. W. Tyrmynydd	2·24	34
,, .	Long Ashton	1·12	30	*Mont* .	Lake Vyrnwy	1·96	34
,, .	Street, Millfield	·47	14	*Denb* .	Llangynhafal	1·43	38
Glos. .	Cirencester, Gwynfa	·66	20	*Mer* .	Dolgelly, Bryntirion	4·46	73
Here .	Ross, Birchlea	·61	18	*Carn* .	Llandudno	1·86	52
,, .	Ledbury, Underdown	·67	22	,, .	Snowdon, L. Llydaw 9	12·05	...
Salop .	Church Stretton	·99	27	*Ang* .	Holyhead, Salt Island	1·97	49
,, .	Shifnal, Hatton Grange	·98	35	,, .	Lligwy	2·51	62
Worc .	Ombersley, Holt Lock	·65	24	*Isle of Man*			
,, .	Blockley	·87	...		Douglas, Boro' Cem.	2·59	57
War .	Birminghm, Edgbaston	·91	33	*Guernsey*			
Leics .	Thornton Reservoir	·80	28		St. Peter P't. Grange Rd.	·58	13

Rainfall: October, 1931: Scotland and Ireland

Co.	Station	In.	Per-cent. of Av.	Co.	Station	In.	Per cent. of Av.
Wigt .	Pt. William, Monreith	2·97	75	*Suth* .	Melvich	3·88	...
,, .	New Luce School	3·37	72	,, .	Loch More, Achfary	7·64	98
Kirk .	Carsphairn, Shiel	5·51	78	*Caith* .	Wick	2·93	99
Dumf .	Dumfries, Crichton, R.I	2·32	...	*Ork* .	Pomona, Deerness	...	...
,, .	Eskdalemuir Obs.	5·33	99	*Shet* .	Lerwick	4·12	104
Roxb .	Branxholm	2·89	89	*Cork* .	Caheragh Rectory	2·08	...
Selk .	Ettrick Manse	4·03	73	,, .	Dunmany Rectory	2·13	35
Peeb .	West Linton	2·82	...	,, .	Ballinacurra	1·23	31
Berk .	Marchmont House	1·43	37	,, .	Glanmire, Lota Lo.	1·36	33
Hadd .	North Berwick Res.	1·81	61	*Kerry* .	Valentia Obsy.	2·47	44
Midl .	Edinburgh, Roy. Obs.	1·41	54	,, .	Gearahameen	4·60	...
Lan .	Auchtyfardle	3·21	...	,, .	Killarney Asylum	2·30	43
Ayr .	Kilmarnock, Agric. C.	...	...	,, .	Darrynane Abbey	2·23	44
,, .	Girvan, Pinmore	3·97	79	*Wat* .	Waterford, Brook Lo.	...	...
Renf .	Glasgow, Queen's Pk.	3·08	95	*Tip* .	Nenagh, Cas. Lough	2·61	77
,, .	Greenock, Prospect H.	6·78	126	,, .	Roscrea, Timoney Park	1·37	...
Bute .	Rothesay, Ardencraig.	5·72	130	,, .	Cashel, Ballinamona	1·67	46
,, .	Dougarie Lodge	4·06	..	*Lim* .	Foynes, Coolnanes	1·92	51
Arg .	Ardgour House	11·00	...	,, .	Castleconnel Rec.	2·32	...
,, .	Manse of Glenorchy	...	...	*Clare* .	Inagh, Mount Callan	4·39	...
,, .	Oban	5·50	119	,, .	Broadford, Hurdlest'n.	2·56	...
,, .	Poltalloch	4·99	101	*Wexf* .	Gorey, Courtown Ho.	1·25	35
,, .	Inveraray Castle	9·12	129	*Kilk* .	Kilkenny Castle	1·56	49
,, .	Islay, Eallabus	5·48	115	*Wic* .	Rathnew, Clonmannon	·98	...
,, .	Mull, Benmore	...	..	*Carl* .	Hacketstown Rectory	2·05	54
,, .	Tiree	3·93	...	*Leix* .	Blandsfort House	1·90	54
Kinr .	Loch Leven Sluice	2·00	58	,, .	Mountmellick	1·98	...
Perth .	Loch Dhu	7·20	101	*Off'ly* .	Birr Castle	1·97	33
,, .	Balquhidder, Stronvar	5·56	...	*Kild'r* .	Monasterevin	...	...
,, .	Crieff, Strathearn Hyd.	1·75	45	*Dubl* .	Dublin, FitzWm. Sq.	·67	25
,, .	Blair Castle Gardens	2·29	74	,, .	Balbriggan, Ardgillan.	1·20	44
Angus .	Kettins School	1·23	43	*Me'th* .	Beauparc, St. Cloud	1·73	...
,, .	Dundee, E. Necropolis	1·21	46	,, .	Kells, Headfort	1·87	56
,, .	Pearsie House	1·21	...	*W.M* .	Moate, Coolatore	1·42	...
,, .	Montrose, Sunnyside	·83	30	,, .	Mullingar, Belvedere	2·38	76
Aber .	Braemar, Bank	2·38	63	*Long* .	Castle Forbes Gdns.	2·27	70
,, .	Logie Coldstone Sch.	1·81	56	*Gal* .	Ballynahinch Castle	2·93	49
,, .	Aberdeen, King's Coll.	1·53	51	,, .	Galway, Grammar Sch.	2·92	...
,, .	Fyvie Castle	1·79	47	*Mayo* .	Mallaranny	4·70	...
Moray .	Gordon Castle	2·67	85	,, .	Westport House	2·78	62
,, .	Grantown-on-Spey	...	...	,, .	Delphi Lodge	5·88	62
Nairn .	Nairn, Delnies	2·06	88	*Sligo* .	Markree Obsy.	3·24	79
Invs .	Ben Alder Lodge	4·37	...	*Cav'n* .	Belturbet, Cloverhill	2·07	71
,, .	Kingussie, The Birches	2·99	...	*Ferm* .	Enniskillen, Portora	2·71	...
,, .	Loch Quoich, Loan	19·50	...	*Arm* .	Armagh Obsy	1·98	73
,, .	Glenquoich	13·72	137	*Down* .	Fofanny Reservoir	3·05	...
,, .	Inverness, Culduthel R.	1·85	...	,, .	Seaforde	1·97	55
,, .	Arisaig, Faire-na-Squir	5·56	...	,, .	Donaghadee, C. Stn.	2·06	71
,, .	Fort William	9·51	...	,, .	Banbridge, Milltown	1·75	...
,, .	Skye, Dunvegan	5·67	...	*Antr* .	Belfast, Cavehill Rd.	2·51	...
R & C .	Alness, Ardross Cas.	2·67	69	,, .	Glenarm Castle	2·96	...
,, .	Ullapool	4·37	90	,, .	Ballymena, Harryville	3·02	82
,, .	Torridon, Bendamph	...	...	*Lon* .	Londonderry, Creggan	3·37	92
,, .	Achnashellach	7·54	..	*Tyr* .	Omagh, Edenfel	2·89	79
,, .	Stornoway	4·99	...	*D'n* .	Malin Head	4·18	...
Suth .	Lairg	4·00	107	,, .	Dunfanaghy	3·19	...
,, .	Tongue	3·61	86	,, .	Killybegs, Rockmount	3·80	68

Climatological Table for the British Empire, May, 1931.

STATIONS	PRESSURE: Mean of Day M.S.L. (mb.)	PRESSURE: Diff. from Normal (mb.)	TEMPERATURE: Absolute Max. (°F.)	TEMPERATURE: Absolute Min. (°F.)	TEMPERATURE: Mean Values Max. (°F.)	TEMPERATURE: Mean Values Min. (°F.)	TEMPERATURE: Mean Values ½ max. and min. (°F.)	TEMPERATURE: Mean Values Diff. from Normal (°F.)	TEMPERATURE: Mean Wet Bulb (°F.)	Relative Humidity (%)	Mean Cloud Am'nt (0—10)	PRECIPITATION: Am'nt (in.)	PRECIPITATION: Diff. from Normal (in.)	PRECIPITATION: Days	BRIGHT SUNSHINE: Hours per day	BRIGHT SUNSHINE: Percentage of possible
London, Kew Obsy.	1011·9	— 4·0	74	48	62·1	46·9	54·5	+ 1·1	49·0	81	6·9	2·48	+ 0·76	15	5·1	33
Gibraltar	1016·0	— 0·1	82	51	74·5	56·8	65·7	+ 0·2	56·2	81	4·4	0·36	— 1·37	4	..	..
Malta	1015·2	+ 0·7	82	54	71·9	60·2	66·1	+ 0·2	60·6	75	4·4	0·92	+ 0·51	6	9·8	70
St. Helena	1014·9	+ 0·9	69	57	67·2	59·6	63·4	+ 0·3	60·5	92	7·9	1·19	..	7	..	..
Sierra Leone	1012·7	+ 1·5	91	67	87·6	72·1	79·9	— 1·6	78·3	84	5·4	10·21	— 1·26	21	..	..
Lagos, Nigeria	1011·3	+ 0·3	91	72	86·9	76·2	81·5	— 0·3	77·2	79	8·9	8·87	— 1·60	17	..	..
Kaduna, Nigeria	1011·8	— 0·9	97	—	90·8	—	—	—	74·3	79	7·1	10·08	+ 4·14	13	..	..
Zomba, Nyasaland	1014·8	— 0·3	83	54	75·9	59·5	67·7	+ 1·9	..	76	7·1	0·60	— 0·44	3	..	..
Salisbury, Rhodesia	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..
Cape Town	1018·7	+ 0·6	84	40	65·2	51·7	58·5	— 0·4	52·7	87	6·5	2·03	— 1·72	14	..	..
Johannesburg	1017·8	+ 1·0	77	45	70·4	50·6	60·5	+ 6·1	47·6	41	1·3	0·00	— 0·76	0	9·9	91
Mauritius	1017·6	+ 1·2	82	59	79·0	66·7	72·9	+ 0·3	69·6	73	4·6	5·00	+ 1·97	20	7·8	70
Calcutta, Alipore Obsy.	1003·2	— 0·3	101	70	94·4	79·0	86·7	+ 0·6	79·8	81	6·0	7·68	+ 2·12	9*	..	..
Bombay	1007·4	0·0	94	77	92·4	80·7	86·5	+ 0·7	78·1	73	3·4	0·00	— 0·55	0*	..	..
Madras	1005·0	— 0·4	106	71	98·3	81·3	89·8	0·0	79·5	71	5·3	1·77	— 0·07	1*	..	..
Colombo, Ceylon	1009·3	+ 0·9	90	72	87·3	77·2	82·3	— 0·5	79·1	82	8·5	11·81	+ 0·87	27	5·5	44
Singapore	1009·2	+ 0·5	94	72	88·8	76·5	82·7	+ 0·6	78·9	82	6·9	6·96	+ 0·31	15	6·2	51
Hongkong	1008·5	— 0·8	89	68	80·7	73·8	77·3	— 0·1	73·9	86	9·0	12·00	+ 0·02	19	3·6	27
Sandakan	..	..	92	74	89·4	76·1	82·7	+ 0·2	78·5	81	..	5·08	— 1·25	9	..	..
Sydney, N.S.W.	1019·1	+ 0·5	81	41	68·3	54·3	61·3	+ 2·5	55·2	78	5·6	3·50	— 1·68	13	5·5	53
Melbourne	1018·5	— 0·7	73	37	63·3	49·5	56·4	+ 2·3	52·8	81	6·9	2·66	+ 0·50	18	4·3	42
Adelaide	1019·3	— 0·7	77	44	65·7	52·1	58·9	+ 1·0	53·3	75	8·2	2·99	+ 0·21	24	3·6	35
Perth, W. Australia	1019·9	+ 1·5	76	40	65·7	49·5	57·6	— 3·1	52·2	73	4·7	6·29	+ 1·32	13	6·5	62
Coolgardie	1020·0	+ 0·6	79	36	63·7	44·7	54·2	— 3·5	49·5	67	5·6	1·27	— 0·06	7	..	..
Brisbane	1020·3	+ 1·7	81	48	74·0	58·8	66·4	+ 1·8	61·2	77	5·8	2·19	— 0·62	12	5·7	53
Hobart, Tasmania	1012·6	— 2·7	70	37	59·2	47·2	53·2	+ 2·7	47·8	74	7·1	2·24	+ 0·34	18	3·8	39
Wellington, N.Z.	1023·0	+ 7·4	60	37	55·0	46·1	50·5	— 2·3	47·6	77	6·7	2·56	— 2·12	16	4·5	45
Suva, Fiji	1013·6	+ 0·9	90	67	81·9	72·1	77·0	+ 0·5	72·6	80	7·7	7·88	— 2·19	22	4·1	36
Apia, Samoa	1011·1	0·0	89	71	85·3	74·6	79·9	+ 1·5	76·9	81	6·5	13·86	+ 7·79	16	5·2	45
Kingston, Jamaica	1011·7	— 1·4	93	70	88·7	74·0	81·3	+ 1·6	73·5	76	5·7	3·76	— 0·63	9	7·4	57
Grenada, W.I.	1013·8	+ 1·2	91	71	87·4	73·9	80·7	+ 1·0	73·9	76	4·9	2·71	— 1·48	14	..	..
Toronto	1012·5	— 2·4	84	30	65·9	45·9	55·9	+ 2·1	49·4	70	4·7	1·89	— 0·90	11	7·4	50
Winnipeg	1013·6	— 0·2	90	16	61·0	39·0	50·0	— 2·0	..	..	4·0	2·43	+ 0·43	7	..	..
St. John, N.B.	1014·2	+ 0·3	75	32	56·6	41·6	49·1	+ 1·4	44·7	74	7·0	4·26	+ 0·55	14	5·9	40
Victoria, B.C.	1018·2	+ 1·5	78	43	62·9	48·0	55·5	+ 2·5	50·7	70	5·2	1·48	+ 0·35	8	10·0	66

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

M.O. 339.

The Meteorological Magazine

Air Ministry :: Meteorological Office

Vol. 66

Dec., 1931

No. 791

LONDON: PUBLISHED BY HIS MAJESTY'S STATIONERY OFFICE

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The Abnormal Weather of November, 1931

The month of November, 1931, was characterised by persistent southerly and south-westerly winds and generally mild weather. In the first half of the month a series of violent gales swept the south coast of England, but after the 16th the conditions became quieter and the month ended in a spell of anticyclonic weather and widespread fog. The chart of deviations of pressure from normal, reproduced in fig. 1, shows a highly abnormal distribution. Pressure was more than 15 mb. below normal over Iceland, the deficit reaching 18·3 mb. at Reykjavik, while over northern and central Russia pressure was much above normal, the excess being 12·4 mb. at Moscow and probably still greater further to the north. This intense and persistent anticyclone prevented depressions from following their normal course to the eastward, and throughout the month a series of disturbances travelled towards the north-east along or off our western coasts.

The month opened brilliantly, most places in the south having more than eight hours' sunshine on the 1st, but a disturbance appeared on the 2nd, and by the 3rd a complex depression lay to the north-west of Ireland and Scotland, and in conjunction with an anticyclone over southern Europe caused gales and strong winds from between south-west and south over the southern half of England and Ireland.

Heavy rain fell in Wales and north-west England on both

(96597) 107/27 1,075 12/31 M. & S. *Gp.303*

the 2nd and 3rd. The records at present available may be tabulated as follows:—

	Nov. 2.	Nov. 3.	Total
Lake District.	*in.*	*in.*	*in.*
Borrowdale (Rosthwaite) ...	2·35	5·24	7·59
Keswick	2·44	4·64	7·08
Patterdale	3·15	5·50	8·65
Rydal	1·85	5·41	7·26
Elan Valley.			
Birmingham Water Works—(Nantgwillt)	1·16	3·90	5·06
Carmarthen.			
Black Mountains (Llyn-y-fan Fach)	2·16	6·52	8·68
Brecon.			
Trecastle (Blaenau-hydfer) ...	2·36	7·25	9·61
Devon.			
Ashburton (Holne)	0·58	4·52	5·10

The rain began a little before midnight on the 2nd, and the heavy totals were therefore concentrated within 36 hours. In Patterdale three inches fell in three hours. Serious flooding developed; Derwentwater and Bassenthwaite, which are about five miles apart, were joined in one great lake, and landslides occurred in the mountains, one of them over an area of two acres. In the Elan Valley on November 3rd and 4th, 2,855 million gallons of water were discharged into the Elan River at Caban Dam. This is the greatest amount in 48 hours since records began in 1908; had the reservoir been full at the beginning of the flood the discharge would have amounted to 3,105 million gallons. At Cranmere Pool, Dartmoor, the total rainfall during the first week of November amounted to 11·50 inches.

The rainfall amounts were unusually large, although not unprecedented for the British Isles. This type of rainfall distribution with very large falls in the mountainous districts of the west is generally assocated with strong winds from the south-west. Serious floods were also recorded in Norway.

A depression of exceptional intensity appeared off western Ireland on the 9th, the barometer reading at Blacksod Point being 961·0 mb. at 13h. on the 10th. A violent gale raged in the Channel throughout this day and the morning of the 11th, and a great deal of damage was done along the south coast by the conjunction of rough seas and an exceptionally high tide. Houses on the shore were battered by the waves. The famous Ship Inn at Winchelsea was partly destroyed; a great lagoon covered the low-lying ground from Winchelsea beach to Rye Harbour, in which furniture was floating about, and the road was four feet under water. At Bungalow Town, Shoreham-by-Sea, about one hundred bungalows were destroyed or damaged, some of the floors being covered by six inches of shingle. Part of the Isle of Wight west of the river Yar and Freshwater Bay was completely cut off from the rest of the island at high tide. In Wales heavy rain fell, and great damage was done by floods.

On the morning of the 11th the depression was centred over northern Scotland, and had already decreased considerably in intensity, and by the 12th it lay far to the north and had ceased to influence the British Isles and a short period of sunny weather occurred. Subsequently the disturbances followed a course far out in the Atlantic, but on the 14th a small secondary caused

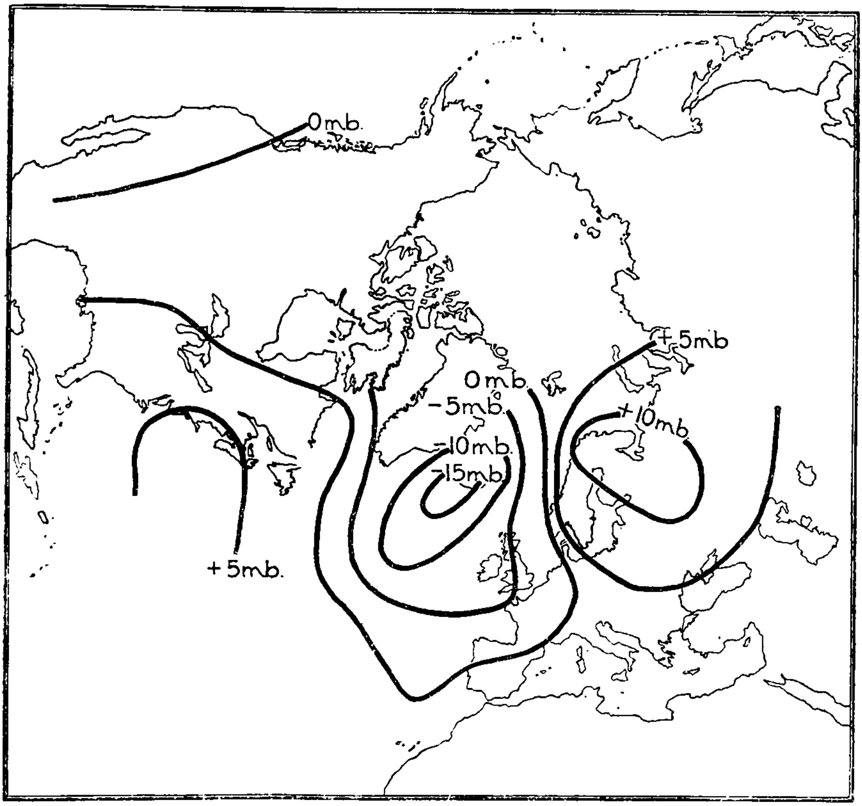

Fig. 1.

heavy rain in Wales and the Isle of Man; 2·42 inches of rain fell at Douglas, Isle of Man, in 22 hours on the 13th and 14th. On the 15th an anticyclone extended from Norway across the British Isles, and a short spell of fair weather occurred. On the 17th, however, fog occurred in many parts of eastern England, especially in the Thames Estuary. The 21st was generally sunny, but the fine spell ended on the 22nd, when a deep secondary to a complex depression in the North Atlantic travelled north-eastward across the country, causing strong winds and heavy rains in Ireland and the western parts of Great

Britain. Among the heavy falls on the 23rd were 2·81 inches at Ballinacurra, Co. Cork, 1·75 inches at Springburn Park, Glasgow, and 1·61 inches at Aberdeen. There was serious flooding in several parts of Scotland, in western Ireland and again in the Isle of Man. Another secondary passed over on the 29th, giving further heavy rain in south-east England. In the rear of this disturbance pressure rose rapidly as an anticyclone spread in from the south-west, and the accompanying light winds favoured the development of widespread fog over most of England and southern Scotland.

