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The Recent Heat and Thunderstorms

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

A sudden spell of hot weather set in towards the end of August, and came as a great surprise after six weeks of cool, unsettled weather, culminating in a widespread gale on August 21st. Last year hot weather also set in late in August, but it was less severe and its onset less sudden. Temperatures of 90°F. or slightly over were recorded at many places (*e.g.*, 92°F. at Cambridge on the 28th and at Tottenham and Norwich on the 29th. 93°F. at Camden Square and 90°F. at Nottingham on the 29th). Over a large area the hot spell was the most intense and prolonged since July, 1923, and was the most outstanding late hot spell since early September, 1906. The most remarkable feature was the suddenness of the change. At Kew Observatory the maximum temperatures for the period August 24th to 27th were 68°F., 72°F., 84°F. and 88°F., while at Eskdalemuir the maximum was 64°F. on the 26th and 83°F. on the 27th. Such sudden rises of temperature can only be produced by the arrival of warm air, which travels with the wind at about 2,000 feet. The surface air movements are slower, but the sun very rapidly warms up the surface air when temperature is high up above. The warm air spread from southern France to southern England between the 25th and 26th and to Scotland on the 27th. On the 27th the temperature at 5,000 feet at Duxford (Cambridgeshire) was 71°F., the highest ever recorded in this country at that level. Over most of England the hot spell lasted for four days,

but in Scotland and Wales it was very brief, and Ireland escaped entirely. The heat was confined to western Europe, and there were no really high temperatures east of long. 10°E. , while beyond long. 15°E. conditions were quite cool.

Thunderstorms were widespread and severe. Some places in the north experienced more than one severe storm, and heavy hail occurred locally. The storms commenced in the west and north on the night of August 26th, associated with a front separating the hot air from cool Atlantic air of polar origin. The front was practically stationary throughout the 28th, on a line roughly from Cornwall to the Shetlands. A notable storm moved northward over east Scotland on the night of the 28th, lasting for five hours at Aberdeen, the front being off the east coast. Next day violent storms broke out over northern England and southern Scotland, and extended to the Midlands and eastern England during the night. Over England they were due to the eastward movement of the front, which took place without any pressure gradient across it. Throughout the hot spell there was a steep lapse rate of temperature above 7,000 feet, and plenty of moisture in the lower layers, favouring severe thunderstorms as soon as the front started off convectional movements. There is no evidence that diurnal heating produced any local afternoon storms. Such storms are rare in hot weather late in the summer.

The complete change in the weather was so unexpected that it is worth while to examine closely the factors leading up to it. The spell of cool, unsettled weather which set in about July 10th was general over nearly the whole of Europe. On the summit of Säntis, in the Alps (8,200 feet), the temperature was often several degrees below the freezing point, with heavy snowfalls. From August 18th onwards, however, the temperature on the Alps was much higher, and the temperature over southern Europe gradually worked up. On the 23rd there was a WSW. gale on Säntis, with a fairly high temperature, and for the next two days there was a strong WSW. wind over an E. wind on adjacent low ground. Since barometric pressure is high over warm air, this wind structure definitely indicated high upper air temperatures over the Mediterranean. The same feature gave cirrus movements of 100 m.p.h. from the W. over England on the 23rd and 24th, and only slightly lower velocities on 25th. Pilot-balloon observations in the Mediterranean area showed mainly westerly winds from the 22nd to the 24th and light variable winds afterwards, so that the warm air probably arrived from the west. Temperature over the Azores was unusually high from the 18th to the 23rd, with six reports of 81°F. from Horta and one of 82°F. ; this figure equals the highest maximum ever reported from there during the period 1903 to 1926. The warm air reached the Azores from south of Bermuda. Temperature was high for a long period over the United States and the Bermuda

area. Probably the hot spells in the United States and in England were not entirely disconnected, though the popular idea of a "heat wave" crossing the Atlantic is misleading.

In order that the warm air should advance from the Mediterranean to England, it was necessary that the pressure distribution should become radically different from that which had prevailed for six weeks previously. The required change took place between August 23rd and 26th when an anticyclone moved east-north-east from the Bay of Biscay, increased in intensity, and became almost stationary. Meanwhile a depression which was rapidly approaching west Ireland early on the 25th was deflected away to northwards. On that date there was a strong WSW. upper current over the anticyclone, which was thus a superficial system. The cirrus movement over England began to back that evening, and by the 27th it was strong southerly, showing that the anticyclone extended to cirrus levels, probably well into the stratosphere. By that time the "heat wave" was already established. This upward extension is typical of the life history of anticyclones, and also of cyclones. The anticyclones extending to the stratosphere are often called "warm" anticyclones, and they usually become stationary for a few days, though they often move again when they start to decay. It is almost certain that their development is due to the northward extension of tropical air at high levels, but it is not yet known exactly how this takes place, or how the upper and lower anticyclones become combined. It is thus not yet possible to predict when or where a moving anticyclone will become stationary. The problem is even more difficult than that of cyclones, for with these we have the warm sector to help us.

