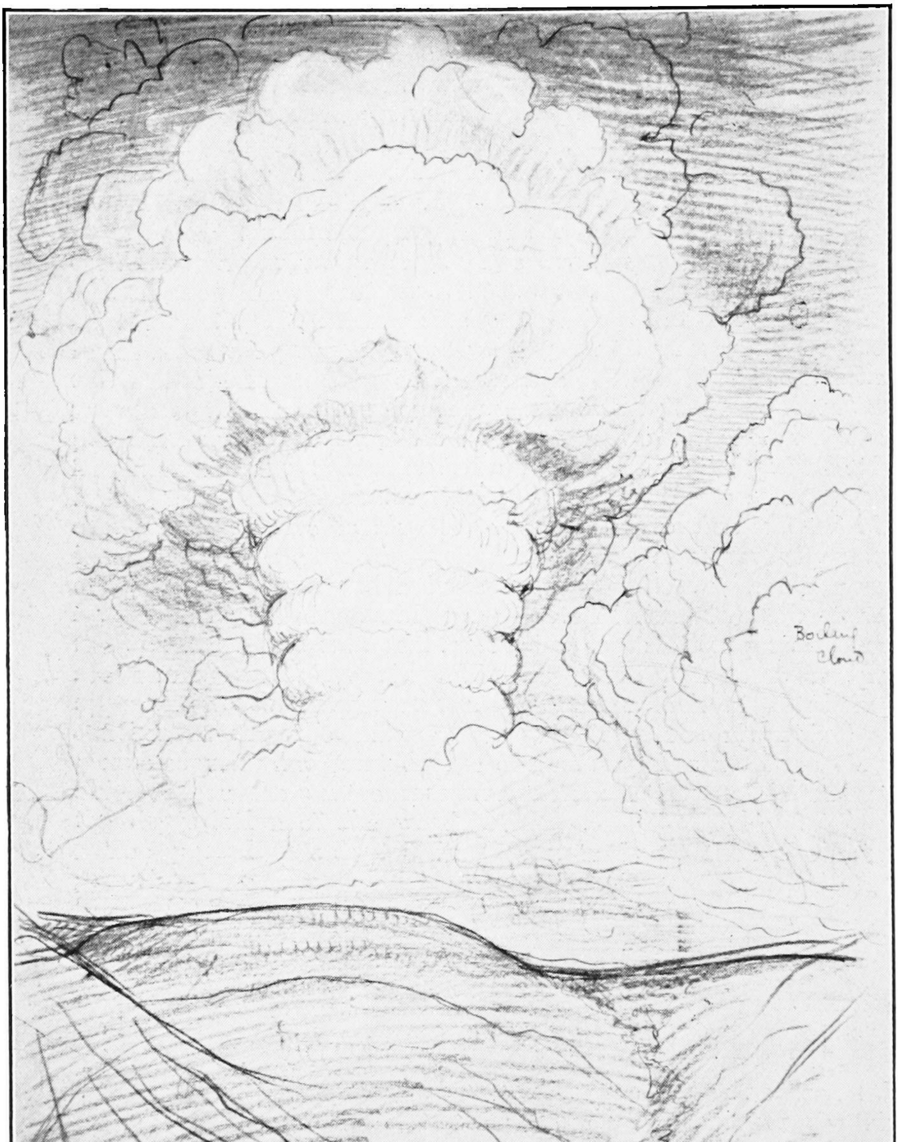


THUNDER CLOUD ABOVE TEESDALE, AUGUST 28th, 1930 (see page 15)

M.O. 339.

The Meteorological Magazine

Air Ministry :: Meteorological Office

Vol. 66

Feb., 1931

No. 781

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.

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*

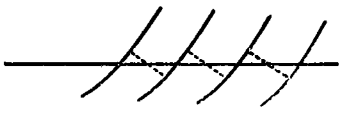
Shoeburyness. Accordingly, Colonel E. L. Bond, Superintendent of Experiments, was good enough to arrange for the provision of a section of this tree from which the measurements in this note were secured.

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.

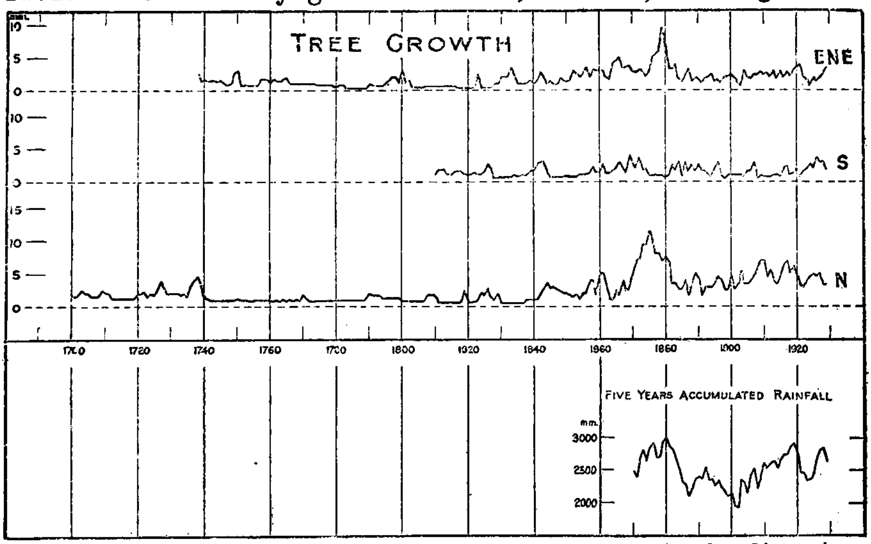


The line (3) was chosen as giving a radius vector along which the rings are reasonably concentric to the centre and along which there were no distortions and few abnormal growths. Appended to this note are tables giving the annual growth in millimetres along these three lines as far back as possible, 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 × 5¾in., 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* 29*th*, 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* 21*st*, 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* .	Birm W. 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 Per-centage 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.