In addition to gales and floods, the month was characterised by generally high temperature. At Kew the average for the month, 46·8°F., was 2·5°F. above normal, and the night of the 3rd to 4th, on which the minimum temperature was 57°F., was the warmest November night for at least 60 years.

The abnormally high temperatures extended over the whole of western and northern Europe; the following figures show the average temperatures in November, 1931, and those in brackets the difference from normal in °F.: Lisbon, 55·7 (+0·7); Zurich, 40·6 (+2·5); Aberdeen, 46·5 (+4·0); Stockholm, 38·8 (+4·6); Haparanda, 32·6 (+9·7); Vardo, 33·9 (+5·7). In Lapland the excess above the normal amounted to 13°F. Still more remarkable were conditions over Spitsbergen, where the average temperature of 29·4°F. was no less than 20·2°F. above normal. As will be seen from fig. 1, Spitsbergen lay just to the north of a region of very strong southerly or south-westerly winds. The normal pressure difference between Vardo in the north of Norway and Stykkisholm in the north of Iceland in November is only 3·9 mb., but this year the difference amounted to 32 mb. Similar conditions prevailed to a lesser extent over the whole of western Europe, which was flooded with warm air from the sub-tropical Atlantic.

In the interior of Europe rainfall was generally below normal, the deficit being 1·4 in. at Zurich. In Sweden rainfall was only about half the normal in Gothaland and eastern Svealand, and was somewhat below normal elsewhere, except in north-eastern Norrland, where the winds blowing off the Baltic gave an excess of rain. At Vardo in northern Norway on the other hand, the rainfall amounted to only about 0.6 in. compared with a normal of 2·4 in.

Weather conditions in the United States appear to have been as abnormal as those in the British Isles. Mr. Earl C. Austin, of Auburn, Maine, writes that a cold spell continued from November 6th to 9th, during which the thermometer at Auburn fell to 19°F. on the 8th. A few warm days followed, the maximum on the 10th being 74°, which is the highest November maximum on record at Auburn. The middle of the month was again cold, the maximum on the 15th being only 38°, while on the morning of the 16th the ground was covered by four inches of snow. The weather contrasts continued, and on the 21st another period of extraordinarily warm weather began, the maxima being 64° on the 21st, 72° on the 22nd, and 68° on the 24th. A temperature of 76° was recorded at Cincinnati on the 22nd, and one of 77° at Boston on the 23rd. The whole of the eastern and middle western States enjoyed summer-like weather, while at the same time the far west experienced very low temperatures and blizzards. This remarkable distribution was caused by the abnormal intensity and westward displacement of the Atlantic anticyclone, shown by the excess of pressure north of Bermuda in fig. 1. Pressure was abnormally high over the eastern States, and abnormally low over the Mississippi Valley, Plains States and the region of the Great Lakes. This distribution, characteristic of summer, was associated with steady southerly winds and a flood of warm air from the Gulf of Mexico over the eastern half of the country. The average temperature for the whole month was probably well above normal in the eastern States.

Over Oregon and the plateau region there was a large anticyclone, which gave cold northerly winds in the far west, and on November 22nd the United States Press reported an unofficial reading of −40°F. near Helena. On the 25th this anticyclone began to advance eastward and a cold wave spread over the whole country, the maximum temperature in Auburn on the 26th being only 32°F. Precipitation was generally light in the east, but above normal in the middle west, where several rivers in Kansas, Oklahoma, Missouri and Iowa reached the flood stage.

Among numerous letters received about the rainfall of November 2nd and 3rd were the following:—

At 9 a.m. yesterday morning the 4th, I measured 3·72 in. of rain for the preceding 24 hours—it fell in 21 hours.

I have kept a record of rainfall for 38 years—nine at this station—and yesterday's fall was the largest I have ever recorded. The nearest approach was 3·63 in. on October 6th, 1929. H. K. G. Rogers.

Seaforde, Mary Tavy, Nr. Tavistock, S. Devon. November 5th, 1931.

On November 4th we experienced the worst flood within living memory. Following upon extremely heavy continuous rain all through the 3rd the river Usk reached an amazing height on the morning of the 4th at 8 a.m. The valley was a huge sheet of water. At Crickhowell the people in some of the houses were forced to take refuge in upper rooms. My rain-gauge gave 4·34 inches in the 24 hours—a record for this station.

It was phenomenally warm, the screen maximum being 59·1°F. and minimum 54·7°F., grass minimum 50·0°F. The wind, which was south, reached 40 m.p.h. in gusts, veering to west on the morning of the 4th, when the rain luckily ceased.

One of our farmers lost 83 sheep. Much damage to walls, fences, &c., and on every hand is evidence of the absolutely record-breaking height reached by the flood.

R. G. SANDEMAN.

Dan-y-Parc, Crickhowell, Breconshire, South Wales. November 5th, 1931.

The Influence of the Moon on the Weather

By LIEUT.-COMDR. C P. SATOW, R.N.

As an amateur, the fact that the belief in the influence of the moon was so very widespread among practical men whose living is dependent on weather conditions led me to think that, possibly, the failure in the past to connect the two was due to investigators not having sufficient data at their disposal, and that to-day, with the far better methods of recording and fuller records, some link might be found.

With this in view I started to analyse the Isopleth Diagrams given on the back of the *Monthly Supplement to the Daily Weather Report.*

I had first to get some figure which I could note down and which would bear a definite relation to the weather on the day in question. I therefore counted the number of lines of the diagram in each section of 24 hours, thus giving one a rough figure for the disturbance of the air on the line for which the diagram was constructed. If the figure was a high one the air was much disturbed, if low then the air was still. These figures

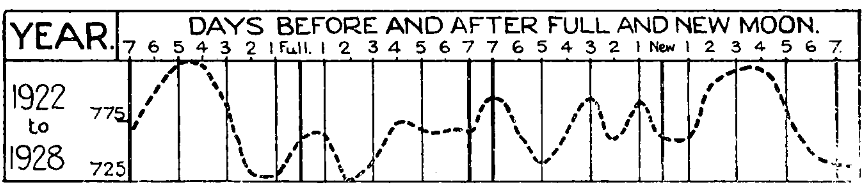

Fig. 1.—TOTALS OF ISOPLETH COUNT FOR THE YEARS 1922-8.

I arranged in accordance with Full and New Moon, allowing a fifteen-day interval between full and new. Of course, this was not always the case, but on occasions when the interval was shorter I repeated the figure for seven days after full and used it for seven days before new, and if the interval was longer I discarded the extra day in the middle. The arrangement gave twelve sets of similarly disposed figures for any one year. The results of seven consecutive years were added together and plotted, the resulting curve being shown in fig. 1.

It will be seen that the curve is decidedly erratic, though there is a tendency for the weather to improve after full moon and to be worse after new. This tendency I had noticed to be most marked in the autumn months, so I divided the year into four parts, three months to each, and then plotted the sums of the last periods, which roughly covered October, November and December. The result is shown on the broken curve in fig. 2.

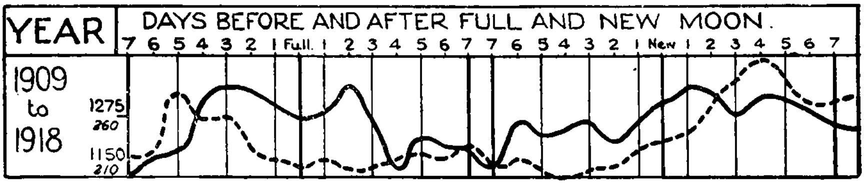

Fig. 2.—Totals of isopleth count for Oct., Nov., Dec., 1921-8. Totals of wind force at Lerwick, Spurn Head, Castlebay, Valentia, Scilly and London, for Oct., Nov., Dec., 1909-18.

The tendency is most marked and the variation between maximum and minimum is proportionately greater. The results for the other three quarters of the year were erratic and showed no indications of any connexion with the lunar period.

The next step was to see if the result obtained for 1921 to 1928 persisted in other years, but here a difficulty occurred as 1921 was the first year that isopleth diagrams were published.

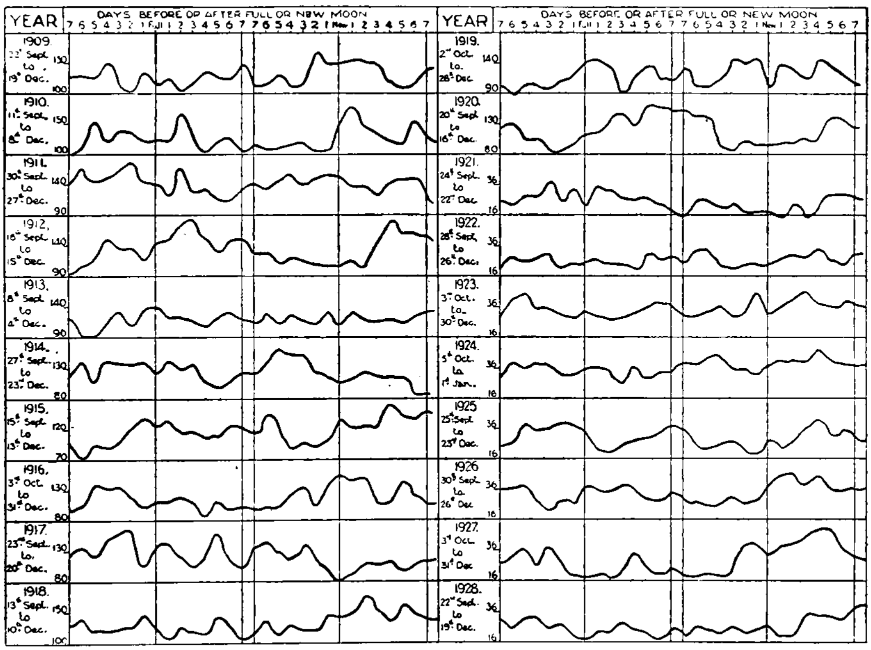

Fig. 3.—1909-20. Totals of wind at Lerwick, Spurn Head, Castlebay, Valentia and London.
1921-8. Totals of isopleth counts.

To overcome this I tried plotting the sum of wind forces at a few selected stations scattered over the British Isles, and the resultant curve followed the curve obtained from the isopleth count almost exactly. Treating these wind force totals in the same way as I had the isopleth numbers, the full curve, shown in fig. 2, was obtained for the years 1909 to 1918, but it will be seen that the tendency previously noticed is not nearly so pronounced. Moreover, the range between maximum and minimum is not so great. The plotting of individual years brings out some interesting points. In fig. 3 it will be seen that the years 1909, 1918 and 1927 bear a decided resemblance to one another. It is in the autumn of these years that Perigee coincides with full moon; 1913 and 1922 also are rather similar, and in these years Perigee coincides with the new moon.

Of course, taking the last three months of the year, since the weather is generally getting more stormy the curves would normally tend to rise slightly from left to right. But, taking the isopleth count figures the average rise would only be 2·2, and this figure was so small that it was not considered to be worth while to attempt to correct the curves for the normal annual effect of the sun.

Whilst it cannot be claimed that the figures shown in the diagrams consistently support the hypothesis that the movements of the moon are related to the weather conditions in the British Isles, it is felt that they are suggestive and that a more detailed examination of the years which show signs of similarity should prove interesting and may produce something of value.

Discussions at the Meteorological Office

November 16th, 1931.—*Historical note on the catch of rain-gauges.* By H. R. Puri (India Meteor. Dept., Sci. Notes, Calcutta III, No. 23, 1931). *Opener*—Dr. J. Glasspoole.

The necessary preliminary to any useful investigation is a survey of our knowledge of the subject. The literature on the catch of rain-gauges is extensive, and the task of summarising must have been arduous. The present paper is a useful supplement to that published in *British Rainfall*, 1900, by Dr. H. R. Mill. It will be recalled that Dr. Mill wrote the paper on "The Development of Rainfall Measurement in the last Forty Years," soon after he became Director of the British Rainfall Organization.

Mr. Puri treats the subject under three main heads: (1) the instruments; (2) the methods of correcting over-exposure; and (3) under-exposure.

In the consideration of the instruments for measuring rainfall the advantage of the standard gauge with the deep Snowdon funnel, over the older pattern with the shallow funnel, is not mentioned. The advantage of the deep funnel gauge is that it gives a better sample of the precipitation during heavy rain or hail, and during snow. On the other hand the deeper gauge exposes a larger area, resulting in a slightly greater loss by evaporation. The advantages of the Snowdon funnel gauge far outweigh this small defect.* Attention is, however, directed to the disadvantage of painting the funnel of the gauge. Paint may swell, become spongy and absorb an appreciable amount of rain, in addition to retaining some in its crevices, so that loss by evaporation may result.

It is interesting to note that the diminution in the catch of a rain-gauge as the rim is raised from the ground level, was explained by the increased effect of wind eddies at higher elevations as early as 1821. Details are given of the various protecting devices which have been adopted to correct the catch of the gauge. The most successful devices are the turf wall and the pit. The turf wall used at Holyhead† was 8 ft. in diameter with the crest of the turf wall horizontal and level with the rim of the gauge, which was 1 ft. above the ground inside the wall and 8 inches above the ground outside. The pit used at Valentia Observatory‡ was 5 ft. square, with vertical sides 1 ft. deep. The gauge was placed in the centre of the pit with the rim level with that of the ground outside.

Since the paper was written the experiments by Mr. F. Hudleston at Hutton John, near Penrith, have been continued. Although the results are summarised in the annual volumes of *British Rainfall*, they are of such outstanding interest that some reference to the conclusions seems warranted. It is shown that the exposure of the gauge in the direction of the prevailing wind is of fundamental importance; that shelter in that direction by gently rising ground or by a wood at a distance from the gauge of about twice the height of the trees results in a reasonable catch; that in a badly over-exposed site on ground sloping down about 1 in 8 in the direction of the prevailing wind the loss due to over-exposure is materially reduced by the use of a turf wall. The turf wall used is 10 ft. in diameter, with the gauge in the centre. It is a few inches thick at the top, the inside wall is vertical, while the outside wall slopes down about 1 in 3. The crest of the turf wall is horizontal and level with the rim of the gauge. The experiments are being continued, and some slight modifications in these details may prove desirable.

The experiments demonstrate that while a turf wall round a gauge in an over-exposed site appreciably reduces the loss, it does not eliminate the error entirely in winds of all strengths. A gauge should wherever possible be set up in a site with suit-

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* *Washington, D.C., Monthly Weather Rev.*, 1931, p. 157, Rain-gauge funnels of different depths, by J. Glasspoole.

†See *British Rainfall*, 1926, p. 282.

‡See *London Q.J.R. Meteor. Soc.*, 52, 1926, p. 67.

able natural shelter, especially in the direction of the prevailing wind, and the turf wall should be used only if such a site cannot be found.

November 30, 1931. *Contribution to the aerology of the Indian monsoon.* By A. Wagner. (Beitr. Geophysik, Leipzig, 30, 1931, pp. 196-238.) (In German.) *Opener*—Mr. S. P. Peters, B.Sc.

This paper consists of three sections dealing respectively with (1) the air circulation in the NE. monsoon, (2) the air circulation in the SW. monsoon, (3) certain aspects of conditions over India during the SW. monsoon. For (1) and (2) the data utilised were pilot balloon observations at 46 stations distributed irregularly over India, Burma, the Persian Gulf, Iraq, Syria and Egypt, the periods covered by the observations varying for different stations and heights from one to 15 years. In particular, it is important to note that for the discussion of the air circulation in the SW. monsoon at heights above 3 Km. the available data are for 20 stations only out of the 46, and in the case of 12 of these stations the observations are for one year only. In treating the NE. monsoon the months December-February were combined, and for the SW. monsoon, June-August, and the main feature of the paper is a series of charts for the two monsoons showing mean lines of flow of air at different heights, without reference to speed.

For the NE. monsoon the author confines his attention to the heights 0·5, 1, 2, and 3 Km. At each of these heights he indicates a surface of separation between an air stream approaching northern India from west or north-west, and the NE. monsoon, this boundary surface being shown at the first two heights as running approximately north to south a little distance to west of the Indus, whilst at 2 and 3 Km. it lies west to east across India between latitudes 15° and 20°N. An examination of the individual resultant wind vectors on which the charts are based (which are given in tables at the end of the paper) does not, however, in itself afford convincing evidence of the existence of fronts so definite in character and position as to justify the boldness with which they are indicated on the charts. Even if one admits the existence of a pronounced boundary surface between the westerly current from Iraq and Arabia and the NE. monsoon, the position assigned to it by Wagner at 0·5 and 1 Km. is open to criticism; but, as was pointed out in the discussion, there is a not uncommon tendency amongst meteorologists to assume the existence of a front on the basis of only slender evidence, and in this particular case an examination of at least the individual pilot balloon observations, or a representative selection of them, is a necessity before the reality of the discontinuity as a permanent feature of the NE. monsoon can be assumed.

In the case of the SW. monsoon, which is considered up to a height of 10 Km., the author indicates up to 5 Km. a surface of separation between a dry continental air stream and the moist monsoon current, and although there are more *prima facie* reasons for accepting the existence of this front than there are in the case of the NE. monsoon, there are again definite objections to be raised against the appearance of finality with which the positions assigned to it on the charts at the various heights up to 5 Km. seem to be invested. In this case the objections rest not only on the basis of the lack of consideration of the results of individual ascents, but also on account of the weighted character of pilot balloon observations, which arises on account of varying cloud amount during different states of development of the monsoon. Cloud is less prevalent, and hence pilot balloon observations are more frequent, during periods of " feeble monsoon " or of " breaks in the monsoon " than during " active monsoon " conditions, and consequently any deductions as to air circulation based only on pilot balloon data are by no means representative of average conditions throughout the SW. monsoon season. Also, for heights above 3 Km., for which, as already pointed out, there are very limited data available both in space and time, the detailed features of the charts cannot be regarded as more than approximations to true average conditions. Actually, on account of the alternations from activity to inactivity which the SW. monsoon current exhibits, and the associated changes in the air circulation which must accompany these alternations, the precise significance and value of charts purporting to show mean conditions of air flow during the SW. monsoon season are open to question, and the value of the results presented in Wagner's paper is better appreciated when it is realised that they refer mainly to inactive monsoon conditions.

Royal Meteorological Society

The opening meeting of this Society for the present session was held on Wednesday, November 18th, at 49, Cromwell Road, South Kensington, Mr. R. G. K. Lempfort, C.B.E., M.A., President, in the Chair.

J Edmund Clark, Ivan D. Margary, Richard Marshall, C. J. P. Cave, and L. C. W. Bonacina.—Report on the Phenological Observations in the British Isles, from December, 1929, *to November,* 1930.