The hot spell was terminated by the development of a new anticyclone in the polar air off our north-west coasts, which produced a northerly wind over the British Isles, quite shallow at first but deeper later. This development of a new anticyclone in polar air and the simultaneous decay of the warm anticyclone was quite typical. Sometimes the new system can be regarded as part of the old one, and if we do this we naturally obtain life histories of anticyclones extending to weeks.

The problems of anticyclones and of cyclones are very closely analogous, and will probably be solved together. The fact that both systems extend upwards suggests that the conditions in the lower levels greatly influence those up above, by some process not yet understood, but the conditions existing up above must of course also be taken into account. When this fundamental problem has been solved, there will be a good prospect of giving definite predictions of such marked weather changes as those recently experienced.

The Drought in North America

During July and the first half of August, the drought which had been intermittently felt in the United States throughout the first half of 1930 became accentuated with serious consequences for farmers in the eastern half of the country, reaching the proportions of a national disaster. The drought does not appear to have been so marked in Canada, except in the southern part of Ontario and in Nova Scotia.

The progress of the drought week by week can be followed in great detail from the tables and descriptions in the invaluable *Weekly Weather and Crop Bulletin*, published by the U.S. Department of Agriculture, Weather Bureau. In addition the issue of the *Bulletin* for the week ending August 12th contains a general survey, a summary of which may be of interest. The drought began in December, 1929, when the rainfall was much below normal in the middle Atlantic area. Similar conditions continued during January, in which month, however, there was heavy rain in the interior valleys. In February the east was again dry, and in March and April the drought extended to the Ohio and middle Mississippi valleys, where large areas received less than half the normal amounts. In May the rainfall was less than half the normal between west Virginia and the Mississippi Valley, and the eastern States were also dry, but the remaining parts of the country received sufficient rain. In June the drought-stricken area extended to the lower Mississippi Valley, where very little rain fell throughout the month. July was exceptionally dry over almost the whole country east of the Rocky Mountains, only limited regions receiving as much as half the normal rainfall. From Maryland in the east to Missouri and Arkansas in the west, this was the driest July on record, the total being less than one-third of normal, while several places were entirely rainless. Over a still more extensive area, including Louisiana and Mississippi, June and July together received only about 40 per cent. of normal and were drier than in any preceding year.

The rainfall distribution in the various districts during the period of nine weeks from June 11th to August 12th is shown week by week in Table I, compiled from statistics for 165 stations published in the *Weekly Weather and Crop Bulletin*, for these weeks. The table gives the average district rainfall in inches and the percentage of normal, and brings out the severity of the drought in the Gulf States, the Missouri Valley, and especially the Ohio Valley. The Pacific coast was practically rainless throughout the whole period, but the summer rainfall in this district is normally very small.

The *Bulletin* for the week ending August 5th contains a map showing the rainfall of July, 1930, as a percentage of normal.

The amounts exceeded 100 per cent. only over the Rocky Mountain region in the west, and in a long broken belt extending the length of the Atlantic coast from Maine to South Carolina. The Mississippi Valley from St. Louis nearly to Vicksburg and part of the Red River valley received less than one tenth of normal. Conditions during the longer period June 11th to August 12th are shown in Fig. 1, a sketch map compiled from the 165 stations in the *Weekly Weather and Crop Bulletin*. Areas with rainfall above normal are shaded, those with less than 50 per cent. are stippled. The number of stations was insufficient to show the details of the distribution, and it is probable that the small shaded areas in the centre and east, which represent the occurrences of intense local thunderstorms should be more numerous but individually smaller. Nevertheless the map gives an interesting picture of the severity of the drought in the east during the two worst months. Its preparation was only made possible through the prompt issue of data by the U.S. Weather Bureau.

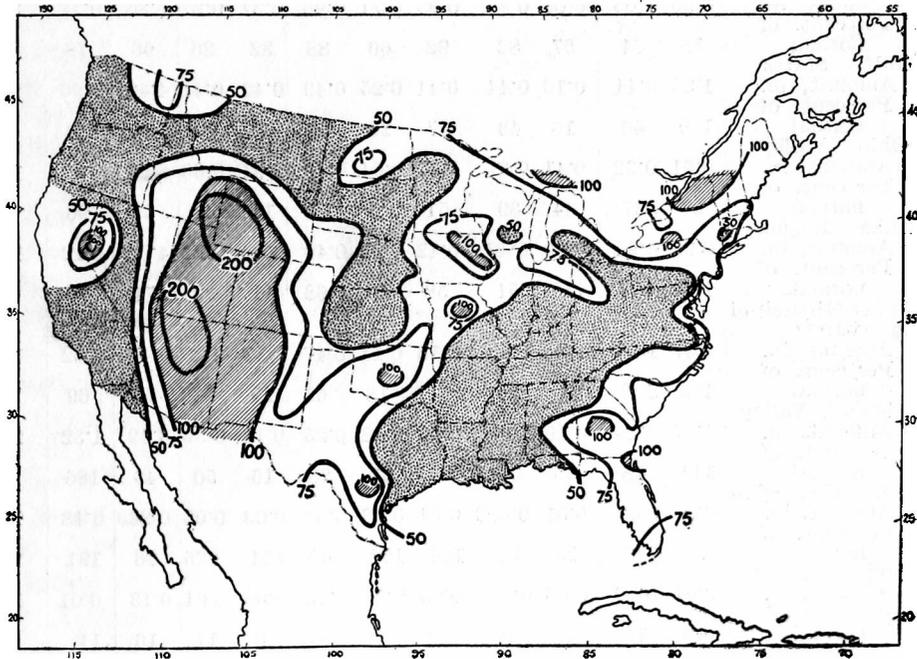


FIG. 1

This is not the place to go in detail into the causes of the drought, but some references to the prevailing types of pressure distribution associated with it may be of interest. The normal pressure distribution over the United States in July shows an anticyclone over the western North Atlantic extending across Florida, and an area of low pressure (about 1,005mb.) over south-eastern California and Arizona. In consequence of this distribution, a broad current of moist equatorial air sweeps northward from the Gulf of Mexico, over the whole of the States

east of the Rocky Mountains. Over the northern part of the States the winds are variable, associated with the passage of a series of anticyclones and depressions eastward across the region of the Great Lakes. The Pacific States have a regime of north-westerly winds which need not be discussed here.

Table I shows that during the week July 9th to 15th the drought was most intense in the Upper Mississippi and Missouri Valleys, the latter receiving only seven per cent. of the normal fall. A glance at the *Daily Weather Maps* issued by the U.S.

TABLE I

	WEEK ENDING										No. of Stations	
	June		July					August		June 11 to Aug. 12		Aug. 13 to 19
	17	24	1	8	15	22	29	5	12			
Atlantic Coast Amount, in.	0.56	1.05	0.66	0.83	0.95	0.71	0.96	0.37	0.27	6.36	0.77	32
Per cent. of normal	58	84	67	82	92	66	88	32	26	66	78	
Gulf States Amount, in.	1.35	0.44	0.19	0.44	0.41	0.25	0.49	0.42	0.41	4.40	0.96	27
Per cent. of normal	150	46	18	43	47	26	54	45	42	51	111	
Ohio Valley Amount, in.	0.61	0.32	0.41	0.37	0.47	0.04	0.40	0.01	0.33	2.96	0.89	14
Per cent. of normal	66	37	44	39	51	4	51	1	41	37	96	
Lake Region Amount, in.	0.93	0.95	0.86	0.43	0.42	0.28	0.49	0.08	0.22	4.66	0.12	18
Per cent. of normal	129	136	110	51	58	43	68	11	32	71	19	
Upper Mississippi Valley Amount, in.	1.57	1.03	1.20	0.48	0.13	0.14	0.47	0.19	0.26	5.47	0.62	14
Per cent. of normal	166	109	138	53	17	18	63	25	33	73	69	
Missouri Valley Amount, in.	1.07	0.44	0.49	0.30	0.05	0.42	0.25	0.11	0.36	3.49	1.32	21
Per cent. of normal	114	48	55	36	7	57	36	16	50	49	186	
Mountain Region Amount, in.	0.01	0.03	0.01	0.003	0.04	0.03	0.02	0.03	0.06	0.233	0.48	28
Per cent. of normal	30	114	28	12	164	122	69	124	225	96	191	
Pacific Coast Amount, in.	0.04	0.02	0.06	0.00	0.00	0.00	0.00	0.00	0.01	0.13	0.01	11
Per cent. of normal	19	11	47	0	0	0	0	0	17	16	11	

Weather Bureau shows that during that week the Atlantic anti-cyclone extended further west than usual, covering the south coast of the Gulf States as far as Texas. The low pressure over California remained, but the great current of equatorial air seems to have had a more westerly origin than usual, passing over the dry plateau of Mexico instead of the Gulf. Hence its humidity was low and it produced little or no rain. During this week the rainiest region was the Atlantic coast, where the south-westerly current met north-westerly winds associated with depres-

sions over the Gulf of St. Lawrence. In the following week the driest region (apart from the Pacific coast) was further east, in the Ohio valley, which received only four per cent. of normal. During the whole of this week, from July 16th to 22nd, the south-eastern States were under the influence of anticyclonic conditions resulting from an extension of the Atlantic high-pressure area towards the north-west. There was, however, a drift of air from the south, and a few places experienced heavy falls of rain during thunderstorms. These scattered falls brought up the average over the Gulf States to 26 per cent. During the week July 23rd to 29th, although the whole country received less than the normal rainfall, these sporadic thunderstorms became more frequent. Some places enjoyed rainfalls of more than an inch, or even two inches in a day, while at neighbouring places the drought remained unbroken. At Macon, Georgia, 2.00 inches fell on the 25th and 2.12 inches on the 26th, the total for the whole week reaching nearly five inches. On the other hand, Little Rock, Arkansas, received less than a quarter of an inch of rain between the beginning of June and the middle of August, and Dallas experienced two months without rain from the middle of June to mid-August.