The year 1930 was officially characterised as " A Wet Year." Abnormal December and January warmth and excess of sunshine in December, 1929, and November, 1930, make very partial amends for almost continuous adverse conditions in between, save only in June and the brief spell of glorious harvest weather which ended August. Hence, for farm and garden, conditions were as a rule bad. The result on the floral calendar was that no district records were early before the convolvulus in July. Spring flowers in southern parts were almost a week late. But the floral isophenes were naturally much nearer normal than in 1929. The corresponding isakairs (lines of equal difference from normal flowering date) were early mainly over southern Scotland and north-west Ireland; they were latest in west Ireland, central Highlands and scattered English areas. Insects and birds were late; the 20 migrants by two days. A natural exception was the very early first song of the thrush. The spring isophenes can now be compared with the chart of return movements, a matter of decided interest.

Sir G. T. Walker, C.S.I., F.R.S., and A. C. Phillips.—The forms of stratified clouds: Part 1, experimental. Part 2, discussion.

In continuation of experimental work on vertically unstable liquids by E. H. Weber, Bérnard, Idrac and Mal, an examination was made of the patterns set up in a heated liquid moving along a rectangular trough. As this did not produce vortices with their axes at right angles to the flow, recourse was had to unstable air flowing along a small wind-channel, the motion being indicated by fumes of titanium tetrachloride. By suitable increases of velocity, from zero, the patterns produced were polygons, transverse vortices, crossed vortices, and longitudinal vortices, and the resemblance to clouds was more obvious than when liquids were used; it must, however, be remembered that the shear changes sign; also, the motion inside the cells was downward, not upward as with liquids. Downward motion in clouds is at times conspicuous half-way up in the wind-channel, but not in cloud stratum.

William Dunbar.—Eighty years' rainfall at North Craig Reservoir, Kilmarnock.

The paper deals with the rainfall records kept at North Craig Reservoir for the past 80 years. Table I gives the yearly totals for the period together with the percentages of these figures to the long average. On this table are also shown the ten driest and ten wettest years. All but one of the driest years occurred during the first 40 years, while the majority of the wet years occurred in the second half of the 80-year period. The table is also divided into decades and brings out the fact which the complete analysis confirms—that the first 40 years of the period were drier than the second 40—only one decade (1861-70) in the first period exceeds the average, while only one (1911-20) in the second half is under the average. The author compares the North Craig figures with those of a gauge in the east of Scotland, and with the average for Scotland, the figures suggest that the west is becoming wetter and the east drier. The analysis of the data of each month, quarter, half-year and seasonal year is fully dealt with giving highest and lowest falls for the period, the highest and lowest for each month, etc., and in these figures the fact of the dryness of the first 40 years is again brought out.

Correspondence

To the Editor, *The Meteorological Magazine.*

Bush Fires and Whirlwinds

The observations of whirlwinds starting from the fire-front of bush fires, given in Mr. Wilson's note,* are of great interest.

The motion of the whirlwinds appears to me to be that which would be anticipated if they were clockwise whirls, the curvature of the path arising from the effect of friction; the curvature of the path would be opposite in anti-clockwise whirls. A clockwise whirl would be a " cyclonic " whirl in Southern Rhodesia.

The great difference of temperature between the fire-front and the air to windward of it (and, to a lesser extent, the air to leeward) would be sufficient to originate the whirls; but I do not think one would have expected them all to have the same direction of rotation. If they do, it is even more surprising than the results for sand-devils recently published by Captain Durward.†

E. GOLD.

Alto-cumulus castellatus and mammato-cumulus clouds

Mr. Petrocokino in his letter published in your September number remarks that he has never seen a mammillated hybrid cirrus sheet with a severe thunderstorm.

On June 6th, 1931, during a heavy thunderstorm, which I believe did considerable damage, a mammillated sheet of false cirrus or alto-stratus was observed at Brundall, Norfolk, at 19h. 45m. G.M.T. The storm was due to surface heating of maritime polar air, which had curved round a large depression west of Ireland and had a long land track over southern England. Heavy and minor storms had occurred in the afternoon and early evening. The centre of the storm passed south of Brundall, and it was thus possible to observe the upper sky to some extent. The mammillated appearance of the " anvil " was sufficiently striking for a record of its occurrence to be made.

A form of mammato-cumulus has often been observed to occur in an atmosphere with a steep lapse rate of temperature in the lowest layers, but with an inversion of temperature higher up.

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* *London Meteorological Magazine,* 66, 1931, p. 236.

† *Nature, London,* 128, 1931, pp. 412-13.

Cumuli develop due to surface heating, but spread out higher up under the inversion, frequently forming a continuous sheet of cloud which often has a mammillated appearance. Perhaps this is the same as Type I mentioned by Mr. Petrocokino. This form of mammato-cumulus is thus formed in what is usually a stable atmosphere and is not associated with any particular phenomenon. The inversion is usually too low for even slight showers to develop.

L. DODS.

School of Artillery, Larkhill, Salisbury Plain. November 5th, 1931.

Fog Bow

Mr. Thomas M. Prosser, Meteorological Observer at the Royal Agricultural College, Cirencester, observed a fog bow at 9 a.m. on November 21st. His description is as follows:—"There was a fairly dense wet fog present (visibility 220 yds.). The fog appeared to be clearing, however, in the upper air, as the sun was just beginning to penetrate through. At about 110 yds. from the observation ground to the north-west there appeared a perfect white arc, and I should imagine the arc was about 80 feet high at the apex, and approximately 200 yds. in length from end to end. As the fog cleared so the arc faded away, until at 9.15 it had disappeared entirely."

The fog bow is a white rainbow seen opposite the sun in fog. It is produced in the same way as the ordinary rainbow, but owing to the smallness of the drops the colours overlap and the bow appears white.

Loss of Human Life in Blizzards in Cornwall

Dr. J. Hambley Rowe, of Bradford, President of the Royal Cornwall Polytechnic Society, has called my attention to his having found among the Registers of Burial of the parishes of Phillack, Breage and Paul, all in west Cornwall, nine burials of persons who died in the snow in December, 1630. . . It would be interesting to learn whether there are any other records of this great fall of snow or of any other human lives being, as the Paul register expresses it, "drowned" in the snow at any other time in Cornwall. Dr. Rowe has examined a great number of Cornish parish registers, but in no other case has he come across deaths in the snow.

WILSON LLOYD FOX.

Carmino, Falmouth. August 15th, 1931.

Destruction of Forests by Peat Moss

Reading "Past and Present" for the first time in forty years, and, by odd coincidence, immediately after Dr. Brooks's most interesting lecture on "Climatic Changes since the Ice Age" (Vict. Inst., May 18th), I came on Carlyle's explanation of the loss of the forests, which may be of sufficient interest to publish. Quoting from *Jocelini Chronica*, p. 21, where it is said that Abbot Samson with his monks "would sit in some opening of the woods, and see the dogs run; but he himself never meddled with hunting, that I saw" (time, about 1200 A.D.; place, St. Edmundsbury), Carlyle goes on to say: "'In an opening of the woods;' for the country was still dark with wood in those days; and Scotland itself still rustled shaggy and leafy, like a damp black American forest, with cleared spots and spaces here and there. Dryasdust advances several absurd hypotheses as to the insensible but almost total disappearance of these woods; the thick wreck of which now lies as peat, sometimes with huge heart-of-oak timber-logs imbedded in it, on many a height and hollow. The simplest reason doubtless is, that by increase of husbandry, there was increase of cattle; increase of hunger for green spring food; and so, more and more, the new seedlings got eaten out in April; and the old trees, having only a certain length of life in them, died gradually, no man heeding it, and disappeared into peat. A sorrowful waste of noble wood and umbrage! Yes, but a very common one; the course of most things in this world."

There may be something in it as regards destruction of the forests in the "recent period," though it leaves the formation of the peat itself unexplained; but on one point we can be quite clear, viz., that, if the distinguished author of "Past and Present" had been present to have heard Dr. Brooks's paper read, he would have withdrawn the term "Dryasdust," repenting in sackcloth and ashes.

T. C. SKINNER.

8, Smoke Lane, Reigate, Surrey. *May 23rd*, 1931.

NOTES AND QUERIES

Abnormal Behaviour of Pressure-Tube Anemograph

We do not know if the effects to be described have been noticed before by observers in charge of pressure-tube anemographs, but as we have not seen any mention in print it seems worth while calling attention to them.

When all adjustments are made to the Dines pressure-tube recorder (M.O. 1065/30) in operation at Worthy Down, *i.e.*, water-level correct and shot adjusted so that the scratch on the pen rod is coincident with the top of the brass collar, and when both pressure and suction taps are turned off, the "floating zero" is nearly 3mm. above the zero mark which can be obtained by depressing the float rod by hand until the float touches the bottom of the water container. Normally, when the wind falls to a dead calm (both taps being on), the velocity pen falls to the correct " floating zero," but on certain occasions the charts show that it has fallen below the zero line;; that is to say, the record shows a negative velocity of 1 or 2 m.p.h.

The effect has been most marked between 5h. and 9h. G.M.T. on the following days :—

April	12th,	1931 (see fig. 1)	July	29th	1931.
,,	30th,	,,	Sept.	8th,	,,
May	31st,	,,	,,	9th,	,,
July	9th,	,, (see fig. 1)	,,	29th,	,,

On each occasion the sun had risen shortly before, and the weather was quiet with little or no cloud after a cold night.

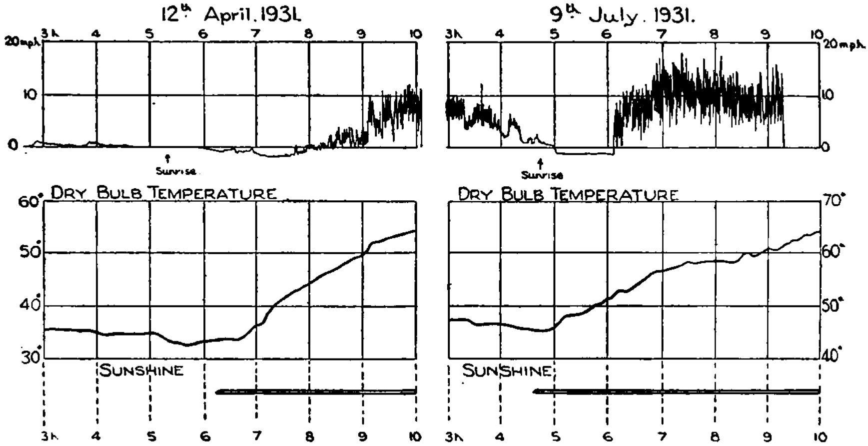

FIG. 1.

The explanation seems to be that a rapid rise in temperature of the iron piping between the vane and the roof of the hut (a distance of 27 feet) is communicated gradually to the air inside the tubes resulting in a diminution of pressure in both pipes. This rarefaction in the pressure tube produces a greater effect in the recorder than that in the suction tube; at midsummer at Worthy Down this is enhanced by the fact that the pressure tube becomes heated more strongly because the mast itself protects the suction tube from the rays of the rising sun. The tubes are 1 inch in diameter and painted black.

The following tests were carried out between 7h. 52m. and 8h. 15m. G.M.T. on September 9th. The sky was cloudless and a very low wind speed of 30 ft./min. (1/3 m.p.h.) from NNW. was recorded by an airmeter which was tied to the top of the vane. The temperature of the outside of the pressure piping was approximately 60°-62°F. at the time of the test, whilst the screen minimum had fallen to 38°F. two hours previously.

With both taps turned either on or off the pen recorded to all intents and purposes a zero wind. When the pressure tap only was turned on, the pen fell almost instantaneously, and the fall was only arrested by the float touching bottom. When the suction tap only was turned on, the pen rose sharply to 3 m.p.h. A little shot was then removed from the cup to bring the pen to the 5 m.p.h. line on the chart with both taps off. With the suction tap only turned on, the pen rose 2 m.p.h., and with the pressure tap only turned on, it fell 3 m.p.h. Similar results were obtained when the vane was taken off.

In order to find out to what extent vertical air currents produced by the warmed corrugated iron roof of the building in which the recorder is housed might be responsible for the suction effects observed in both tubes, the airmeter was then suspended from the vane with its axis vertical. A rising current of 28 ft./min. (approximately 1/3 m.p.h.) only was registered over a five-minute interval.

It has been noted frequently that when the pipes are subjected to bright sunshine with a wind of as much as 6 m.p.h., turning off the pressure tap makes no appreciable difference to the recorded mean wind speed—it may even increase it if there is hot sunshine. When cloud appears, however, and the sun's rays are cut off, the suction :pressure ratio assumes its normal value.

It would appear therefore that—

(1) when a "bad zero" is shown on a pressure-tube anemogram it may not mean that the instrument is out of adjustment;

(2) the accuracy of measurement of low wind speeds is impaired under certain conditions, especially if one pipe is exposed to bright sunshine whilst the other is in shadow;

(3) the testing of an anemometer by noting the behaviour of the velocity pen when the pressure and suction taps are turned off and on is best done on a cloudy day. On a bright morning with a light wind, the fact that the pen fails to respond properly when the pressure tap is turned on is by no means a sure indication that there is a fault in the pipe or the recording mechanism.

C. V. Ockenden,
C. F. J. Jestico.

R.A.F. Station, Worthy Down, Winchester. *October 20th,* 1931.

The point raised in the above letter is of considerable interest. There is no doubt that if a pressure-tube anemometer is tested in a light wind by turning on the pressure and suction taps alternately, and at the same time the vertical connecting pipes are strongly heated by sunshine, the resulting movement of the pen is somewhat disconcerting. This is due, as is pointed out, to the fact that the heated air in the pipes is of different density to that of the surrounding atmosphere. Thus, if there were no wind blowing so that the pressure inside the pressure and suction tubes at the head were identical with that outside the head at the same level, there would be a difference of pressure at the recorder between the room and the inside of either of these pipes, the room pressure being the higher. Assuming that both pressure and suction pipes are at the same temperature, the effect will be the same in both and there will be no error in the records of the instrument in normal working. Although this statement appears at first sight to be contradicted by a statement in Mr. Ockenden's and Mr. Jestico's note, that when the suction tap only was turned on the pen rose from 5 to 7 m.p.h., while with the pressure tap only turned on it fell from 5 to 2 m.p.h., this experiment actually shows that the pressure effect in the two pipes was closely similar, the change of pressure required to move the pen from 5 to 7 m.p.h. being practically the same as that required to move the pen from 2 to 5 m.p.h. An error will, therefore, only be introduced into the records if the pressure and suction pipes are heated differently. This may happen, as pointed out, if the sun is shining and one pipe is in the shadow of the mast, while the other is exposed to the full sunshine. It is easy to calculate the effect which may occur in this case. Assuming that 30 feet are exposed to sunshine and that the difference of temperature is 20°F. (probably a somewhat extreme figure), the pressure difference at the bottom introduced by this differential temperature effect will be ·47mm. of water. If there is no wind blowing the instrument will record 5 m.p h. if the suction tube is the one heated. The error rapidly falls with increasing velocity, being 1¼ m.p.h. at 10 m.p.h., and only ½ m.p.h. at 20 m.p.h. Fortunately, strong differential heating of this kind will only occur in this country with the sun fairly high in the heavens and calms during the daytime are of much less frequent occurrence than during the night so that the full error of 5 m.p.h. will seldom occur.

It would be of interest if observers, in charge of anemometers, so arranged that the suction pipe was exposed to sunshine for a few hours after sunrise in the summer, while the pressure pipe was shielded, would study their records to see whether there was any indication of a fictitious rise of wind due to the heated suction pipe. Such a fictitious wind would, presumably, be free from gusts.

With regard to the anemometer at Worthy Down in which the pen is able to fall 3mm. below the zero position, this degree of latitude is unusual. As a rule the zero mark on the pen rod almost coincides with the position of rest of the float on the bottom of the tank. The control of the pen movement given by the buyancy of the shaped part of the float ceases when the pen reaches the zero mark, so that movements of the float below this point are practically uncontrolled and have little meaning.

It may be of interest to mention that the effect of heating the pressure and suction pipes of anemometers was first noticed by me many years ago when working on the pressure-tube anemograph at the Upper Air Station at Pyrton Hill. At this time I designed a head in which the pressure and suction were brought down in two concentric tubes, the outer one of which formed the anemometer mast. One advantage of this design was that the inner pipe naturally took up the same temperature as that of the outer one so that errors in the record due to differences of heating in the two pipes were eliminated. Practical difficulties were, however, found in this design which prevented its coming into general use. J. S. DINES.

The Vertical Temperature Gradient in the Arctic

A recent publication of the Administration of Hydrography, Leningrad, Hydro-meteorological section,* gives the results of 44 kite ascents in 1914 and 1915 between latitudes 73° and 78° N., longitudes 80° and 105° E. The tables give for various heights, in steps of a few hundred metres, the temperature, relative humidity, wind direction and velocity, remarks and control observations made on board the vessel.

A glance at the tables is sufficient to indicate the usual presence of an inversion of temperature in the lower layers, which is more marked the lower the surface temperature. To bring this out, I prepared the following tables, employing the 34 ascents which exceeded a height of 500 metres. As a rule the

TABLE 1. SEASONAL VARIATION.

Temperature	*Winter (Nov.-Feb.)*	*Summer (May-Aug.)*	*Equinox (Mar., Apr., Sept., Oct.)*
	°C.	°C.	°C.
Average at 0m.	—27·5	—1·2	—23·5
Change of temperature—			
0–500m.	+3·7	+0·4	+4·8
500–1000m.	+1·9	—1·2	+1·6
1000–1500m.	—	—0·8	—2·0

TABLE 2. RELATION BETWEEN SURFACE TEMPERATURE AND INVERSION.

	Surface temperature.				
	Below —30° C.	*—30 to —20° C.*	*—20° to 0° C.*	*Above 0° C.*	*All readings.*
Number of ascents ...	9	7	10	8	34
Average at 0m. ...	—36·7	—23·7	—6·1	+3·0	—15·7
Change of temperature—					
0–500m. ...	+7·6	+4·4	—0·5	+0·7	+3·0
500–1000m. ...	+2·0	+0·3	—1·9	—0·9	+0·2
1000–1500m. ...	—	—2·0	—1·3	—0·2	—1·2

---

* Observations hydro-météorologiques des expéditions hydrographiques. Matériaux de l'Expédition Hydrographique de l'Océan Glacial du Nord 1910-15. By N. Evgenov. Leningrad 1931. Les résultats des observations aérologiques reçues par des levers de serf-volant sur le navire hydrographique "Taimyr," faites en 1913-15.

data are for each 500-metre level, both ascending and descending; in a few ascents the figure at the exact level had to be interpolated from neighbouring readings. The averages of the ascending and descending readings were taken for each ascent.

It appears that the presence and extent of the inversion of temperature are closely related to the surface temperature. The latter, of course, varies with the season, but no other seasonal effect on the inversion is obviously shown. The correlation coefficient between surface temperature and change of temperature between 0 and 500 m. is $-0{\cdot}69$ and the regression equation :—

$$\frac{\text{Change of temp.}}{\text{0–500m. (°C.)}} = -1{\cdot}0 - 0{\cdot}24 \times (\text{surface temp.})$$

Thus, on the average, the inversion disappears when the surface temperature rises to $-4°$ C., but there is some irregularity at the higher temperatures.

The average depth of the inversion is about 1,000 metres in the equinoxes and below 500 metres in summer. None of the winter ascents reached the summit of the inversion, but by extrapolation it would appear to lie at about 1,250 metres.

C. E. P. BROOKS.

REVIEWS

Physics of the Earth—III—Meteorology. Washington, D.C., National Academy of Sciences, National Research Council, Bulletin No. 79, 8vo., pp. xi + 289, *Illus.* 1931.