The drought reached its greatest intensity over nearly the whole country during the week July 30th to August 5th, when the whole of the Ohio valley was practically rainless. Inspection of the weather maps shows that during this week the United States was crossed by a series of anticyclones moving slowly along irregular paths. Winds were light and variable, and there was no general influx of maritime air to produce favourable conditions for precipitation. Droughty conditions were relieved to some extent after August 12th, as will be seen from the column for August 13-19th in Table 1, but the drought persisted in the Lake region.

The effects of the continued scarcity of rain were accentuated in many districts by the high temperatures. Maxima of at least 108°F. were recorded at one or more of the stations included in the daily weather map on 25 days between June 28th and August 6th, but most of these occurred at Phoenix and Yuma in Arizona, at both of which temperatures of 114°F. were experienced. In the Central States 110°F. was recorded at Omaha, Nebraska, on August 4th, and 108°F. at stations in Indiana on July 29th, Missouri and Arkansas on July 29th and 30th, and Kansas on August 3rd to 5th. On July 29th and 30th conditions were anticyclonic, with light winds and clear skies favouring intense insolation; but the maxima of August 3rd to 5th were associated with light south-westerly winds apparently originating in the desert regions of Arizona and northern Mexico.

Official Publication

The following publication has recently been issued.

PROFESSIONAL NOTES—

No. 57. *The effect of variation in relative wind force on the readings of the wet- and dry-bulb thermometers in a portable screen on board ship.* By E. G. Bilham, B.Sc., and J. E. Belasco, B.Sc. (M.O. 273q).

The paper contains the results of trials carried out in four of H.M. Survey Ships, simultaneous readings from Assmann psychrometers being taken for comparison. Taking the Assmann readings as representing the true values, the following conclusions were reached:—

(1) Provided the readings are taken on the windward side of the ship, the temperature readings in the screen will agree to within 1°F. with the true value on more than 90 per cent of the occasions.

(2) With similar precautions the relative humidity determined from dry- and wet-bulb thermometers in the screen will be within 5 per cent of the true value on 95 per cent of occasions.

(3) Large discrepancies between screen and Assmann readings are not conspicuously associated with light winds. The results do not justify a recommendation to ignore readings taken in relative winds below force 3 on the Beaufort scale.

Correspondence

To the Editor, *The Meteorological Magazine*

Thunderstorm in Scotland, August 29th

Particulars of a very severe hailstorm last Friday morning, August 29th, may possibly be of interest to your readers. The storm burst about 11 a.m. at Peebles, but it only appears to have struck with its full force the eastern side of the town; windows on the north-west side of the house we were staying in were all broken, and the greenhouses smashed to bits. Apples, &c., were knocked down and any fruit remaining on the trees was cut or bruised by the hailstones. The Hydro Hotel had over 1,200 panes smashed, all on the west side.

The storm caught us on the hills, on our way to shoot grouse; thunder was incessant overhead, but appeared to be at an immense height; suddenly it became intensely dark, and a few hailstones, about the size of a pigeon egg began to fall slowly, so we went for shelter, but the storm burst just before we reached it. A terrific roar was heard in the distance just prior to the breaking of the storm. Hailstones of 5 inches in circumference and over then fell for 10 minutes in a mass, accompanied by a deluge of rain, and a wind of 50 m.p.h. or more, from the NW.; the thunder and lightning were incessant. The hailstones were

very interesting; they were nearly all round, the shape of a soap tablet, but the centres were bulged out each side; a few were like coral in appearance, but these were probably due to several small stones binding together. The round ones had a "snow" centre, about $\frac{1}{4}$ in. in diameter and the remainder of the "stone" was composed of very hard frozen ice. These "stones" remained on the ground for over five hours before dissolving, though the temperature on the hills after the storm was up to 70°F. These round ice stones were similar to those which fell at Peebles. The hills mentioned were about 3 miles north-east of Peebles, and the storm appears to have started at Peebles, and spent its fury in the open hills to the north-eastward, fortunately for everyone concerned.

We proceeded with the shoot after the storm, and 5½ brace of dead and wounded grouse were picked up, and also three rabbits. The keeper had a bad knock on his shoulder from a chunk of ice, but he recovered in a few moments, and got into shelter. A shepherd was hit twice, and the following day his arm looked as if it had been burnt, which possibly means he was struck by lightning. The storm appears to have followed a very narrow path, at a great speed, for about 5 miles.

ARTHUR VENABLES, Commander R.N., ret'd.

Onny Cottage, Bromfield, Ludlow. September 1st, 1930.

Thunderstorm, August 29th-30th, 1930

Before the severe thunderstorm on the above date the presence of instability at high levels was already indicated as early as August 27th at 04.30, when cumulus tops with false cirrus were visible above the west horizon; during the day alto-cumulus castellatus developed in the north-east between 16.00 and 18.00. August 28th, apart from early morning fog and some cirrus tufts to north-east at 12.00, was cloudless. Small hard convection cumulus first appeared at 14.00 on August 29th, but did not develop to any extent, and had disappeared by 17.00 at which hour there was considerable cirrus over the sky, dense in places.