In 1926 a Committee of the National Research Council of the United States of America was appointed to prepare a series of Bulletins on the Physics of the Earth, the purpose being "to give to the reader, presumably a scientist, but not a specialist in the subject, an idea of its present status, together with a forward-looking summary of its outstanding problems." It was realized that geophysics occupied a kind of middle place among the other physical sciences, and that there were lacking systematic treatises in English dealing with its various branches. This volume on meteorology forms one of a series of nine volumes which are intended to cover the field of geophysics. It consists of an introduction, six chapters, and an index, as follows :—

Introduction, 4½ pp. Development of the Science of Meteorology, by H. H. Kimball.

Chap. I, 14 pp. The Atmosphere : Origin and Composition, by W. J. Humphreys.

Chap. II, 19 pp. Meteorological Data and Meteorological Changes, by A. J. Henry.

Chap. III, 31 pp. Solar Radiation and its Rôle, by H. H. Kimball.

Chap. IV, 65 pp. The Meteorology of the Free Atmosphere, by W. R. Gregg, L. T. Samuels and W. R. Stevens.

Chap. V, 100 pp. Dynamic Meteorology, by H. C. Willett.

Chap. VI, 45 pp. Physical Basis of Weather Forecasting, by R. H. Weightman.

The book consists therefore of a number of essays on meteorological subjects, written by different persons in collaboration. The essays do not cover the whole of the subject (a notable omission being meteorological optics), and the collaboration is not close enough to avoid a certain amount of duplication. The work is consequently not a text-book on meteorology, and perhaps it was not intended to be one.

It can be stated that Mr. Willett's chapter on Dynamic Meteorology is at once the longest and most important chapter in the book; it is also the chapter which will be most attractive to the majority of students of meteorology. It contains a fairly detailed mathematical discussion of the thermodynamics and dynamics of the atmosphere, followed by a purely descriptive account of recent theories on the general circulation of the atmosphere, and on the origin, growth and decay of cyclones and anticyclones. A considerable portion of the mathematical part might well have been omitted, as being otherwise available in English, and the space re-allotted to an expansion of the descriptive part at the end, which has been written in an interesting and thoughtful way, and should be of considerable use to English readers. This author succeeds well in giving "a forward-looking summary of outstanding problems."

Turning to the other chapters, Prof. Humphreys writes in his usual interesting manner on the origin and composition of the atmosphere; he does not fail to introduce to his readers the relations which have recently been found between ozone and meteorological phenomena.

Prof. Henry describes very briefly the nature of the meteorological record from geological times to the present day. He refers to the information derived from tree trunks, discusses the Brückner cycle, and passes on to modern instrumental records, which are set out in a form suitable for statistical treatment.

The chapters on Solar Radiation, and on the Meteorology of the Free Atmosphere contain, in the main, careful summaries of instrumental methods and of results of observation.

The last chapter on the Physical Basis of Weather Forecasting is for the most part a description of the methods of weather forecasting used in the United States Weather Bureau, and of methods of long-distance forecasting with the aid of correlation coefficients.

Throughout the book references have been made to the most important recent papers which have been published throughout the world, and at the end of each chapter these papers are listed. This is a valuable feature of the work.

The authors and publishers have done good service by the production of this volume for the benefit of English-speaking peoples.

R. CORLESS.

Indian Meteorological Department. Scientific Notes. Vol. II. Nos. 13-14, pp. 21-36. *Illus.* Calcutta, 1930, 1s. 6d. and 8d. net.

Indian Meteorological Department. Memoirs. Vol. XXV. Part V. pp. 163-193 (with 6 additional pages of plates). Calcutta, 1930, 3s. 6d. net.

The Indian Journal of Physics. Vol. IV, Part VI. pp. 477-502. *Illus.* Calcutta University Press, 1930.

These four papers afford pleasing evidence of the continuance of fruitful activity in India about meteorology.

In the first, Dr. K. R. Ramanathan discusses, under the title of " Atmospheric Instability at Agra associated with a Western Disturbance," the results obtained by observations on eight pilot balloons sent up in succession at Agra on March 30th, 1928, within a period of, approximately, half an hour in the early afternoon. The tail method was employed in each of the ascents; and the surface pressure distribution prevailing was that of a feeble depression. Ascending and descending currents of considerable magnitude were found to exist in addition to considerable fluctuations in the horizontal winds at various heights. Marked peculiarities noted in the distribution of the up and down currents are explained as due to the interposition of a layer of abnormally warm air between two layers of potentially colder air, while the fluctuations in the horizontal winds are deemed to be largely independent either of the strength or direction of the wind, or of the height.

In the second paper, Barkat Ali sets out, under the title of " Horizontal Atmospheric Visibility at Agra," certain empirical relationships found between the horizontal visibility at Agra and other meteorological elements, such as wind direction and force, relative humidity, and the like. The paper follows the lines made familiar to English meteorologists by similar investigations relating to places in the British Isles during the last decade, and is a useful addition to the literature of what may be termed local visibility. It is interesting to record that the results obtained at this inland station in India do not, where they are comparable, differ greatly from those obtained, say, for Cranwell, in England; especially is this similarity noticeable in regard to the relationship between horizontal visibility and wind force.

The third paper, " Discussion of Results of Sounding Balloon Ascents at Agra during the Period July, 1925, to March, 1928, and some Allied Questions," by Dr. K. R. Ramanathan, is a sequel to a well-known paper by Dr. W. A. Harwood,* in which simlar observations during the period 1915-8 were discussed. Certain discrepancies from Dr. Harwood's results are noted and

* *Indian Meteorological Dept., Memoirs,* Vol. xxiv, *Part* vi. The free atmosphere in India, Observations with kites and sounding balloons up to 1918.

examined. Dr. Ramanathan's paper is a storehouse of valuable tables and of diagrams, and deserves to be noted by every serious student of the upper air.

Dr. Banerji, in the fourth paper, " The Effect of the Indian Mountain Ranges on the Configuration of the Isobars," gives an analysis of the part played by the mountain ranges of India in shaping the stream lines in the air during a steady south-west monsoon, and concludes that the peculiarities exhibited by the mean sea-level isobars during typical months of the south-west monsoon as seen in the maps taken from Eliot's " Climatological Atlas of India " are due in very large measure to the mountain barriers. Dr. Banerji reasons closely, and certainly puts new wine into the old bottles of the maps of mean monthly pressures. He has made a contribution to the literature of the monsoons that is to be welcomed.

WILLIAM H. PICK.

Books Received

Enregistrements de l'ultrarayonnement cosmique à Muottas-Muraigl. By F. Lindholm. (Reprinted from Arc. Sci. Phys. Geneva, 5th period, vol. II, pp. 271-2.)

Obituary

Professor Robert de Courcy Ward.—We regret to announce the sudden death on November 12th of R. de C. Ward, Professor of Climatology at Harvard University. Professor Ward was born at Boston on November 29th, 1867; he was educated at Harvard, and after his graduation in 1889 he was appointed Assistant in climatology. He became Instructor in 1895, Assistant Professor in 1900, and Professor in 1910.

Ward had a facile pen, and his lucid and interesting books and articles have done much to spread an interest in climatology in this country as well as in America. His first book, " Practical Exercises in Elementary Meteorology," appeared in 1899, and includes a good introduction to the climatology of the United States, as well as instructions in the reading of meteorological observations. In 1903 he published a translation into English of the first part of Hann's great " Handbuch der Klimatologie," and this translation of a standard work has been widely read in Great Britain as well as in North America. In 1908 Ward published his well-known book on " Climate, considered especially in relation to man," a second edition of which appeared in 1918, and in 1925 he issued a comprehensive study of " Climates of the United States."

In addition to these major works, Ward did a great deal to popularise meteorology in America by writing numerous very readable articles, especially on the practical applications of meteorology to every-day life. He always insisted that a knowledge of meteorology added greatly to the pleasure of travelling, and he himself visited many parts of the world in search of practical experience of the climates which he described. In 1926 he received the Gold Medal of the Travellers Club of Boston.

Professor Ward also took an active part in the administrative side of meteorology, both in Harvard and in the numerous scientific societies of which he was a valued member. He was President of the Association of American Geographers in 1917, and of the American Meteorological Society in 1920 and 1921. He joined the Royal Meteorologcal Society in 1895, subsequently becoming a Life Fellow, and contributed two important papers to the *Quarterly Journal*. He leaves a wife and two sons.

It is noted with great regret that Mr. James Davidson, Kirkwall, died in Aberdeen on November 23rd as a result of injuries received in a motor accident on November 12th. Mr. Davidson, who was a sub-agent of the National Bank of Scotland, had, since 1926, taken charge of the climatological station at Kirkwall as a voluntary observer. His work was marked by meticulous accuracy, and the station soon came to be regarded as one of the best in the country. In 1928 a new pressure tube anemograph was added by the Office to the equipment at Kirkwall.

A. H. R. Goldie.

We regret to learn of the death of Mr. J. T. Williams on November 15th, 1931, at the age of 71. Mr. Williams joined the Meteorological Office in 1881 and worked first in the Instruments Division. He was transferred to the Marine Division in 1885, and served there until his retirement in March, 1925.

News in Brief

The Council of the Royal Meteorological Society has awarded the Symons Gold Medal for 1932 to Professor V. F. K. Bjerknes, of the Physical Institute of the University, Oslo, Norway. The medal is awarded for distinguished work in connexion with meteorological science and will be presented at the annual general meeting on January 20th, 1932.

The Copley Medal has been awarded by the Royal Society to Sir Arthur Schuster, F.R.S., for his distinguished researches in optics and terrestrial magnetism.

We learn that M. Louis Néel has been appointed Director of the Puy de Dôme Observatory in succession to Prof. E. Mathias, who retired on October 1st, 1931.

The Weather of November, 1931

The account of the weather of the month over Europe and the British Isles will be found on page 249.

The distribution of bright sunshine was as follows:—

	Total (hrs.)	Diff. from normal (hrs.)		Total (hrs.)	Diff. from normal (hrs.)
Stornoway	45	+ 2	Liverpool	44	—15
Aberdeen	47	— 8	Ross-on-Wye	63	0
Dublin	70	— 1	Falmouth	90	+14
Birr Castle	69	+ 5	Gorleston	53	— 9
Valentia	50	— 15	Kew	59	+ 7

The special message from Brazil states that the rainfall in the northern and central regions was generally scarce with ·04 in. and 0·51 in. below normal respectively and in the southern regions plentiful with 0·87 in. above normal. The coffee, cane and cotton crops were in good condition. Six anticyclones passed across the country. At Rio de Janeiro pressure was 0·2 mb. above normal and temperature 2°F. below normal.

Miscellaneous notes on weather abroad culled from various sources. As the result of heavy rains small landslips were reported from various mountain districts above the French Riviera and floods occurred near Mandelieu. Torrential rain fell in Corsica on the 14th and 15th. The fine weather in Switzerland which began early in the month came to an end on the 28th, when after heavy rain, snow fell over the country down to the level of Geneva. (*The Tmes*, November 10th-30th, 1931.)

Severe storms caused loss of life and extensive damage and flooding in the south of Tunisia early in the mouth. (*The Times*, November 7th, 1931.)

In the eastern United States temperature was mainly below normal early in the month and much above normal later, while in the mountainous regions and along the Pacific coasts the reverse was the case, and in the central States it was mainly above normal all the time. Rainfall was below normal generally for the first half of the month, but later it was in excess except along the Atlantic coasts. (*Washington, D.C., U.S. Dept. Agric. Weekly Weather and Crop Bulletin.*)

A severe snowstorm, beginning on the 21st, swept across the mountainous deserts of western New Mexico and 600 Indians were marooned on the top of the high mesas. A hurricane struck the oil-producing town of Maracaibo, Venezuela, early in the month. No deaths were reported. Many gales were experienced on the North Atlantic. (*The Times*, November 7th-28th, 1931.)

Rainfall, November, 1931—General Distribution

England and Wales	143	per cent of the average 1881-1915.
Scotland	143	
Ireland	192	
British Isles	153	

Rainfall: November, 1931: England and Wales

Co.	Station	In.	Per-cent of Av.	Co.	Station	In.	Per-cent. of Av.
Lond .	Camden Square.........	1·99	84	*Leics* .	Belvoir Castle..........	1·89	85
Sur .	Reigate, Alvington.....	3·64	117	*Rut* .	Ridlington..............	2·22	96
Kent .	Tenterden, Ashenden...	4·55	151	*Linc* .	Boston, Skirbeck........	1·89	94
,, .	Folkestone, Boro. San..	4·45	...	,, .	Cranwell Aerodrome...	2·24	120
,, .	Margate, Cliftonville...	2·72	113	,, .	Skegness, Marine Gdns	1·58	73
,, .	Sevenoaks, Speldhurst	3·84	...	,, .	Louth, Westgate........	2·79	108
Sus .	Patching Farm.........	3·04	85	,, .	Brigg, Wrawby St.....	2·65	...
,, .	Brighton, Old Steyne..	4·29	134	*Notts* .	Worksop, Hodsock.....	2·83	144
,, .	Heathfield, Barklye....	5·86	159	*Derby* .	Derby, L. M. & S. Rly.	2·87	133
Hants .	Ventnor, Roy. Nat. Hos.	4·27	133	,, .	Buxton, Devon Hos....	6·86	147
,, .	Fordingbridge, Oaklnds	5·51	161	*Ches* .	Runcorn, Weston Pt...	4·41	159
,, .	Ovington Rectory.......	4·79	144	,, .	Nantwich, Dorfold Hall	5·21	...
,, .	Sherborne St. John.....	3·40	119	*Lancs* .	Manchester, Whit. Pk.	5·56	205
Berks .	Wellington College.....	2·61	102	,, .	Stonyhurst College.....	6·50	144
,, .	Newbury, Greenham...	3·37	120	,, .	Southport, Hesketh Pk	6·45	205
Herts .	Welwyn Garden City...	2·75	...	,, .	Lancaster, Strathspey	7·25	...
Bucks .	H. Wycombe, Flackwell	3·05	...	*Yorks* .	Wath-upon-Dearne.....	3·37	165
Oxf . .	Oxford, Mag. College..	2·94	133	,, .	Bradford, Lister Pk....	6·03	206
Nor .	Pitsford, Sedgebrook...	2·78	126	,, .	Oughtershaw Hall......	8·98	...
,, .	Oundle..................	1·74	...	,, .	Wetherby, Ribston H.	4·46	191
Beds .	Woburn, Crawley Mill	2·61	117	,, .	Hull, Pearson Park.....	2·79	127
Cam .	Cambridge, Bot. Gdns.	1·90	99	,, .	Holme-on-Spalding.....	3·75	...
Essex .	Chelmsford, County Lab	1·74	77	,, .	West Witton, Ivy Ho.	4·35	126
,, .	Lexden Hill House....	1·69	...	,, .	Felixkirk, Mt. St. John	4·37	178
Suff .	Hawkedon Rectory.....	2·04	90	,, .	Pickering, Hungate....	3·08	124
,, .	Haughley House........	1·66	...	,, .	Scarborough............	1·59	64
Norf .	Norwich, Eaton...... ...	1·87	73	,, .	Middlesbrough..........	1·87	88
,, .	Wells, Holkham Hall	1·68	78	,, .	Baldersdale, Hury Res.	4·28	...
,, .	Little Dunham..........	2·57	99	*Durh* .	Ushaw College..........	3·09	123
Wilts .	Devizes, Highclere......	4·21	158	*Nor* .	Newcastle, Town Moor	2·16	89
,, .	Bishops Cannings.......	3·28	115	,, .	Bellingham, Highgreen	6·06	177
Dor .	Evershot, Melbury Ho.	8·20	192	,, .	Lilburn Tower Gdns....	4·34	129
,, .	Creech Grange..........	5·02	122	*Cumb* .	Geltsdale................	4·77	...
,, .	Shaftesbury, Abbey Ho.	3·65	113	,, .	Carlisle, Scaleby Hall	5·31	177
Devon .	Plymouth, The Hoe....	6·25	171	,, .	Borrowdale, Seathwaite	23·10	170
,, .	Polapit Tamar..........	...	...	,, .	Borrowdale, Rosthwaite	19·10	...
,, .	Holne, Church Pk. Cott.	15·89	247	,, .	Keswick, High Hill.....	12·66	...
,, .	Cullompton	5·68	165	*West* .	Appleby, Castle Bank..	6·79	204
,, .	Sidmouth, Sidmount...	5·41	173	*Glam* .	Cardiff, Ely P. Stn.....	5·95	143
,, .	Filleigh, Castle Hill....	6·84	...	,, .	Treherbert, Tynywaun	18·11	...
,, .	Barnstaple. N. Dev. Ath	6·00	153	*Carm* .	Carmarthen Friary.....	12·70	255
,, .	Dartm'r, Cranmere Pool	16·70	...	*Pemb* .	Haverfordwest, School	11·55	234
Corn .	Redruth, Trewirgie.....	10·79	221	*Card* .	Aberystwyth............	7·02	...
,, .	Penzance, Morrab Gdn.	8·31	182	,, .	Cardigan, County Sch.	10·63	...
,, .	St. Austell, Trevarna...	8·72	177	*Brec* .	Crickhowell, Talymaes	12·00	...
Soms .	Chewton Mendip........	4·65	109	*Rad* .	Birm W. W. Tyrmynydd	11·89	178
,, .	Long Ashton............	4·69	148	*Mont* .	Lake Vyrnwy...........	10·30	185
,, .	Street, Millfield	3·63	132	*Denb* .	Llangynhafal............	4·90	159
Glos. .	Cirencester, Gwynfa....	4·41	148	*Mer* .	Dolgelly, Bryntirion...	10·59	171
Here .	Ross, Birchlea...........	5·29	209	*Carn* .	Llandudno..............	3·81	123
,, .	Ledbury, Underdown..	3·98	163	,, .	Snowdon, L. Llydaw 9	30·50	...
Salop .	Church Stretton.........	6·39	217	*Ang* .	Holyhead, Salt Island	6·14	148
,, .	Shifnal, Hatton Grange	3·69	154	,, .	Lligwy..................	7·03	186
Worc .	Ombersley, Holt Lock	3·41	149	*Isle of Man*			
,, .	Blockley.................	4·20	...		Douglas, Boro' Cem....	11·08	235
War .	Birminghm, Edgbaston	3·76	116	*Guernsey*			
Leics .	Thornton Reservoir....	2·39	106		St. Peter P't. Grange Rd.	4·61	122