At 19.00 well marked alto-cumulus castellatus was in evidence in the west and south-west, and cumulus tops were just showing above the southern horizon; an anvil, not well developed, was indicated in the north-west. Sheet lightning was first seen in the south-west at 19.45, and at 20.40 the rate of flash discharge averaged 20 per minute. Between 20.45 and 22.15 the flashes disclosed much false cirrus with alto-cumulus and very large towering cumulo-nimbus, separate storm centres being in evidence to south and west. Thunder was distant, and sheet lightning more frequent than fork. At 22.45 the rate of flash discharge had risen to 37 per minute, and the cloud sheet had become almost uniform. From a flat calm the wind rose in a

sudden squall at 23.05, and heavy rain commenced at 23.09; at this hour the flash discharge was at the rate of 50 per minute, there was a subsequent increase to 63 per minute at 23.30 which had decreased to 56 per minute at 23.45. Between 23.30 and 24.00 thunder and lightning were almost incessant. Lightning continued visible in the north and north-west, and distant thunder was heard to about 04.00 on August 30th. All times are G.M.T.

The above rates of flash discharge are in excess of any I have personally recorded in south-east England during the past 25 years. On August 22nd, 1917, a flash rate of 50 per minute was registered, and during the great storm on July 9th-10th, 1923, the maximum flash rate per minute was 47. The latter storm was of a more severe character, the majority of the flashes being of the cloud-to-earth type, and the thunder more intense and of very prolonged duration. During the present storm cloud-to-cloud flashes predominated, and the thunder, though intense, was not of prolonged duration.

SPENCER RUSSELL.

Worcester Park, Surrey.

It may interest some of your readers to know that during the thunderstorm here on the night of Friday to Saturday, August 29th-30th, 1930, the number of distinct lightning flashes per minute at one time reached 44. The values I obtained looking towards the north-east at quite a small patch of sky were:—

Time (B.S.T.)	No. of flashes per min.	Time (B.S.T.)	No. of flashes per min.
0.35	... 44	0.51	... 36
0.40	... 40	0.57	... 37
0.43	... 27	1.00	... 32
0.47	... 24	1.05	... 22

J. E. BELASCO.

21, Gunter Grove, Chelsea, S.W.10. Sept. 5th, 1930.

Rare Cloud Form

On July 12th I observed a remarkable formation of cloud similar to that which I had observed at Hastings in 1922 and recorded in your magazine shortly afterwards* and noted as the "Noah's Ark," so termed by the Orkney fishermen, who will not proceed to sea if such is observed. On each of these occasions the days were brilliant with sunshine, and after each a gale was experienced, although locally here at Bristol it was not felt, but in the Bristol Channel it was in force.

The character of this July cloud was similar in shape, but the north end was more pointed than the south end but its boat form was the same, the whole reaching from ENE to WSW,

*See *Meteorological Magazine*, 60, 1925, p. 215.

nearly half of the sky; the north end on its east side had an exquisite feathery edge, and the filling being of the alto-cumulus and alto-stratus type, whilst the north side developed a number of cubic strata portions: parallel with this large body was one smaller, with pointed ends and a formation like the backbone of a large fish and the under filling of stratus cloud. The whole formation had drifted by us soon after sunset; the first was observed about 7h. S.T.

HENRY A. ROGERS.

31, Fernbank Road, Redland, Bristol.

Halo Phenomena in False Cirrus

On August 12th, at 12.25 p.m., there was a row of cumulo-nimbus heads along the western horizon, the altitude of the highest being about 17° . From this there rose a large mass of false cirrus reaching exactly to the zenith. Rain began at 12.42 and ceased at 12.58, at which instant the cumulo-nimbus had passed and false cirrus was again visible. A brilliant parhelion of the halo of 22° appeared immediately above the sun, and so did a part of an inverted inferior arc of contact to the same halo. The halo was invisible, but the brilliance of the parhelion was almost as great as that of the sun itself, veiled, as it was, by much false cirrus. The *Meteorological Magazine* contains record of an observation of a mock sun in false cirrus at Aberdeen on November 27th, 1920. These observations would indicate that, since false cirrus gives rise to the halo type of optical phenomena, it consists of ice crystals and is therefore similar to the "true" cirrus. Capt. C. J. P. Cave (*Nature*, February 6th, 1926) has given measurements made on January 24th, 1926, of a sheet of alto-cumulus at a height of 10,000-10,500ft. with cirrus below it, appearing darker and travelling faster. It would appear unnecessary to class false cirrus as a separate form of cloud. Sir Napier Shaw has suggested the use of the term "low cirrus." To-day, at 11.18 a.m., an inverted superior arc of contact to an invisible halo of 22° was observed.

S. E. ASHMORE.

Windchistle Cottage, Grayshott, Hindhead, Surrey. August 17th, 1930.

Underground Water Level in the North Downs

The prediction made in July, 1929,* that the present year was likely to be one of low underground water level has not been fulfilled. Up to the end of September, 1929, scarcity of rainfall continued at Detling, but the succeeding four months entirely altered the outlook. From October, 1929, to January, 1930, inclusive, the rainfall amounted to 18.51in., and the number of rain-days to 93 out of a possible 123. The heavy

*See *Meteorological Magazine*, 64, 1929 p. 161.

rainfall, coupled with the persistence of the daily falls, caused the underground water level to rise quickly at the beginning of the present year.