Rainfall : November, 1931 : Scotland and Ireland

Co.	Station	In.	Per-cent. of Av.	Co.	Station	In.	Per cent. of Av.
Wigt .	Pt. William, Monreith	8·77	203	*Suth* .	Melvich..................	1·61	...
,, .	New Luce School......	9·32	182	,, .	Loch More, Achfary...	3·83	45
Kirk .	Carsphairn, Shiel	17·44	221	*Caith* .	Wick	2·64	84
Dumf.	Dumfries, Crichton, R.I	8·38	...	*Ork* .	Pomona, Deerness......	2·73	69
,, .	Eskdalemuir Obs.......	11·26	194	*Shet* .	Lerwick	5·86	138
Roxb .	Branxholm..............	6·11	185	*Cork* .	Caheragh Rectory	11·35	...
Selk .	Ettrick Manse	10·84	199	,, .	Dunmany Rectory......	12·70	205
Peeb .	West Linton	4·44	...	,, .	Ballinacurra..............	10·08	251
Berk .	Marchmont House......	3·81	127	,, .	Glanmire, Lota Lo......	10·34	241
Hadd .	North Berwick Res....	3·34	149	*Kerry*.	Valentia Obsy...........	12·27	225
Midl .	Edinburgh, Roy. Obs.	4·16	193	,, .	Gearahameen............	18·70	...
Lan .	Auchtyfardle	5·95	...	,, .	Killarney Asylum.......	12·05	215
Ayr .	Kilmarnock, Kay Pk.	6·80	...	,, .	Darrynane Abbey	10·48	205
,, .	Girvan, Pinmore	10·77	202	*Wat* .	Waterford, Brook Lo...	9·63	255
Renf .	Glasgow, Queen's Pk. .	6·64	178	*Tip* .	Nenagh, Cas. Lough ...	7·23	180
,, .	Greenock, Prospect H.	8·97	140	,, .	Roscrea, Timoney Park	8·40	...
Bute .	Rothesay, Ardencraig.	10·46	206	,, .	Cashel, Ballinamona ...	8·91	252
,, .	Dougarie Lodge.........	8·84	...	*Lim* .	Foynes, Coolnanes	5·46	134
Arg .	Ardgour House	12·08		,, .	Castleconnel Rec........	7·07	...
,, .	Manse of Glenorchy...	...	...	*Clare* .	Inagh, Mount Callan...	8·65	...
,, .	Oban......................	8·60	156	,, .	Broadford, Hurdlest'n.	6·49	...
,, .	Poltalloch	9·10	162	*Wexf*.	Gorey, Courtown Ho...	8·37	240
,, .	Inveraray Castle........	10·29	122	*Kilk* .	Kilkenny Castle	7·51	244
,, .	Islay, Eallabus	7·23	134	*Wic* .	Rathnew, Clonmannon	7·22	...
,, .	Mull, Benmore	20·40	...	*Carl* .	Hacketstown Rectory..	7·03	180
,, .	Tiree......................	6·58	...	*Leix* .	Blandsfort House.......	8·34	249
Kinr .	Loch Leven Sluice......	6·21	173	,, .	Mountmellick...........	7·57	...
Perth .	Loch Dhu................	14·70	169	*Off'ly* .	Birr Castle	6·16	199
,, .	Balquhidder, Stronvar	11·93	..	*Kild'r*.	Monasterevin	6·42	...
,, .	Crieff, Strathearn Hyd.	8·66	199	*Dubl* .	Dublin, FitzWm. Sq....	3·82	143
,, .	Blair Castle Gardens...	6·40	182	,, .	Balbriggan, Ardgillan.	6·65	231
Angus.	Kettins School..........	5·33	191	*Me'th* .	Beauparc, St. Cloud...	5·60	...
,, .	Dundee, E. Necropolis	4·82	198	,, .	Kells, Headfort.........	6·17	181
,, .	Pearsie House...........	7·45	.	*W.M* .	Moate, Coolatore......	4·51	...
,, .	Montrose, Sunnyside...	5·98	226	,, .	Mullingar, Belvedere...	6·69	196
Aber .	Braemar, Bank.........	6·69	174	*Long* .	Castle Forbes Gdns......	6·03	167
,, .	Logie Coldstone Sch....	3·58	117	*Gal* .	Ballynahinch Castle...	10·83	181
,, .	Aberdeen, King's Coll.	4·39	149	,, .	Galway, Grammar Sch.	5·03	...
,, .	Fyvie Castle	3·45	100	*Mayo* .	Mallaranny............ ...	8·91	...
Moray.	Gordon Castle...........	2·28	79	,, .	Westport House........	9·21	188
,, .	Grantown-on-Spey......	2·24	75	,, .	Delphi Lodge............	17·46	176
Nairn.	Nairn, Delnies	1·47	62	*Sligo* .	Markree Obsy............	6·64	159
Invs .	Ben Alder Lodge	8·60	...	*Cav'n*.	Belturbet, Cloverhill...	4·96	159
,, .	Kingussie, The Birches	3·94	...	*Ferm* .	Enniskillen, Portora...	5·54	...
,, .	Loch Quoich, Loan......	12·75	...	*Arm* .	Armagh Obsy	4·70	166
,, .	Glenquoich	11·96	98	*Down*.	Fofanny Reservoir	14·16	...
,, .	Inverness, Culduthel R.	1·66	...	,, .	Seaforde	7·99	211
,, .	Arisaig, Faire-na-Squir	6·52	...	,, .	Donaghadee, C. Stn....	6·61	217
,, .	Fort William............	11·01	...	,, .	Banbridge, Milltown...	5·07	...
,, .	Skye, Dunvegan.........	8·39	...	*Antr* .	Belfast, Cavehill Rd...	5·88	...
R & C.	Alness, Ardross Cas....	3·12	78	,, .	Glenarm Castle.........	6·86	...
,, .	Ullapool	3·18	60	,, .	Ballymena, Harryville	6·33	156
,, .	Torridon, Bendamph...	...	...	*Lon* .	Londonderry, Creggan	4·45	109
,, .	Achnashellach	5·87	...	*Tyr* .	Omagh, Edenfel.........	4·84	127
,, .	Stornoway	4·88	...	*D.n* .	Malin Head..............	4·86	...
Suth .	Lairg......................	2·14	54	,, .	Dunfanaghy..............	4·66	...
,, .	Tongue	2·04	44	,, .	Killybegs, Rockmount .	6·34	101

Climatological Table for the British Empire, June, 1931.

STATIONS	PRESSURE Mean of Day M.S.L. mb.	PRESSURE Diff. from Normal mb.	TEMPERATURE Absolute Max. °F.	TEMPERATURE Absolute Min. °F.	TEMPERATURE Mean Values Max. °F.	TEMPERATURE Mean Values Min. °F.	TEMPERATURE Mean Values ½ max. and min. °F.	TEMPERATURE Mean Values Diff. from Normal °F	TEMPERATURE Mean Wet Bulb °F.	Relative Humidity %	Mean Cloud Am'nt 0—10	PRECIPITATION Am'nt in.	PRECIPITATION Diff. from Normal in.	PRECIPITATION Days	BRIGHT SUNSHINE Hours per day	BRIGHT SUNSHINE Percentage of possible
London, Kew Obsy.	1017·1	+ 0·4	77	45	68·7	53·1	60·9	+ 1·7	54·5	80	7·8	1·66	— 0·49	10	5·8	35
Gibraltar	1017·0	— 0·4	91	55	82·2	63·6	72·9	+ 2·4	62·3	80	3·8	0·20	— 0·28	4	..	..
Malta	1017·2	+ 2·0	99	62	84·4	70·5	77·5	+ 4·8	69·3	67	2·5	0·04	— 0·05	1	12·5	86
St. Helena	1017·6	+ 1·4	69	55	64·1	57·1	60·6	+ 0·1	58·0	92	8·2	2·51	..	15	..	..
Sierra Leone	1015·1	+ 3·1	90	66	85·2	70·6	77·9	— 2·4	77·6	88	5·8	13·20	— 6·84	25	..	..
Lagos, Nigeria	1011·8	— 1·1	90	71	84·5	74·9	79·7	+ 0·4	76·6	84	9·3	17·73	— 0·92	20	..	..
Kaduna, Nigeria	1014·6	+ 0·8	91	65	88·3	69·5	78·9	+ 2·4	73·4	83	7·3	7·21	— 0·64	16	..	..
Zomba, Nyasaland	1019·3	+ 1·8	77	48	70·0	53·1	61·5	— 1·4	..	67	5·1	0·05	— 0·43	1	..	..
Salisbury, Rhodesia	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..
Cape Town	1024·2	+ 4·1	79	33	63·6	45·6	54·6	— 1·1	46·9	85	4·8	1·18	— 3·32	11	..	..
Johannesburg	1024·8	+ 2·6	68	29	61·8	41·6	51·7	+ 1·0	39·8	38	1·4	0·16	+ 0·02	1	9·6	91
Mauritius	1018·9	— 0·1	81	63	77·7	67·1	72·4	+ 3·0	68·5	72	3·8	2·07	— 0·73	17	8·4	77
Calcutta, Alipore Obsy.	999·9	+ 0·2	102	76	95·3	81·4	88·3	+ 3·2	82·2	87	6·2	6·02	— 5·89	9*	..	..
Bombay	1004·9	+ 0·9	95	75	91·3	81·3	86·3	+ 2·3	79·5	78	6·1	6·08	— 13·79	8*	..	..
Madras	1003·1	— 0·7	108	75	100·4	82·4	91·4	+ 1·4	76·9	59	5·2	3·25	+ 1·28	4*	..	..
Colombo, Ceylon	1009·4	+ 0·8	87	75	85·6	77·6	81·6	0·0	78·1	83	8·8	10·60	+ 3·28	29	5·2	42
Singapore	1009·5	+ 0·6	93	73	88·3	76·9	82·6	+ 0·7	78·3	82	6·8	10·17	+ 3·32	14	6·4	53
Hongkong	1005·6	— 0·4	90	73	85·1	78·3	81·7	+ 0·3	77·7	82	8·6	11·60	— 4·25	18	4·5	33
Sandakan	..	..	92	72	88·8	75·0	81·9	+ 0·2	77·8	82	..	8·25	+ 0·75	15	..	..
Sydney, N.S.W.	1019·9	+ 2·0	80	40	64·3	48·7	56·5	+ 1·8	50·1	77	5·2	2·26	— 2·48	12	5·6	57
Melbourne	1019·1	+ 0·6	61	33	56·5	44·5	50·5	+ 0·1	47·1	85	8·3	3·85	+ 1·79	19	2·3	23
Adelaide	1020·0	+ 0·9	63	38	59·3	47·1	53·2	— 0·3	48·6	79	9·1	5·46	+ 2·36	20	3·0	31
Perth, W. Australia	1020·1	+ 2·1	71	37	60·8	44·8	52·8	— 4·0	48·1	73	4·9	6·54	— 0·40	12	5·7	57
Coolgardie	1020·9	+ 2·0	71	32	59·0	38·9	48·9	— 3·9	44·4	70	5·3	2·71	+ 1·45	9	..	..
Brisbane	1021·7	+ 3·4	79	46	70·9	53·8	62·3	+ 2·1	56·0	75	5·6	0·57	— 2·20	10	6·5	63
Hobart, Tasmania	1015·4	+ 1·1	60	34	52·7	42·6	47·7	+ 0·7	43·5	80	6·6	3·36	+ 1·13	16	3·5	38
Wellington, N.Z.	1016·9	+ 2·0	58	35	51·3	41·8	46·5	— 3·0	44·2	79	6.9	5·71	+ 0·94	17	3·7	40
Suva, Fiji	1015·0	+ 1·4	86	65	79·7	69·6	74·7	0·0	70·8	80	6·7	3·34	— 3·37	17	4·1	37
Apia, Samoa	1011·9	+ 0·3	86	68	83·6	73·3	78·5	+ 0·7	75·6	79	5·8	10·65	+ 5·30	13	6·5	58
Kingston, Jamaica	1013·0	— 0·8	93	71	89·3	75·1	82·2	+ 0·9	74·4	81	6·6	2·78	— 1·32	12	5·5	42
Grenada, W.I.	1013·3	0·0	89	70	85·8	72·8	79·3	+ 0·3	72·9	75	7·5	12·93	+ 4·68	28	..	..
Toronto	1015·4	+ 0·7	91	43	75·7	56·1	65·9	+ 2·1	60·1	71	4·3	2·16	— 0·50	8	9·1	59
Winnipeg	1009·6	— 2·2	87	37	74·8	53·3	64·1	+ 1·8	54·1	77	4·7	2·55	— 0·56	11	9·1	56
St. John, N.B.	1014·3	+ 0·8	87	37	67·0	50·9	58·9	+ 2·4	54·8	85	8·0	2·46	— 0·81	10	6·7	43
Victoria, B.C.	1017·2	+ 0·4	82	45	63·9	49·4	56·7	— 0·3	52·3	75	6·1	0·66	— 0·18	6	9·1	57

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

SOLAR HALO. LEUCHARS, (FIFESHIRE) NOVEMBER 16TH. 1931, 14h. (see p. 290).

M.O. 339.

The Meteorological Magazine

Vol. 66

Jan., 1932

No. 792

Air Ministry :: Meteorological Office

LONDON: PUBLISHED BY HIS MAJESTY'S STATIONERY OFFICE

To be purchased directly from H.M. STATIONERY OFFICE at the following addresses: ADASTRAL HOUSE, KINGSWAY, LONDON, W.C.2; 120, GEORGE STREET, EDINBURGH; YORK STREET, MANCHESTER; 1, ST. ANDREW'S CRESCENT, CARDIFF; 15, DONEGALL SQUARE WEST, BELFAST; or through any Bookseller.

A note on Alto-Cumulus Cloud

By C. S. DURST, B.A.

Alto-cumulus cloud is formed at a height far above the limit of the normal convection due to the heating of the air by contact with the ground. That the cloudlets are due to convection in a comparatively shallow unstable layer of the atmosphere has long been suspected and recently in the work of S. Mal* has been fairly definitely established. But for that shallow layer to persist without degenerating into neutral equilibrium demands that there should be (i) some source of heat below and cold above, or (ii) a rising of the whole layer in which convection is taking place (with a discontinuity in the water content above and below the convection layer), or (iii) the continuous introduction of a (potentially) colder stream of air over a warmer.

I.

The first alternative is the simplest, since on a clear night the radiation from the earth and the atmosphere below the cloud layer will be greater than the radiation flowing from the cloud's lower surface, while the cloud's upper surface will be giving out more radiation to space than it receives from the atmosphere above the cloud layer. The same argument, however, does not necessarily apply during daylight hours, since then insolation may be taking place on the upper surface of the cloud. At a meeting of the Royal Meteorological Society when Sir Gilbert

Beitr. Physik. Atmosph. Leipzig, 17, 1930, pp. 40-68.

(96957) 107/27 1,075 1/32 M. & S. *Gp.303*

Walker's paper on Mal's work* was being discussed, Col. Gold suggested that it was probable on these grounds that there was a definite diurnal variation in the frequency of alto-cumulus cloud. It is, however, remarkable that the observations made by Russell† do not support this expectation. His figures (for the whole year) show a maximum frequency of 8·0 per cent in the occurrence of alto-cumulus at 9 a.m. followed by a decrease to 4·8 per cent at 2 p.m. and after a slight increase between 3 p.m. and 7 p.m. a decrease to a minimum of only 0·7 per cent at 1 a.m. and 2 a.m. The frequency of cirro-cumulus, it is interesting to note, also follows almost the same curve.

In the obtaining of frequencies of occurrence of the higher clouds such as Russell attempted there are two grave difficulties, (*a*) on many occasions the higher cloud is hidden by lower cloud. This will throw out statistics of the diurnal frequency of the upper cloud if there is a pronounced diurnal variation of the amount of low cloud, (*b*) on a dark night it is practically impossible to assign a classification to upper cloud, and, especially when not near the zenith, it may even go unobserved. The first difficulty may be in part overcome if instead of the frequency of occurrence there is obtained the amount of sky covered. Since the amount of low cloud can be observed it is easy to obtain the proportion of the remaining sky which is covered by the particular type of higher cloud.

Observations made at Cardington for January, April, July and October of three years were treated in this way, with the result shown below :—

PERCENTAGE OF SKY (UNCOVERED BY LOW CLOUD) COVERED WITH ALTO-CUMULUS CLOUD.

Hour G.M.T.	7h.	10h.	13h.	16h.	18h.	21h.	Mean Sunset Hour G.M.T.
January	(5)	10	10	14	(8)	(5)	16h. 17m.
April	9	9	7	8	11	(3)	18h. 54m.
July	10	12	11	10	14	(9)	20h. 8m.
October	11	8	9	9	(9)	(5)	17h. 7m.

The figures in brackets in this table refer to observations made after sundown and show how the apparent extent of the alto-cumulus cloud decreases after sundown. The daylight figures are in general corroboration of those of Russell in showing a tendency to a minimum during the afternoon.

The second difficulty mentioned above can be dealt with by the selection of dates, for, at seasons of full moon, the character of

*London, *Q.J.R. Meteor Soc.* 57, 1931, p. 413.
†London, *Q.J.R. Meteor. Soc.* 39, 1914, p. 271.

high cloud can be distinguished almost as easily by night as by day. There were unfortunately not a sufficient number of night observations made at Cardington for the Cardington data to be used, so recourse was made to the telegraphic reports of the *Daily Weather Report*. The years 1928 and 1929 were used and on days of full moon as well as two days before and two days after the amount of sky predominantly covered by alto-cumulus cloud at Cranwell, Croydon and Lympne was extracted for the hours 1h. and 13h. G.M.T. The results are shown in the table below :—

PERCENTAGE OF SKY (UNCOVERED BY LOW CLOUD) COVERED WITH ALTO-CUMULUS CLOUD.

Month Hour G.M.T.	D.J.F.	M.A.M.	J.J.A.	S.O.N.	Year
1h.	13	8	14	11	12
13h.	5	4	3	5	4

It should be noted that in this table the figures are based on the occasions when alto-cumulus cloud is reported, though it may be present on other occasions when it is not the predominant cloud. It is quite clear from this table that from two to four times as much alto-cumulus cloud is present by night as by day and that the apparent minimum which Russell found at night may be attributed to the invisibility of the cloud rather than to its absence.

The monthly variation obtained by Russell ranged from a percentage frequency of 6·1 in September to 2·6 in July. The figures for the seasons being :—

PERCENTAGE FREQUENCY OF OBSERVATIONS OF ALTO-CUMULUS CLOUD.

D.J.F.	M.A.M.	J.J.A.	S.O.N.
5·1	3·9	3·5	5·8

which follows closely the same course as the percentage of sky covered at 13h. in the last table. The seasonal variation of the percentage of sky covered at 1h. does not, however, follow the same definite seasonal variation.

It may be concluded then that radiation plays an important part in the formation of alto-cumulus cloud, and that even in the cases in which the cloud is not due to this cause the intensity of the solar radiation dissipates the cloud as is shown by the smaller extent of alto-cumulus cloud by day in summer than in winter.

II.

It is of interest to see if any quantitative values can be assigned to the radiation received by cloud at the height of alto-cumulus and if such values show that radiation is sufficiently potent to play this rôle. The simplest case will be taken, namely, a limited sheet of alto-cumulus cloud at night at a height of 5 Km. above the earth's surface, the temperature of the air at that height being assumed to be 255°A. and the earth's temperature 282°A.; there are assumed to be no other clouds in the sky.

In fig. 1 is given a diagram showing the radiation which has to be considered. It is first to be noticed that any radiation which passes the level of the cloud (which is assumed to be of small area) and is then scattered and reflected, will pass the cloud level in both directions, and so need not be taken into account (item **e**).

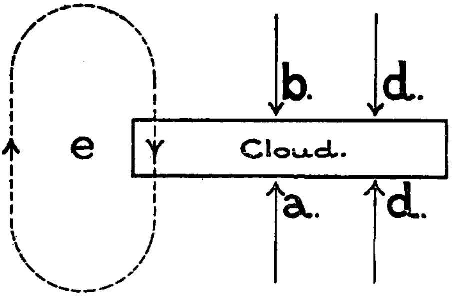

FIG. 1.—NOTE—The arrows marked **d** should be pointing away from the cloud.

Item **a** represents the flux of long-wave radiation emitted from the earth and its atmosphere below the cloud. Item **b** represents the flux of long-wave radiation emitted from the earth's atmosphere above the cloud. Item **d** represents the radiation emitted by the cloud, which is the same both upwards and downwards. The computation of these values may be made on the lines adopted by Simpson in his paper on terrestrial radiation.*

This computation was made, the earth's temperature being assumed to be 282°A. and the cloud being assumed to absorb and emit radiation as a black body, at a temperature of 255°A. The conclusion reached was that the excess of long-wave radiation falling on the lower surface of the cloud over that falling on the upper surface (item **a**—item **b**) would be not less than 0·15 cal/cm²/min. or 30 per cent of the black body radiation at 282°A.

It is not known how much of this radiation is absorbed by the surface of the cloud and how much transmitted into the interior or even through the whole cloud. Water is a very powerful absorber of long-wave radiation, however (Shaw† states that it lacks but 4·4 per cent. of radiating and absorbing as much as a perfect radiator), so that it is possible, if the cloud is of the right texture to absorb the available radiation, the amount absorbed on the lower surface will be of the order of 0·10 cal/cm²/min. in excess of that absorbed on the upper surface.

If we consider the temperature in a column of ascending air in a cloud layer, it is seen that if v is the velocity averaged over the whole of the ascending column, and $\frac{\delta T}{\delta z}$ is the upward vertical gradient of potential temperature, the upward flux of heat across any plane is approximately $-\rho\sigma v \frac{\delta T}{\delta z} dt$ in time dt, (ρ being the density and σ the specific heat). This has to be counter-balanced by a (cooling or) warming at the bottom and

London, Mem. R. Met. Soc., Vol. III., No. 21.