The three hill wells reached a maximum level at the commencement of May; below the hill this was attained in March, being a month earlier in both cases than is normally experienced.

1930		Depth of Water	Diff. from Average (1911-29)	1930		Depth of Water	Diff. from Average (1911 29)
		ft. in.	ft. in.			ft. in.	ft. in.
May	Hucking	64 4	+3 5	Mar.	Detling	27 1	+7 8
„	Little Pett	55 3	+4 1		(Croft)		
„	Stockbury	40 0	-0 8	„	Detling	19 9	+6 8
					(Naylor)		

At Detling (Croft) where plumbings are taken daily the water level fell to 5ft. 9in. on December 1st, 1929, and a maximum of 27ft. 10in. was reached on March 15th, 1930. Since the attainment of maximum water levels, both on and below the hill, the rate of depletion has been slow, and a heavy rainfall in May, 3.93in., retarded the fall still further.

SPENCER RUSSELL.

The Croft, Detling, Maidstone, Kent. July 23rd, 1930.

NOTES AND QUERIES

Halo into Circumzenithal Arc

Dr. F. J. W. Whipple has kindly sent us the following letters from M. Louis Besson, of the Observatory of Montsouris, Paris: "The perusal of the note entitled 'Halo into circumzenithal arc' in the *Meteorological Magazine* for October, 1929, has led me to consult the statistics of the Montsouris Observatory. I have limited my search to the period from January 1st, 1919.

Since that date we have observed:—

Circumzenithal arc without 46° halo	...	...	91 times
46° halo without circumzenithal arc	...	...	32 times
The two simultaneously or consecutively	...	...	11 times
and lastly, a short arc of undetermined curvature which we call summit of 46° halo	...	...	35 times

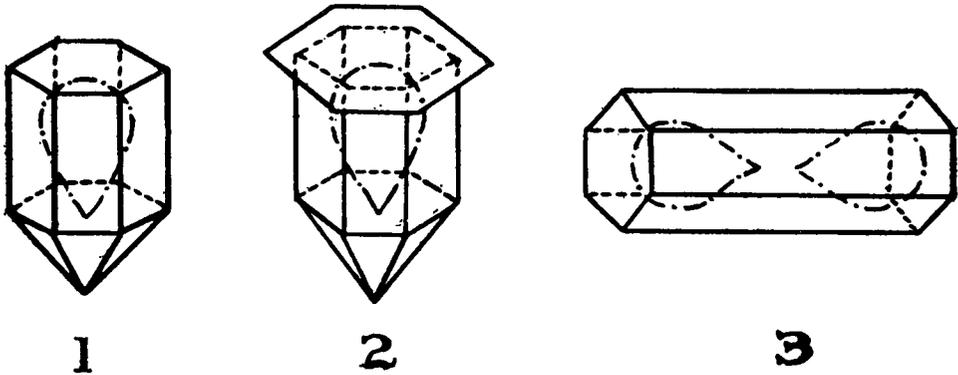
In the eleven cases in which the halo and the arc have both been seen:—

The arc succeeded the halo	...	...	.....	3 times
The halo succeeded the arc	...	...	...	0 times
The halo has been preceded and followed by the arc	...	...	...	1 time
The two phenomena have been visible together, at least during part of the time	...	...	...	7 times

The following, in my opinion, is the reason why we sometimes

see the halo, sometimes the arc:—

The fundamental form of prismatic ice is a hexagonal prism terminating at one end in a pyramid and enclosing a cavity. Nordenskjöld has compared these small bodies to bottles (form 1). The refraction of light in the dihedrons of 90° gives a phenomenon at 46° from the sun. If the dimensions of these bodies are almost the same in all directions, they have not any definite orientation in falling and the halo of 46° is seen. It may happen, however, that owing to the empty space inside, the pointed ends may be the heavier and the bodies have a certain tendency to stay vertical. The 46° halo is then reduced to the upper part (which is generally the case). In order that the circumzenithal arc should develop, the prisms must be orientated exactly vertical, which happens if they have in addition a projecting lamella forming a parachute (form 2). In a good proportion of cases the arcs, concave to the



sun, that are seen at 46° from the sun, are not the halo, but supralateral arcs produced by prisms with horizontal axes. Form 1 tends to take this position when its length is greater than its transverse diameter, but the horizontal position is chiefly taken up by form 3, which results from the union of two prisms at their points.

These ice forms are not at all hypothetical; they have been described or photographed many times.

In Mr. Parker's observations, it seems that form 1 elongated may at first predominate, giving the lateral arcs of the large halo (see sketches of the supralateral arcs). There was probably at the same time a maximum of light at the summit of the 22° halo (see sketch of the upper tangent arc of 22°). A little later, form 1 shortened, and finally form 2 acquired the predominance whence the appearances of the lateral parts of the halo of 22° , the disappearance of its upper part, concentration of the light at the summit of the 46° halo, and finally the appearance of the circumzenithal arc marking doubtless the apogee of form 2."

In his reply to this Dr. Whipple remarked:—

"Personally I find it difficult to believe that the ice crystals can develop caps to serve as parachutes sufficiently rapidly to

explain the transformation which I described in the *Meteorological Magazine*.

“ Perhaps the rôle played by turbulence in producing such phenomena has not been considered enough. If a shower of crystals fell from a turbulent region to a calm one it might happen that crystals which were oscillating violently in the turbulent region would get steady when they reached the calmer air. The result would be a transformation of the halo.”

M. Besson replied :—

“ As a general rule halo phenomena other than the 22° and 46° circles appear rather suddenly, sometimes even very suddenly. I remember in particular a parhelic circle, the whole of which suddenly became visible. An unknown factor had entered into play at the same moment over a considerable area. Now experience shows that the formation of small crystals is very sudden in solutions. Why should it not be the same in the atmosphere?

“ Your suggestion about the rôle of turbulence is certainly one to retain and examine. But I will first put a prejudicial question: Are there, in fact, any oscillations? I doubt it. A little lamella of cigarette paper of some tenths of a millimetre in diameter falls quite flat without any oscillations under ordinary pressure, and yet that is the form most subject to oscillations. Is it the same in rarefied air for bodies of the same dimensions or smaller? It would be necessary to make the experiment, but it appears probable to me. I suspect that the crystals are diverted from their normal orientation not by oscillations but by irregularities of form, either “ congenital ” or due either to evaporation or to a deposit of hoar frost.

Floods in Ceylon, May, 1930

Capt. A. J. Bamford has kindly sent us the following additional information about the floods in Ceylon, which were the subject of a brief reference in the *Meteorological Magazine* for June, page 128 :—

“ The days of heaviest rain were the 5th and 6th, when the centre of a depression was moving northward off the east coast, and on which the average rainfalls for the whole of the Kelani catchment were 5½ in. and 7 in. respectively. In most high Kelani floods in the past the bulk of the trouble has originated in a particular part of the catchment, where rainfall of the order of 15 in. or more has occurred. In this case comparatively few stations recorded over 10 in. in a day, but the striking feature was the universality of the heavy rain, not only over the whole of the catchment, but over a great deal of the rest of the island.

As early as the 7th, *i.e.*, after the rainfall figures of the 6th came in, I was able to say with melancholy confidence that we

were in for a 10ft. flood, which, owing to lack of data from previous floods, is as high as my rainfall river height coefficients go. As a matter of fact the maximum height as recorded at the standard (Nagalagan St.) gauge was 11ft. 1in. at about 1 a.m. on the 10th, which puts the crest about $1\frac{1}{2}$ in. above that in 1913. Your correspondent's excess of 3ft. may, of course, have occurred in a cul-de-sac. His reference to the 8th as the crucial day is probably due to this being the day on which one of the protecting embankments burst. As a matter of fact, the rainfall on that day was not so heavy, though quite bad enough to add to the difficulties of relief work and bund reinforcement. On the 9th, with the centre of the storm over southern India, it got in a further attack on us from the west, and was responsible for rain of the order of 4in. on that day."

The Development of Buys Ballot's Law

The name of Buys Ballot is to be found in almost every text book of meteorology and his law of the relation of wind direction and pressure distribution is taught in many schools which nowadays include elementary meteorology in their curriculum. It may therefore be of some interest to trace briefly the formulation of this law. Professor Buys Ballot, Director of the Dutch Meteorological Institute and Professor of Physics at Utrecht was amongst the pioneers in the use of synoptic meteorology for the issue of forecasts and storm warnings. In dealing with observations of pressure and temperature he made use of deviations from average values and in a paper* presented to the Paris Academy of Sciences in 1857 he discussed the results obtained from observations at three stations in Holland. After showing that strong winds are indicated by large differences between the deviations, he proceeded to explain that if pressure was higher at Helder than at Maastricht (*i.e.*, higher in the north than in the south), then the wind was from the east while if pressure was higher at Maastricht the wind was from west or north-west. In the *Jaarboek of the Meteorological Institute of the Netherlands* for the same year (published in 1858), p. 347, this conclusion is stated in more general terms. Translated into English it reads: "great barometric differences, within the limits of our country, are followed by stronger winds, and the wind is in general perpendicular, or nearly so, to the direction of the greatest barometric slope in such a way that a decrease of pressure from North to South is followed by an East wind, and a decrease from South to North by a West wind." In 1860 he published a paper entitled "Eenige Regelen voor aanstaande weersveranderingen in Nederland" (Some rules for approaching changes in the weather in the Netherlands), in which the law appears in its

* Note sur le rapport de l'intensité et de la direction du vent avec les écarts simultanés du baromètre. *Paris, C.-R. Acad. Sci.* 45, 1857, pp.765-8.

well-known form (p. 90). "Thus the rule for wind direction is this: if one places oneself in the direction of the wind with one's back to the place from which it is coming, then one has the lowest place (*i.e.*, pressure) on the left-hand just as in the case of hurricanes." These storms had long been known to have a whirling motion and the distinction between the anti-clockwise rotation in the northern hemisphere and the clockwise rotation in the southern hemisphere had been expounded by Dove in 1828.