†*Manual of Meteorology*, Part III., p. 157.

a (warming or) cooling at the top which may be called $\rho\sigma \frac{\delta T'}{\delta t} dt$

Hence we get the relation

$$v = -\frac{\delta T'}{\delta t} \Big/ \frac{\delta T}{\delta z} \quad \text{.........................(i)}$$

Now if h is the thickness of the cloud, a formula due to Rayleigh* gives the relation for stability in the cloud. This formula is

$$\frac{\rho_2 - \rho_1}{\rho_1} < \frac{27\pi^4 \kappa\nu}{4gh^3} \quad \text{.....................(ii)}$$

where ρ_1 and ρ_2 are densities at the top and bottom of the cloud, κ the coefficient of thermal conduction and ν the coefficient of viscosity.

For stability in a thin layer this may be thrown into the form

$$\left|\frac{\delta T}{\delta z}\right| > \frac{27\,\pi^4\,\kappa\nu\,T'}{4gh^4} \quad \text{....................(iii)}$$

where T′ is the temperature.

Moreover, let R_1 be the net flow between incoming and outgoing radiation absorbed in the upper surface of the layer and R_2 be the net flow absorbed in the lower surface of the layer.

Then $$\rho\sigma \frac{\delta T'}{\delta t}\frac{h}{2} dxdydt = \frac{R_1 + R_2}{2} dxdydt \quad \text{..............(iv)}$$

or $$\frac{\delta T'}{\delta t} = \frac{R_1 + R_2}{h\rho\sigma} \quad \text{.........................(v)}$$

Substituting in (i) from (iii) and (v) the value of v for critical values of temperature gradient is

$$v = \frac{(R_1 + R_2)\, 4gh^3}{27\pi^4\kappa\nu T'\rho\sigma} \quad \text{.....................(vi)}$$

If T′ is 255°, $\rho = 5{\cdot}9 \times 10^{-4}$ and $R_1 + R_2$ is assumed to be 0·1 calories per square centimetre per minute, and if h is assumed to be of the order of 50 metres which is in accordance with Mal's† observations, then $$v = \frac{1{\cdot}2 \times 10^8}{\kappa\nu} \text{ m/s} \quad \text{....................(vii)}$$

The values to be assigned to the coefficient of thermal conductivity and to the coefficient of turbulence at such heights are not known, but near the earth's surface they are both of the order of 10^4 (though at height of 5 Km. or so they probably are less than that value). Hence v would appear to be of a magnitude that is not unreasonable, though it must be recognised that the value of v increases rapidly with increase of h. At the same

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**Phil. Mag., London*, XXXII, 1916. p. 529.

†*London, Q.J.R. Meteor. Soc.*, 57, 1931, p. 413. This is, however, probably a low estimate, as Gregg in "Aeronautical Meteorology" gives 120 metres, and Hann in "Lehrbuch de Meteorologie" gives 194 metres as the average thickness.

time any diminution of the amount of radiation absorbed (*e.g.*, by reflection) would decrease the value of v.

Hence it may be considered that the hypothesis of alto-cumulus cloud being due to radiation is not contradicted by the magnitudes of the quantities involved.

III.

In the computation above it has been assumed that no radiation is being received from the sun. The amount of short-wave radiation reflected by clouds is known to be high but until considerably more accurate quantitative values are known for the coefficient of reflection, it is not possible to say how far radiation can be accountable for the formation of alto-cumulus cloud by day.

An Example of the use of Percentiles in Climatology

By H. Jameson, B.Sc.

The extreme values of meteorological factors already observed at a station are frequently tabulated, as an indication of the extreme values likely to be observed in the future. "Likely," however, is an indefinite term, and it is desirable to give some indication of the frequency of outstanding values.

For this purpose, the statistical method of percentiles,* applied to tables of the maximum values observed in each of a number of years, seems advantageous. As an example, the highest daily rainfall in each calendar year is usually tabulated among the records of a rainfall station. If the figures of such a table are ranked in order of magnitude, then a number which has 10 per cent of these figures, and 90 per cent less than it, is the highest decile. It may also be more usefully defined as a value of daily rainfall that will probably not be exceeded in more than one year out of ten. It is, of course, usually indeterminate within limits, and must be computed according to an arbitrary definition, but if the table is of reasonable length, the possible error is not serious. Similarly, the upper quartile and the median are unlikely to be exceeded in more than one year in four, and one year in two, respectively.

These figures will be referred to as the decile, quartile, and median maximum, respectively.

For all Ceylon stations, having, to the end of 1930, at least 40 years' records (40-62 years), from the tables of maximum daily rainfall each year the decile, quartile and median maxima have been computed and plotted as rainfall maps.

These give fairly smooth contours. The decile maxima are shown in the map. Although only stations with at least 40 years

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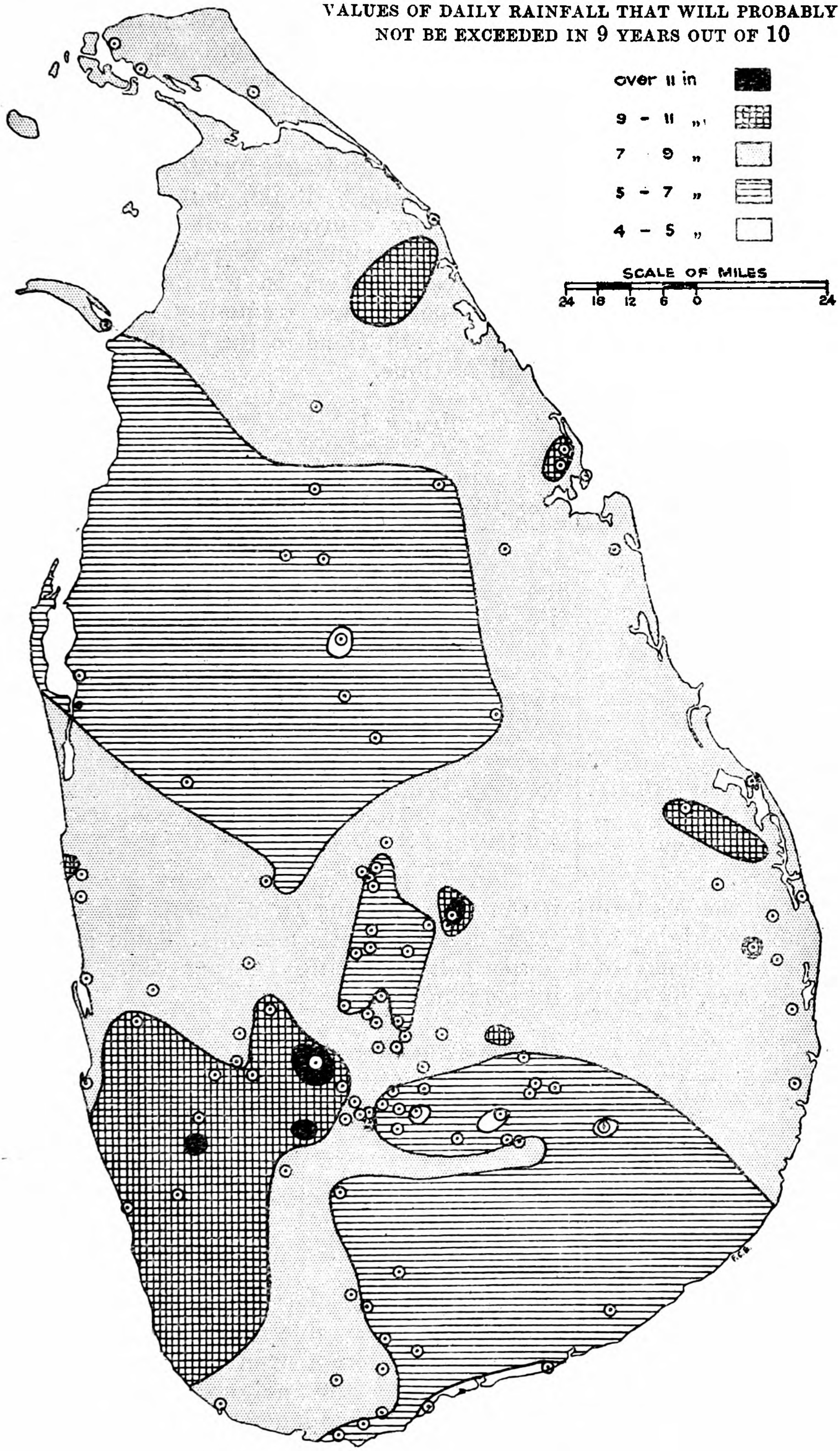
*See, for example Yule's "Introduction to the Theory of Statistics."

VALUES OF DAILY RAINFALL THAT WILL PROBABLY NOT BE EXCEEDED IN 9 YEARS OUT OF 10



of records are shown on this map, shorter records have been used with judgment as a guide in drawing the contours, where sufficient long period records are not available. The quartile and median maxima give contours of approximately the same shape, but, of course, with lower values.

Ceylon records are not long enough to give reasonably accurate percentiles higher than the highest decile, but some further information can be obtained by expressing all figures in any table, greater than the decile maximum, as percentages of it, and taking these percentages together, in groups of stations. The table below shows the percentage frequency of such percentages, grouped as follows:—Stations to the south-west of the island; other stations; all stations.

TABLE I.

Group	100% – 110%	110 -120	120 -130	130 -140	140 150	150 -160	160 -170	170 -180	180 -190
South-west stations	40·5	20·4	17·3	10·1	4·3	2·3	2·1	0·6	1·6
Other stations ...	34·5	19·1	15·7	9·2	5·7	5·4	0·7	2·2	2·2
All stations... ...	37·3	19·7	16·4	9·6	5·1	3·9	1·3	1·4	1·9

Group	190 -200	200 -210	210 -220	220 -230	230 -240	240 -250	250 -260	260 -270	over 270%
South-west stations	0·4	0·4	0	0	0	0	0	0	0
Other stations ...	1·4	0·7	0·7	0·4	0·2	0·2	0·9	0·5	0·4
All stations... ...	1·0	0·6	0·4	0·2	0·1	0·1	0·5	0·3	0·2

On the assumption that all stations in a group are equally liable to high percentages of their decile maxima, Table II shows the expectancy of a daily fall exceeding 110 per cent, 120 per cent, &c., of the decile maximum.

TABLE II.

Group		110%	120%	130%	140%	150%
South-west stations...	One year in	17	26	46	85	135
Other stations	,, ,, ,,	15	22	33	47	63
All stations	,, ,, ,,	16	23	38	59	84

From a consideration in detail of the figures from different stations, this assumption seems reasonable over the greater part of the south-west of the island, though even there certain districts, the Kegalle district and the neighbourhood of the Ginigathena Pass, show a greater tendency to unusually high rainfalls. Data from the rest of the island are much more scanty in proportion to area, but the liability to abnormal rainfall is certainly greater there than in the south-west, and this greater liability seems to be distinctly concentrated in certain areas, *e.g.*, the Mullaittivu district and the northern slopes of the hills. Eliminating all figures from such districts, both in the south-west of the island and elsewhere, the expectancy of a daily fall exceeding 110 per cent, 120 per cent, &c., of the decile maximum becomes as shown in Table III.

TABLE III.

Group		110%	120%	130%	140%	150%
South-west stations...	One year in	17	26	47	97	152
Other stations	,, ,, ,,	16	25	42	82	133
All stations	,, ,, ,,	16	25	45	89	141

From the figures of Tables II and III the following rule would seem to be a reasonable extension of the idea of the decile maximum, for Ceylon.

"If the records of a district do not show an unusual number of abnormal falls, increases of 10 per cent, 20 per cent and 30 per cent in the decile maximum of any station will give figures for daily rainfall that are not likely to be exceeded in more than one year in 16, 25 and 45 respectively."

Table I shows a fairly regular decrease of frequency with increase of rainfall till 170 per cent of the decile maximum is reached, but frequencies beyond this are higher than might be expected. This phenomenon seems analogous to that found in the theory of errors, that the number of large errors found exceeds that given by theory, and, like it, probably indicates some cause of an abnormal character. Rainfalls between 100 per cent and 170 per cent of the decile maximum might therefore be termed exceptional, and those above 170 per cent abnormal. At the 109 stations, with records between 40 and 62 years, that appear on the map, 34 such abnormal falls were recorded, from 28 stations. These were booked as occurring on 26 different days, though, owing to the possibility of misdating rainfalls, this figure might have to be reduced to 23, of which two were consecutive. While some of these figures might be spurious, owing to observers' mistakes, corresponding figures from the same 109 stations for the last 20 years (1911-30), which have been under much more careful supervision than the earlier records, are 15 falls, from 14 stations, on 10 separate days (two consecutive), giving a frequency of about the same order of magnitude.

Nearly all these abnormal falls occurred between October and January (principally in December), and in May.

Discussions at the Meteorological Office

The subjects for discussion for the next three meetings will be :—

January 18th, 1932.—*Geophysical evidence in support of changes in solar radiation.* By J. Bartels (Ergeb. exakt. Naturwiss., Berlin, 9, 1930, pp. 38-78) (in German). *Opener*—Prof. S. Chapman, F.R.S.

February 1st, 1932.—*Investigations concerning the variations of the general circulation.* By A. Wagner (Geog. Ann., Stockholm, 11, 1929, pp. 33-88) (in German). *Opener*—Dr. C. E. P. Brooks.

February 15th, 1932.—*Synoptic-aerological investigations on cold fronts.* By E. Palmén (Beitr. Geophysik, Leipzig, 32, 1931, pp. 158-172) (in German). *Opener*—Mr. R. Corless, M.A.

Royal Meteorological Society

The monthly meeting of this Society was held on Wednesday, December 16th, in the Society's Rooms, at 49, Cromwell Road, South Kensington, Mr. R. G. K. Lempfert, M.A., F.Inst.P., President, in the Chair.

W. C. Kaye, B.Sc., and C. S. Durst, B.A.—Some examples of the development of depressions which affect the Atlantic.

Three typical cases are examined of the development of families of depressions over North America and its eastern seaboard. These show examples of :—

(1) a polar depression being intensified by the introduction of warm air from the Gulf of Mexico;

(2) the formation of a family of depressions between Pacific maritime polar air and warm Gulf air;

(3) the formation of depressions on a quasi-stationary front.

It is suggested that a majority of the families of depressions which cross the Atlantic originate in one or other of these ways.

Alfred A. Barnes, Assoc.M.Inst.C.E.—(a) *Rain-gaugings near Belper and Duffield, Derbyshire;* (b) *Rainfall reviewed: A common long-average period for each country of the British Isles.*

(*a*) This paper represents a complete analysis of the yearly readings taken at 19 rain gauges at the southern end of the Pennine Chain during a period of 66 years from 1865 to 1930 inclusive. All annual records are quoted, the long-average rainfall at each gauge is established, and the percentage relation to the individual long-average is given at each gauge for every year. In addition, a complete table is presented which accumulates these percentages on a common basis, thus illustrating the correct continuity of all the readings and producing one standard gauge for the district over the 66 years. A symmetrical residual-mass percentage curve is shown, which proves that the 44-year period 1865 to 1908 inclusive correctly balances the wet and dry years. This period has therefore been adopted for the long-averages. A later short period of 35 years, 1891 to 1925 inclusive, is found, giving a result which is practically identical with the basic normal, and which may therefore be used in this district for long-averages in the future.

(*b*) This review forms a new survey of the annual rainfall over England and Wales, Scotland, Ireland and the British Isles as a whole, during a period of 68 years from 1863 to 1930 inclusive. The rainfall of each country is tabulated—the annual figures being based upon the percentages given in the *Rainfall Atlas*—and the residual-mass tables and diagrams show a remarkable symmetry about the end of the year 1908. The period of 44 years 1887 to 1930 inclusive is shown by three methods to give the true normal rainfall for each country, and on this common basis a complete comparison is deduced for 34 overlapping periods of 35 years. The presentation of these last-named values in the form of 4 superimposed curves proves that the 35-year period 1891 to 1925 also gives a correct long-average for each country. The writer accepts the recognised annual figures for the individual countries, and the result of his review is to place a higher value on the normal for each country as follows:—

	1881-1915.	1887-1930.
England and Wales ...	35·23 inches.	35·65 inches.
Scotland	50·32 ,,	51·41 ,,
Ireland	43·30 ,,	43·96 ,,
British Isles	41·41 ,,	41·81 ,,

W. H. Pick, B.A., F.Inst.P.—***Visibility with saturated air.***

This paper examines for two stations, Worthy Down and Felixstowe, over a period of 4 years, the horizontal visibilities which occurred whenever the air was saturated, and shows that all degrees of visibility (except the very best) were well represented. Especially it is shown that a large percentage of the cases of saturated air were unaccompanied by either fog or mist. The effect of wind force upon the visibility accompanying saturated air is also examined.

Correspondence

To the Editor, *The Meteorological Magazine.*

Fog, Friday, December 18th

The following may be of some interest. Morning, thick fog and hoar frost. Fair and sunny midday. Wind light—NE. Afternoon and evening, blinding fog, which made the eyes run with water, and smelling strongly of soot. My brother and I, after pedal-cycling through fog during the evening, returned home with complexions and clothes the colour of nigger minstrels. Traffic was chaotic. Next morning trees, vegetation, telegraph wires and clothes lines were an inch thick with dirty black frost. Cabbages, &c., were filthy and had to receive many ablutions.

The evening fog drifted from north-west and visibility was at times less than three feet. F. CLAUDE BANKS.

Market Gardens, Horndon-on-the-Hill, Essex. December 28th, 1931.

Gale on December 23rd, 1931

At 9h., using my anemometer (or rather small air meter) as a check, I estimated the force of the wind as 12, velocity = 80 m.p.h. at least. It was difficult to make a correct estimate as I had to cling to a paling post to keep steady. Some structural damage was done; a brick chimney was blown down, some roofs of outhouses lifted clean off and others shifted. I heard of some elderly people being blown down, but no one on this island seems to have been hurt. The gale lasted for about 15 hours. During some of the gusts my car was actually blown to a standstill. (Car, a 23 h.p. Ford.)

T. EDMONSTON SAXBY.

Baltasound, Kirkwall, Orkney.

Sunless Periods

Dr. C. C. Vigurs has sent the following records of sunless periods of 6 or more consecutive days in 39 years at Newquay, Cornwall :—

WET DAYS.

1893, January 3rd-10th, 8 days, rain 0·85 in. cool.

1910, November 22nd-27th, 6 days, rain 1·27 in., temperature normal.

1912, December 22nd-28th, 7 days, rain 2·58 in., warm.

1918, November 28th-December 4th, 7 days, rain 1·45 in., mild.

DRY DAYS.

1898, January 24th-February 1st, 9 days; January 24th-31st, rainless; February 1st, 0·11 in., pressure high, mild, lowest minima 41°F.

1917, November 17th-23rd, 7 days, rain 0·01 in. on the 19th, 0·06 in. on the 23rd, pressure high, temperature normal (a minimum of 51°F) from the 20th -23rd.

1926, December 9th-14th, 6 days, rain 0·04 in., pressure high, temperature normal.

1931, December 10th-15th, 6 days, rain 0·01 in., pressure high, temperature normal.

Loss of Human Life in Blizzards in Cornwall

The great snowfall of December, 1630, in Cornwall referred to by Mr. Fox in the *Meteorological Magazine* for December, 1931, was also noted by Dr. Vigurs in the issue for December, 1924

(p. 261). In reply to Mr. Fox's query about other instances of loss of human life in blizzards in Cornwall, I find on referring to the "Blizzard in the West, March, 1891," a little book now out of print (see *Meteorological Magazine*, April, 1927), that persons were found lying dead in the snow or buried in drifts near Penzance, Newquay, Redruth and Padstow. In each case the victims had lost their way in the storm and were overwhelmed, the accounts answering to their having been "drowned" in the snow as in 1630. L. C. W. BONACINA.

27, Tanza Road, Hampstead. December 26th, 1931.

NOTES AND QUERIES

Remarkable Coloured Halos

The remarkable halo complex observed by Mr. W. F. A. Ellison on September 4th, 1931, at the Observatory, Armagh, and described in the *Meteorological Magazine* for October, 1931, p. 210, was also seen by Mr. Patrick L. J. Heron, of Castleroe, Coleraine, Co. Derry. Mr. Heron saw the halos across the waters of Lough Beg, Toome, Co. Antrim, between 5 and 6 p.m The weather at the time was fine but hazy with a cold north wind. At about 5.30 p.m., when the sun was 15° above the horizon, according to Mr. Heron's sketch, reproduced in fig. 1, the

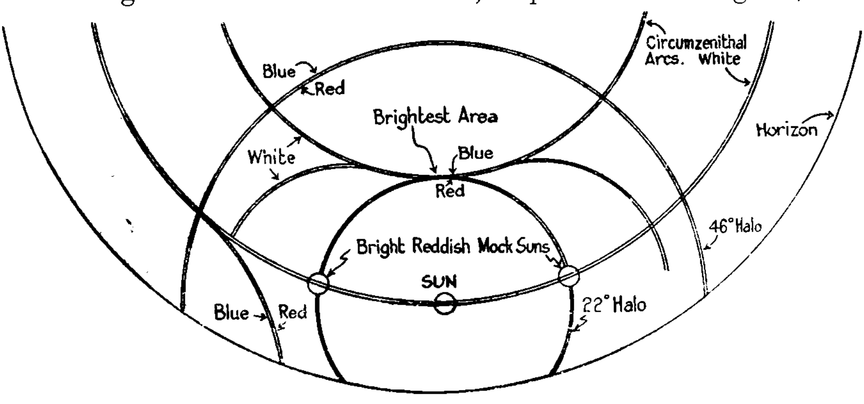


FIG. 1.

complex showed a white halo of 22°, with the mock sun ring and bright reddish mock suns on either side. Above this the upper arc of contact was visible, with a brilliant parhelion at the point of contact. The sketch also shows a circumzenithal arc tangential to the upper surface of the 22° halo. The halo of 46° was present and showed prismatic colours, while on the left-hand side of this arc a short coloured arc convex to the sun extended from at or near the point of intersection with the mock sun ring obliquely downwards towards the base of the 22° halo. This arc was most brilliant in its middle and lower parts.

The phenomena agree with those seen by Mr. Ellison, with, in addition, the mock sun ring, the upper circumzenithal arc and the small oblique arc on the left. The two latter features are most unusual; the upper circumzenithal arc resembles one observed by Lambert on January 24th, 1838, in Wetzlar, and reproduced as fig. 97 in the second edition of Pernter and Exner's "Meteorologische Optik."

The small arc on the left descending from the point of intersection of the mock sun ring and the halo of 46° was observed in a halo complex in South Finland on March 10th, 1920.* Only two of ten observers in Finland noted this peculiarity, of whom one saw the arc in the same position as Mr. Heron, while the other some distance off recorded a similar arc in an almost corresponding position to the right of the sun. The sketch made by the former of these two observers bears a remarkably close resemblance to Mr. Heron's. The altitude of the sun at the time was 22°. Johansson remarks that this arc had not previously been described.

The whole complex must be one of the most remarkable and complete ever observed in these islands, and our thanks are due to Mr. Ellison and Mr. Heron for calling attention to it.

Solar Halo observed at Leuchars

An abnormally bright solar halo of 22° radius was observed at Leuchars on November 16th, 1931. At 12h. 50m. cirrus cloud began spreading over the sky from the north-west, and by 13h. 30m. the sky was almost completely covered, the cloud appearing to be abnormally thick vertically, judging by its very grey appearance. This gave rise to the bright halo, which was easily distinguishable with the naked eye. The colours, however, were not brilliant. At 14h., when the photograph forming the frontispiece to this number of the magazine was taken, the complete ring, with an upper arc of contact, was visible, though in order to save blurring by the sun, the plate was exposed behind a hangar. The halo persisted with decreasing brilliancy until 15h. 40m., when the sun had sunk so low that only the upper part of the halo was visible. It is probably only a coincidence that the 18th was the wettest November day recorded at Leuchars.

High Upper Air Temperature

A very large temperature inversion was observed at Duxford (near Cambridge) at 9h. on January 4th, 1932, the readings being 37·5°F. at 3,500 feet and 53°F. at 5,000 feet, the latter figure being 28°F. above the January normal. Comparison may be made with December 30th, 1926, when there was an inversion

*Helsingfors. *Acta Soc. Sci. Fenn.*, 50, No. 1, 1920. Die ausserordentliche Haloerscheinung am 10 Marz, 1920, in Sud-Finnland, by O. V. Johansson.

of 18°F. and a reading of 52°F. at 5,500 feet.* This was the highest temperature recorded at that level in the British Isles during the period December to April, the season of low upper air temperature. The recent example creates a new record at 5,000 feet, but at greater heights the temperature was slightly lower than in the earlier case. On both days the synoptic situation was the northern boundary of an anticyclone, and the relative humidity was low above the inversion, so that dynamical warming due to subsidence had evidently played its part, in addition to the source of the air.

At 5,000 feet there was a rise of temperature amounting to 40°F. during the four days ending on the morning of January 4th, while at 20,000 feet there was a rise of 36°F. in five days, the rise commencing a day earlier. Most of the change may be attributed to the replacement of polar air by tropical air. Probably the greater part of the rise had taken place by January 2nd, but there was no observation till the 4th.

C. K. M. DOUGLAS.

Exhibition by the Royal Meteorological Society at the Science Museum

An exhibition, which has been arranged by the Royal Meteorological Society, is being held in the Geophysical Gallery of the Science Museum, by permission of the Director, Sir Henry Lyons. The exhibition was formally opened on January 11th, when Mr. R. G. K. Lempfert, President of the Society, took the Chair at an inaugural address by Sir Napier Shaw. The exhibits include modern types of observing instruments approved by the Meteorological Office, such as the latest type of thermometer screen with steel stand, equipped with sheath thermometers, the "octapent" mountain rain-gauge and a stream-lined wind-vane which embodies a number of new features. These are lent by the Director, who is also showing a series of instruments illustrating the history of the sunshine recorder, culminating in the latest type Mark II with adjustments for level and azimuth, and several historical meteorological instruments of various types. Stands of instruments of special interest are shown by some of the leading British makers, including a new form of automatic pollution gauge and examples of "distant-reading" thermometers. Another case illustrates the development of lightning conductors and there are a few examples of meteorolgical work in schools. Another feature is a magnificent collection of cloud photographs, including a series arranged by Sir Gilbert Walker to illustrate recent work on the artificial production of cloud forms. The exhibition will be open until February 10th.

In connexion with the exhibition a series of lectures is being

* See *Meteorological Magazine* 61, 1926, p. 291.

given on Thursdays at 4.30 p.m. in the public lecture theatre. On January 14th Mr. D. Brunt described the influence of meteorology on history. The remaining lectures are as follows :—

January 21st.—Dr. G. C. Simpson, F.R.S., on "Weather forecasting."

January 28th.—Capt. C. J. P. Cave, on "Clouds."

February 4th.—Sir Henry Lyons, F.R.S., on "Historic Meteorological Instruments."

The Rainfall of 1931

The year 1931 continued the remarkable run of wet years which set in about 1922. General values for the rainfall of 1931, expressed as percentages of the average, 1881 to 1915, are:— England and Wales 108, Scotland 104, Ireland 109, British Isles 107. The accumulated excess over the British Isles during the last 10 years has amounted to 97 per cent., so that in that period we have received practically as much rain as falls on the average in 11 years. Over the country generally 1931 was not as wet as any of the recent years 1930, 1928, 1927, 1924 or 1923, while in Scotland only two of the previous eight years were drier.

The rainfall over the country as a whole was below the average in only three months, viz., March, October and December. The rainfall of each of the six summer months, April to September, exceeded the average, the total excess during this period amounting to 5·7 in. Practically the whole of this excess was confined to the four months, April to July, and the rainfall of these months exceeded that of any other April to July since before 1870. November was the wettest month of the year, with 6·4 in., and the total rainfall equalled that of the whole of March, October and December. July and June were the next wettest months with 4·6 in. and 4·4 in. respectively, and August and January were nearly as wet.

General values for each month are set out in the table below, as percentages of the average for the period 1881 to 1915 :—

	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
	%	%	%	%	%	%	%	%	%	%	%	%
England and Wales	103	124	36	173	150	148	153	143	123	32	143	45
Scotland	128	118	42	106	145	193	136	61	55	82	143	81
Ireland	88	104	101	111	162	174	121	81	101	56	192	66
British Isles	107	118	51	143	151	165	142	104	102	49	153	57

Among the more striking features of the rainfall of 1931, mention may be made of the following incidents. The thunderstorm rains of May 27th-28th gave as much as 4·18 in. at

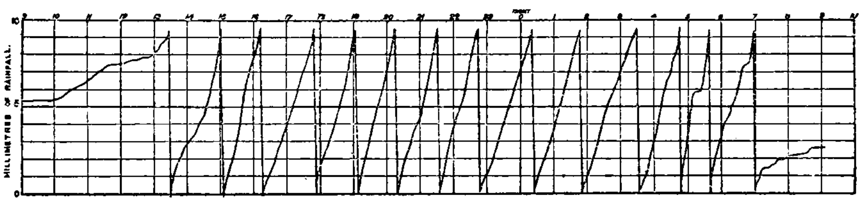
Cardiff, of which 3·60 in. fell in 3½ hours. The last occasion on which so much rain fell in a day in Cardiff was July 14th, 1875. The tornado of June 14th, which caused devastation in Birmingham, was also accompanied by heavy rain in certain localities. The weather of August was characterised by an extraordinary series of violent storms, of which in south-west London those of the 5th and 14th were most striking. On the former occasion 0·88 in. fell in 25 minutes at Merton Park and on the latter 2·34 in. during a few hours at Worcester Park. The rainfall of September 3rd was remarkable in that 4·97 in. was recorded at Kildale Hall, in the north Yorkshire Wolds, the same station which recorded 11·04 in. during the persistent cyclonic rains of July 20th-23rd, 1930. Perhaps the most striking rains of the year were those of November 2nd and 3rd, which were not only widespread but gave as much as 8·65 in. at Patterdale in the English Lake District and 9·61 in. at Blaenauhydfer to the north of the Black Mountains.

In each country less than the average rainfall was recorded at many stations. These were most numerous in the north-west of Scotland and the south-east of England, while less than the average was also recorded in the south-west of Ireland, along the north-east coast of England and in Anglesey. Deficiencies occurred over most of Scotland to the north-west of a line drawn from Arran to Elgin, but excluding most of Sutherland and Caithness. In London the rainfall was slightly above the average, though less than the average occurred both to the north and to the south, the latter area including most of the south coast from Margate to Weymouth. Less than the average also occurred near Louth in Lincolnshire and from Morpeth to Berwick-on-Tweed. The areas with the largest excesses occurred in the central portion of England and Wales. There was more than 120 per cent. over a large area stretching from Barmouth and Birmingham in the south-west, to Hull and Middlesbrough in the north-east. More than 120 per cent. was also recorded over small areas in central and eastern Ireland and in the Isle of Man. Small areas in the neighbourhood of Manchester, Barnsley and Goole received rather more than 130 per cent. of the average. In most parts of the British Isles the rainfall was therefore fairly close to the average. The main features of the distribution of the rainfall of 1931 was the area across the southern Pennines with a rainfall markedly in excess of the average. This was mainly due to the unusual prevalence of cyclonic rains, especially in the summer months. The more congenial weather in the north-west of Scotland during the late summer and autumn stands out in marked contrast. The dry October and December in the south-east of England were mainly responsible for the small annual totals in that region.

J. GLASSPOOLE.

Rainfall at Princetown, November 3rd-4th, 1931

In the article on *The Abnormal Weather of November*, 1931, in the December number of this magazine, details are given of the unusually heavy rain of November 2nd and 3rd, at certain stations in the mountainous areas of the west of England and Wales. A copy of the trace from the recording rain-gauge at Princetown Prison on Dartmoor for the "rainfall day" of the 3rd is reproduced. The amounts recorded at this station for



the 2nd and 3rd were 0·80 in. and 5·39 in. The gauge was not apparently in perfect adjustment as the pen-arm has not risen to the top of the chart. The amount recorded by the check gauge alongside is, however, in close accord with that shown by the chart if each ascent is taken as 10 mm. The fall is remarkable not only for the amount, but also because of the persistence of the heavy rain. The total duration of the rainfall of that day was 23 hours. The rain was accompanied by fog.

J. GLASSPOOLE.

Books Received

Deutsches Meteorologisches Jahrbuch, 1929. Freie Hanrestadt, Bremen. Edited by Dr. A. Mey, Jahrgang 40, Bremen, 1930.

Rêsumés mensuels et annuels des Observations Météorologiques faites aux stations de II ordre du Réseau de l'Observatoire Geophysique à l'orient lointain. Année 1920. Fascicule III. Vladivostok, 1930.

Tätigkeit des Schweizerischen Forschungsinstitutes für Hochgebirgsklima und Tuberkulose in Davos, 1929-30.

La perméabilité de tissus de vêtements pour le rayonnement solaire dans diverses régions spectrales. (Reprinted from C.R. Soc. Suisse de Géophys. Météor. Astr.).

Obituary

Mr. Preston C. Day.—We regret to record the death of Mr. P. C. Day on his 72nd birthday, on October 21st, 1931. Mr. Day was born near Damascus, Md.; he joined the Signal Corps of the United States Army in June, 1883, and was associated with meteorology from that date until his retirement in 1930. For nearly 25 years he compiled or edited the climatological text, charts and tables in the *Monthly Weather Review*. He also prepared a number of statistical monographs, including "Winds of the United States and their economic uses" and "Daily, monthly and annual normals of precipitation," and edited the well-known "Bulletin W," a series of climatic summaries for the United States, Alaska and Hawaii.

News in Brief

The Prix Henri Wilde, of the French Academy of Sciences, has been awarded to M. Edmund Rothé, Director of the Institut de Physique du Globe at Strasbourg, for his geophysical work, including the first radiogoniometric researches in France

Capt. A. Hoffmann has been appointed Chief of the Meteorological Bureau of Chile. M. Waldo Nuño, the former Chief, will continue to assist the service.

The Weather of December, 1931

Pressure was above normal in a belt extending from north Africa and Turkey across southern and central Europe, southern Scandinavia, the Azores, Iceland, southern Greenland to north-east Canada and also over the Atlantic in the neighbourhood of the Bermudas, the greatest excess being 15·7 mb. at the Scilly Isles. Pressure was below normal over northern Scandinavia, Russia, Spitsbergen, part of the North Atlantic from Madeira to Newfoundland and over most of the United States and western Canada, the greatest deficit being 12·9 mb. at Spitsbergen. Temperature and rainfall were both above normal in Spitsbergen and Scandinavia, being as much as 11°F. and 54 mm. respectively in excess at Spitsbergen. Further south they were about normal, and in central and southern Europe they were both below normal.

Apart from two cold spells from about the 16th-22nd and again from the 29th-31st, December was very mild. The month was also very dry and in many parts sunshine was below normal. On the first the western part of a large anticyclone, which was moving away eastwards, still lay over England and caused widespread mist and fog inland and much sun on the coasts, 6·5 hrs. at Falmouth and 6·0 hrs. at Lowestoft, while Scotland and Ireland were already under the influence of the depression centred over the North Atlantic. From now until about the 10th, depressions continued to move north-east off the north of Scotland. Strong winds or gales occurred in the western half of the country on the night of the 2nd-3rd and extended to all districts on the 3rd and 4th. Weather was unsettled with rain, heavy locally at times but bright intervals, 1·60 in. of rain fell at Blaenau-hydfer (Brecon) and 1·35 in. at Dunmanway (Co. Cork) on the 2nd, 1·81 in. at Dalwhinnie on the 3rd and 0·99 in. at Brighton on the 6th. The 7th was a sunny day over the kingdom generally, 7·2 hrs. bright sunshine occurred at Rothamsted. Thunderstorms occurred in Lincolnshire on the 3rd and at Eskdalemuir on the 5th. Temperature began to rise on the 2nd and on the 4th maxima reached 60°F. locally in the south. At Kew the maximum, 60°F., was a record for December. On the 10th, the weather became anticyclonic but continued mild until the 14th, when a depression west of Iceland moved eastwards, displacing the anticyclone. In the rear of this depression cold northerly winds brought a considerable drop in temperature and an anticyclone moved south from Iceland. This remained centred near the British Isles until the 22nd, giving very cold weather with slight local rain and from the 17th-20th considerable fog, though the 18th was sunny in some districts. Some low maxima were reported, 27°F. at Ross-on-Wye on the 18th and 19th and at Cheltenham on the 19th, and 31°F. at Leamington on the 18th, while minima in the screen fell to 18°F. at Rhayader on the 19th and on the grass to 10°F. at Rhayader on the 18th and to 14°F. at several places. By the 23rd the winds had become south-westerly again and mild weather was experienced everywhere, especially in Scotland where maxima were higher than in England or Ireland. At Aberdeen the maximum on the 24th, 61°F., was a record for December. Heavy rain was experienced in the west on the 23rd, 3·02 in. at Dungeon Ghyll and 2·65 in. at Sawrey (Lancs.), but over the Christmas season the weather was mild and dry with some sun most days. Thunderstorms occurred in north-west England on the 28th. On the 29th, however, cold northerly winds swept across the country and snowstorms were reported from Scotland, north-east England and the Midlands, and slight snow or sleet from elsewhere in the British Isles. On the 30th and 31st snow still lay thick in the north and it remained cold in the south, but from the evening of the 31st until January 2nd there was a large rise in temperature as the wind backed to south-west. Mr. Wooldridge, of 17, Gardiner Street, Market Harborough, has sent the following notes :—

"December 31st.	Maximum	34°	11 p.m.	18° (minimum).
January 1st.	9 a.m.	35°	9 p.m.	49°
,, 2nd.	,,	51°	,,	53° (minimum).

Thus from a minimum of 18°F. on the night of December 31st-January 1st we had a continuous rise to 53°F. two nights later."

The distribution of bright sunshine for the month was as follows :—

	Total (hrs.)	Diff. from normal (hrs.)		Total (hrs.)	Diff. from normal (hrs.)
Stornoway	11	—12	Liverpool	36	— 7
Aberdeen	45	+ 9	Ross-on-Wye	46	+ 4
Dublin	30	—18	Falmouth	42	—13
Birr Castle	32	--11	Gorleston	35	—10
Valentia	14	—27	Kew	29	— 8

The special message from Brazil states that the rainfall was scarce in the northern and central regions with averages 0·91 in. and 2·64 in. below normal respectively, and irregular in the southern regions with an average 0·04 in. above normal. Coffee, cane and cotton crops were in good condition, but the weather was unfavourable for vegetables and cereals. Eight anticyclones passed across the country. At Rio de Janeiro pressure was normal and temperature 1·1°F. above normal.

Miscellaneous notes on weather abroad culled from various sources.

Bad weather was experienced in central and southern Italy about the middle of the month, and a gale and snowstorm swept across Tuscany on the 13th. After 3 days of continuous rain the Maritza overflowed and interrupted railway communications between Bulgaria and Turkey. Severe cold occurred in Switzerland about the 22nd and several minor lakes were frozen over, but owing to the drought there was no snow under 5,000 ft. The rain which fell in Florence on the 28th froze on reaching the ground and formed a surface of ice, a rare occurrence so far south. Snow fell in Switzerland on the 29th down to 3,000 ft., breaking the drought which had prevailed throughout December. Navigation had closed at most of the Finnish ports by the 24th (*The Times*, December 9th-30th).

Severe storms occurred off the coasts of Algiers on the 9th-14th, and Constantine and the surrounding country were covered with snow. A storm in Tunis disorganised all communications to that town. Heavy SE. gales which swept Cape Province from the 28th to January 1st brought torrential rains (unusual for December) over wide areas, especially the Midlands district. The Sundays River and the Gamtoos River both flooded low-lying lands in their vicinity, and the railway between Riversdale and Port Elizabeth was badly damaged (*The Times*, December 15th-January 2nd).

Floods occurred in the south of Queensland early in the month destroying much of the wheat crop and drowning three people. A heat wave was experienced in South Australia from about the 24th to the end of the month, when a temperature of 115°F. was reported from Adelaide on the 29th, which is a record there for December (*The Times*, December 10th-30th).

Temperature was above normal generally in the United States except during the first half of the month in the Mountainous Regions and along the Pacific coast, and rainfall was mainly about normal except in the Gulf States and Ohio Valley about the middle of the month, when it was heavy (*Washington, D.C., U.S. Dept. Agric., Weekly Weather and Crop Bulletin*).

Rainfall, 1931—General Distribution

	Dec.	Year	
England and Wales ...	45	108	per cent of the average 1881-1915.
Scotland	81	104	
Ireland	66	109	
British Isles	57	107	

Rainfall : December, 1931 : England and Wales

Co.	Station	In.	Per-cent. of Av.	Co.	Station	In.	Per-cent. of Av.
Lond .	Camden Square.........	·82	34	*Leics* .	Belvoir Castle...........	·76	31
Sur .	Reigate, Alvington.....	·85	27	*Rut* .	Ridlington...............	·96	38
Kent .	Tenterden, Ashenden...	·58	19	*Linc* .	Boston, Skirbeck........	·88	41
,, .	Folkestone, Boro. San..	·67	...	,, .	Cranwell Aerodrome...	·97	44
,, .	Margate, Cliftonville...	·41	18	,, .	Skegness, Marine Gdns	1·32	60
,, .	Sevenoaks, Speldhurst	·55	...	,, .	Louth, Westgate........	1·24	44
Sus .	Patching Farm.........	·90	27	,, .	Brigg, Wrawby St.....	1·07	...
,, .	Brighton, Old Steyne..	1·24	40	*Notts* .	Worksop, Hodsock.....	1·02	43
,, .	Heathfield, Barklye....	1·13	31	*Derby*.	Derby, L. M. & S. Rly.	1·14	44
Hants.	Ventnor, Roy. Nat. Hos.	·93	28	,, .	Buxton, Devon Hos....	2·02	36
,, .	Fordingbridge, Oaklnds	1·04	26	*Ches* .	Runcorn, Weston Pt...	1·57	50
,, .	Ovington Rectory.......	·62	16	,, .	Nantwich, Dorfold Hall	1·75	...
,, .	Sherborne St. John.....	·72	22	*Lancs*.	Manchester, Whit. Pk.	1·39	43
Berks .	Wellington College.....	·52	18	,, .	Stonyhurst College.....	3·29	68
,, .	Newbury, Greenham...	·95	30	,, .	Southport, Hesketh Pk	1·82	56
Herts .	Welwyn Garden City...	1·09	...	,, .	Lancaster, Strathspey	3·58	...
Bucks.	H. Wycombe, Flackwell	·84	...	*Yorks*.	Wath-upon-Dearne.....	·60	25
Oxf . .	Oxford, Mag. College..	·96	41	,, .	Bradford, Lister Pk....	1·48	44
Nor .	Pitsford, Sedgebrook...	·81	33	,, .	Oughtershaw Hall......	4·00	...
,, .	Oundle....................	·57	...	,, .	Wetherby, Ribston H.	1·09	44
Beds .	Woburn, Crawley Mill	·88	38	,, .	Hull, Pearson Park.....	1·07	44
Cam .	Cambridge, Bot. Gdns.	·82	42	,, .	Holme-on-Spalding.....	·86	...
Essex .	Chelmsford, County Lab	·63	28	,, .	West Witton, Ivy Ho.	1·95	53
,, .	Lexden Hill House....	·51	...	,, .	Felixkirk, Mt. St. John	1·38	57
Suff .	Hawkedon Rectory.....	1·16	48	,, .	Pickering, Hungate....	1·00	40
,, .	Haughley House........	·79	...	,, .	Scarborough.............	1·57	66
Norf .	Norwich, Eaton...... ...	1·79	69	,, .	Middlesbrough..........	·96	49
,, .	Wells, Holkham Hall	1·15	56	,, .	Baldersdale, Hury Res.	2·51	...
,, .	Little Dunham..........	...	...	*Durh* .	Ushaw College..........	·86	34
Wilts.	Devizes, Highclere......	·96	31	*Nor* .	Newcastle, Town Moor	·99	41
,, .	Bishops Cannings.......	·97	30	,, .	Bellingham, Highgreen	2·28	63
Dor .	Evershot, Melbury Ho.	1·94	38	,, .	Lilburn Tower Gdns....	1·85	70
,, .	Creech Grange..........	1·30	38	*Cumb*.	Geltsdale.................	2·33	...
,, .	Shaftesbury, Abbey Ho.	1·29	36	,, .	Carlisle, Scaleby Hall	2·52	78
Devon.	Plymouth, The Hoe...	2·21	44	,, .	Borrowdale, Seathwaite	14·50	94
,, .	Polapit Tamar..........	...	...	,, .	Borrowdale, Rosthwaite	9·99	...
,, .	Holne, Church Pk. Cott.	4·22	50	,, .	Keswick, High Hill.....	4·42	...
,, .	Cullompton	1·92	44	*West* .	Appleby, Castle Bank..	2·75	70
,, .	Sidmouth, Sidmount...	1·80	46	*Glam* .	Cardiff, Ely P. Stn.....	2·50	49
,, .	Filleigh, Castle Hill....	3·06	...	,, .	Treherbert, Tynywaun	6·03	...
,, .	Barnstaple. N. Dev. Ath	2·32	52	*Carm* .	Carmarthen Friary.....	2·86	50
,, .	Dartm'r, Cranmere Pool	5·40	...	*Pemb* .	Haverfordwest, School	2·69	47
Corn .	Redruth, Trewirgie.....	2·17	35	*Card* .	Aberystwyth............	3·44	...
,, .	Penzance, Morrab Gdn.	2·82	50	,, .	Cardigan, County Sch.	1·99	...
,, .	St. Austell, Trevarna...	2·10	35	*Brec* .	Crickhowell, Talymaes	2·50	...
Soms .	Chewton Mendip........	1·36	25	*Rad* .	Birm W. W. Tyrmynydd	4·26	52
,, .	Long Ashton............	2·23	58	*Mont* .	Lake Vyrnwy...........	4·50	65
,, .	Street, Millfield	1·30	38	*Denb* .	Llangynhafal............	1·98	60
Glos. .	Cirencester, Gwynfa....	1·79	53	*Mer* .	Dolgelly, Bryntirion...	5·49	80
Here .	Ross, Birchlea...........	1·35	45	*Carn* .	Llandudno...............	1·41	45
,, .	Ledbury, Underdown..	1·07	38	,, .	Snowdon, L. Llydaw 9	14·90	...
Salop .	Church Stretton.........	1·49	44	*Ang* .	Holyhead, Salt Island	2·27	55
,, .	Shifnal, Hatton Grange	·97	53	,, .	Lligwy....................	3·70	93
Worc .	Ombersley, Holt Lock	·89	34	*Isle of Man*			
,, .	Blockley..................	1·15	...		Douglas, Boro' Cem....	3·57	72
War .	Birminghm, Edgbaston	·88	33	*Guernsey*			
Leics .	Thornton Reservoir....	1·01	38		St. Peter P't. Grange Rd.	1·59	39

Rainfall : December, 1931 : Scotland and Ireland

Co.	Station	In.	Per-cent of Av.	Co.	Station	In.	Per cent. of Av.
Wigt.	Pt. William, Monreith	...	...	*Suth.*	Melvich	4·21	...
,,	New Luce School	4·72	85	,,	Loch More, Achfary	15·05	163
Kirk.	Carsphairn, Shiel	8·12	87	*Caith.*	Wick	2·80	91
Dumf.	Dumfries, Crichton, R.I	3·56	...	*Ork.*	Pomona, Deerness	5·64	135
,,	Eskdalemuir Obs.	5·29	76	*Shet.*	Lerwick	6·34	132
Roxb.	Branxholm	2·39	65	*Cork.*	Caheragh Rectory	4·29	...
Selk.	Ettrick Manse	5·34	86	,,	Dunmany Rectory	3·94	49
Peeb.	West Linton	2·87	...	,,	Ballinacurra	2·02	39
Berk.	Marchmont House	·75	27	,,	Glanmire, Lota Lo.	2·38	43
Hadd.	North Berwick Res.	·57	26	*Kerry.*	Valentia Obsy.	5·04	76
Midl.	Edinburgh, Roy. Obs.	1·06	49	,,	Gearahameen	7·00	...
Lan.	Auchtyfardle	4·03	...	,,	Killarney Asylum	4·32	59
Ayr.	Kilmarnock, Kay Pk.	4·58	...	,,	Darrynane Abbey	3·54	60
,,	Girvan, Pinmore	5·36	90	*Wat.*	Waterford, Brook Lo.	...	...
Renf.	Glasgow, Queen's Pk.	3·92	93	*Tip.*	Nenagh, Cas. Lough	2·73	59
,,	Greenock, Prospect H.	7·70	98	,,	Roscrea, Timoney Park	2·41	...
Bute	Rothesay, Ardencraig.	6·77	124	,,	Cashel, Ballinamona	2·23	51
,,	Dougarie Lodge	4·21	...	*Lim.*	Foynes, Coolnanes	2·60	55
Arg.	Ardgour House	16·53	...	,,	Castleconnel Rec.	4·08	...
,,	Manse of Glenorchy	...	...	*Clare.*	Inagh, Mount Callan	6·26	...
,,	Oban	6·62	98	,,	Broadford, Hurdlest'n.	3·70	...
,,	Poltalloch	5·70	89	*Wexf.*	Gorey, Courtown Ho.	2·53	66
,,	Inveraray Castle	11·02	111	*Kilk.*	Kilkenny Castle	1·61	46
,,	Islay, Eallabus	4·71	79	*Wic.*	Rathnew, Clonmannon	1·56	...
,,	Mull, Benmore	17·80	...	*Carl.*	Hacketstown Rectory	2·58	63
,,	Tiree	3·46	...	*Leix.*	Blandsfort House	2·41	65
Kinr.	Loch Leven Sluice	1·58	40	,,	Mountmellick	2·92	...
Perth.	Loch Dhu	10·20	111	*Off'ly.*	Birr Castle	2·07	63
,,	Balquhidder, Stronvar	6·19	...	*Kild'r.*	Monasterevin	1·76	...
,,	Crieff, Strathearn Hyd.	2·79	57	*Dubl.*	Dublin, FitzWm. Sq.	·99	40
,,	Blair Castle Gardens	2·84	74	,,	Balbriggan, Ardgillan.	1·25	43
Angus.	Kettins School	1·21	40	*Me'th.*	Beauparc, St. Cloud	2·11	...
,,	Dundee, E. Necropolis	·92	35	,,	Kells, Headfort	2·74	72
,,	Pearsie House	1·69	..	*W.M.*	Moate, Coolatore	2·60	...
,,	Montrose, Sunnyside	1·03	37	,,	Mullingar, Belvedere	3·07	83
Aber.	Braemar, Bank	2·88	81	*Long.*	Castle Forbes Gdns.	2·60	65
,,	Logie Coldstone Sch.	...	.	*Gal.*	Ballynahinch Castle	7·19	96
,,	Aberdeen, King's Coll.	1·39	43	,,	Galway, Grammar Sch.	4·10	...
,,	Fyvie Castle	1·77	52	*Mayo.*	Mallaranny	6·30	...
Moray.	Gordon Castle	1·74	65	,,	Westport House	4·35	76
,,	Grantown-on-Spey	1·57	58	,,	Delphi Lodge	10·97	91
Nairn.	Nairn, Delnies	1·07	48	*Sligo.*	Markree Obsy.	3·49	74
Invs.	Ben Alder Lodge	7·44	...	*Cav'n.*	Belturbet, Cloverhill	2·33	63
,,	Kingussie, The Birches	3·67	..	*Ferm.*	Enniskillen, Portora	...	...
,,	Loch Quoich, Loan	20·55	...	*Arm.*	Armagh Obsy	2·58	82
,,	Glenquoich	...	...	*Down.*	Fofanny Reservoir	5·60	...
,,	Inverness, Culduthel R.	2·04	..	,,	Seaforde	3·34	81
,,	Arisaig, Faire-na-Squir	6·11	...	,,	Donaghadee, C. Stn.	2·95	93
,,	Fort William	11·32	...	,,	Banbridge, Milltown	2·15	...
,,	Skye, Dunvegan	6·14	...	*Antr.*	Belfast, Cavehill Rd.	3·23	...
R & C.	Alness, Ardross Cas.	4·30	104	,,	Glenarm Castle	4·30	...
,,	Ullapool	4·84	76	,,	Ballymena, Harryville	3·32	75
,,	Torridon, Bendamph	...	...	*Lon.*	Londonderry, Creggan	3·74	85
,,	Achnashellach	13·98	...	*Tyr.*	Omagh, Edenfel	4·40	104
,,	Stornoway	5·69	...	*D'n.*	Malin Head	2·81	...
Suth.	Lairg	5·99	148	,,	Dunfanaghy	4·14	...
,,	Tongue	4·41	89	,,	Killybegs, Rockmount	4·19	57

Climatological Table for the British Empire, July, 1931.

STATIONS	PRESSURE		TEMPERATURE								Relative Humidity	Mean Cloud Am'nt	PRECIPITATION			BRIGHT SUNSHINE	
	Mean of Day M.S.L.	Diff. from Normal	Absolute		Mean Values				Mean				Am'nt	Diff. from Normal	Days	Hours per day	Per-cent-age of possible
			Max.	Min.	Max.	Min.	½ max. and min.	Diff. from Normal	Wet Bulb								
	mb.	mb.	° F.	° F.	° F.	° F.	° F.	° F	° F.		%	0—10	in.	in.			
London, Kew Obsy.	1010·2	— 5·6	76	50	69·4	55·2	62·3	— 0·4	56·0		81	7·5	2·91	+ 0·74	12	4·9	30
Gibraltar	1015·4	— 1·4	95	63	83·4	66·8	75·1	+ 0·3	64·6		78	3·5	0·00	— 0·03	0	..	..
Malta	1014·6	— 0·1	103	67	87·3	74·3	80·8	+ 2·5	72·6		68	1·3	0·00	— 0·05	0	12·5	88
St. Helena	1017·2	+ 0·5	66	53	60·5	54·6	57·5	— 1·0	55·6		94	9·1	4·80	..	25	..	..
Sierra Leone	1014·4	+ 1·7	86	67	82·1	69·5	75·8	— 2·8	75·0		91	8·9	40·65	+ 5·07	30	..	..
Lagos, Nigeria	1013·2	— 0·6	85	72	81·6	74·3	77·9	— 0·1	74·6		87	9·3	17·81	+ 7·13	19	2·3	..
Kaduna, Nigeria	1013·8	— 1·1	90	..	87·4	..	..	..	71·6		87	9·0	12·20	+ 4·00	19	..	..
Zomba, Nyasaland	1015·8	— 2·7	81	47	72·1	54·2	63·1	+ 1·1	..		68	3·8	0·36	+ 0·01	3	..	..
Salisbury, Rhodesia	..	..	..	..	..	..	..	..	..		..	..	..	..	..	..	..
Cape Town	1022·6	+ 1·3	81	33	62·7	47·6	55·1	+ 0·4	48·6		85	4·2	1·55	— 2·07	15	..	..
Johannesburg	1021·1	— 2·7	65	29	56·9	39·8	48·3	— 2·1	40·0		61	4·5	1·97	+ 1·64	12	7·4	69
Mauritius	1019·0	— 1·4	78	55	76·1	63·5	69·8	+ 1·5	66·2		74	4·6	1·86	— 0·63	15	8·1	74
Calcutta, Alipore Obsy.	999·9	+ 0·7	93	75	89·3	79·3	84·3	+ 0·6	80·0		90	9·2	13·70	+ 1·00	16*	..	..
Bombay	1003·4	— 0·5	89	73	85·4	76·1	80·7	— 0·7	78·0		89	9·3	47·50	+ 23·23	30*	..	..
Madras	1005·1	+ 0·6	101	70	94·3	78·4	86·3	— 1·3	75·8		70	7·9	5·73	+ 1·89	6*	..	..
Colombo, Ceylon	1010·0	+ 0·9	86	71	84·9	76·5	80·7	— 0·5	77·2		81	8·2	12·12	+ 7·69	23	5·8	46
Singapore	1009·8	+ 0·9	92	72	87·3	76·1	81·7	— 0·2	77·6		81	7·6	6·94	+ 0·17	15	5·9	49
Hongkong	1006·9	+ 2·2	90	76	87·4	79·0	83·2	+ 0·7	79·1		77	7·6	9·86	— 4·16	27	7·4	55
Sandakan	..	..	90	73	87·9	75·0	81·5	— 0·3	76·7		83	..	5·01	— 1·71	14	..	..
Sydney, N.S.W.	1016·1	— 2·2	77	38	63·5	45·5	54·5	+ 1·8	48·2		74	4·4	12·77	+ 7·97	9	6·7	66
Melbourne	1016·9	— 2·0	64	35	55·8	42·7	49·3	+ 0·6	45·3		83	6·5	2·09	+ 0·23	19	3·5	36
Adelaide	1019·3	— 1·0	66	38	57·9	45·0	51·5	— 0·3	46·9		80	8·6	3·73	+ 1·09	22	2·7	27
Perth, W. Australia	1017·1	— 1·9	69	39	62·4	50·2	56·3	+ 1·1	51·6		77	6·9	7·90	+ 1·34	21	4·3	42
Coolgardie	1019·8	0·0	69	32	60·3	43·3	51·8	+ 0·6	46·8		73	7·1	0·78	— 0·09	9	..	..
Brisbane	1018·0	— 0·4	81	42	69·1	50·4	59·7	+ 1·2	52·4		67	3·3	1·79	— 0·49	6	8·1	76
Hobart, Tasmania	1010·4	— 3·3	61	30	50·7	40·1	45·4	— 0·3	40·5		75	6·9	2·64	+ 0·46	19	3·6	38
Wellington, N.Z.	1009·8	— 4·1	59	34	51·5	42·0	46·7	— 1·3	44·4		80	7·4	5·39	— 0·24	19	3·9	41
Suva, Fiji	1015·0	+ 1·0	84	65	80·3	70·6	75·5	+ 2·1	71·2		80	6·5	8·70	+ 3·77	21	5·3	47
Apia, Samoa	1012·3	+ 0·4	87	66	84·1	73·0	78·5	+ 1·3	74·7		74	5·6	3·93	+ 0·95	9	8·4	74
Kingston, Jamaica	1012·9	— 1·8	92	71	88·1	73·7	80·9	— 0·8	73·2		83	6·6	7·80	+ 6·18	9	5·4	41
Grenada, W.I.	1012·9	— 0·4	89	72	86·5	73·8	80·1	+ 0·9	73·6		76	7·2	18·11	+ 8·68	31	..	..
Toronto	1012·3	— 2·1	98	54	82·7	64·5	73·6	+ 4·5	66·5		71	5·7	3·10	+ 0·26	10	8·6	57
Winnipeg	1010·6	— 1·7	98	48	79·4	57·4	68·4	+ 2·0	57·8		83	4·7	3·08	— 0·02	16	..	..
St. John, N.B.	1013·4	— 0·2	80	49	70·2	54·3	62·3	+ 1·9	58·6		87	7·0	5·07	+ 1·44	17	6·0	39
Victoria, B.C.	1016·5	— 0·8	86	49	69·7	53·3	61·5	+ 1·4	56·5		74	2·5	0·33	— 0·09	2	12·5	80