Reviews

Wind Pressure on Buildings. Experimental Researches (First Series). By J. O. V. Irminger and Chr. Nokkentved, translated from the Danish by A. C. Jarvis and R. Halfdan-Nielsen. Size $10\frac{1}{4} \times 7$, pp. 88 + 47 diagrams. Copenhagen, 1930. Price 10 kr.

The wind pressure to which an engineering structure will be submitted is a matter of fundamental importance to engineers, who, in the absence of accurate knowledge on the subject, have to work to a high factor of safety in order to avoid risk of disaster. A single occurrence like the collapse of the Tay Bridge in 1879 in a gale may lead to the expenditure of hundreds of thousands of pounds in providing increased strength on future structures which, if the facts were fully known, would be found to be unnecessary. The importance of research into this subject is fully recognised. Two methods of inquiry are open: (1) experiments on models in a wind tunnel, (2) measurements made on actual buildings. The authors of the present paper hold that the best method of attack is to conduct a comprehensive series of model experiments and then with the knowledge so gained to proceed to full-scale measurements in the open. If time were of no object, there would be nothing to be said against this programme, but in view of the urgency of the problem it would seem better, if possible, to conduct the model and full-scale experiments simultaneously, regarding each as supplementary to the other in order to obtain practical answers to the questions which are so urgently confronting engineers.

For the model experiments described in the paper, the authors used a wind tunnel of about one square foot section in which were placed model spheres, cubes, prisms and buildings. The pressure at different points on the surface of each was then determined by the following ingenious method:—

A series of holes 1mm. in diameter was bored over the surface of the model, which was, in every case, hollow, the inside being connected to a manometer. All the holes except one being covered with adhesive tape, the pressure in the position of the one hole was then read off. The other side of the manometer was connected to a static head.

The results obtained are set out fully in diagrams, in some

cases tables being added. The authors call attention to a point which may easily be over-looked, *i.e.*, that in calculating the stress on a structure, it is necessary to take account of the internal pressure as well as the external. To determine the value of the internal pressure, they left silk threads through the holes in the models before covering the holes with adhesive tape, thus producing a model building with permeable walls. Actually it was found that all the holes could equally well be left open, the same result being obtained. These measurements show that in a wind of 25 metres per second, the internal pressure in a building may differ by as much as 3mm. of mercury from the static pressure in the surrounding air, and the importance of this fact with regard to obtaining accurate readings of barometric pressure in meteorological work is pointed out.

The intention of the authors being to confine their work to model experiments, it would be unreasonable to expect to find much reference to actual wind conditions and this side of the subject is treated in one chapter of five pages. Open-scale anemograph records are given to show the rapid changes of speed and direction of an ordinary wind and after reference to the data available, the conclusion is reached that in Europe a speed of 40 metres per second may be laid down as one which will practically never be exceeded.

The authors appear to write with considerable understanding of the subject and the frequent references to papers by other workers throughout the book show a very wide study. Among well-known English names to which reference is given may be mentioned Shaw, Dines, Cave and Taylor among meteorologists, and Sir John Wolfe Barry, Sir Benjamin Baker, Sir Ernest Stanton and Osborne Reynolds among engineers.

Tipos de distribución isobárica y de tiempo en el Golfo de Vizcaya. I. Introducción y generalidades. By the Director of the Observatory, M. Doperto, Trabajos del Observatorio de Igueldo (San Sebastian). Publ. 4. Size $8\frac{3}{4} \times 6\frac{1}{4}$ in., pp. 40, 16 diagrams, 1 pl. San Sebastian, 1929.

The northern coast of Spain offers little shelter from north-westerly and northerly winds; gales and a variety of line-squall, known locally as the "galerna" have at times brought disaster to the fishing fleets, so that "local forecasting" for that region is of great practical importance. For some years now the Observatory on Monte Igueldo at San Sebastian has been doing valuable work in forecasting conditions in the Bay of Biscay, and the present "Introduction" is stated by the author to be based on five years' study of synoptic data and over two years' work in actual forecasting for the region. A short summary of previous work on weather types is given, followed by a description, with diagrams, of 12 isobaric types and brief notes of the

weather usually associated with each type. The real test of a study of this kind is, of course, its usefulness in practice, but to the general reader the descriptions of types seem likely to be of considerable help in understanding the meteorology of northern Spain. Most of the studies of weather types date from before the rise of the polar-front theory, and Señor Doperto may be regarded as one of the pioneers in combining the Norwegian methods with the older methods of "types." A study of weather types on these lines for other parts of Europe would be of much service to the forecaster. An example of the local daily weather report is given showing the 7h. chart with "fronts" in the conventional markings; there are also spaces for a local forecast and any gale warning transmitted to the navigators' associations.

The author concludes with a useful note on the relation between state of sea and wind force and direction. He intends in future studies to extend the application of the Bjerknæs methods to the individual weather types, and we look forward with much interest to the publication of the continuation of this work.

S. T. A. MIRRLEES.

Books Received

- Annali dell'Ufficio Centrale Meteorologico e Geodinamico Italiano.*
Serie Seconda. Vol. XXIII. Parte II, 1901. Osservazioni degli Osservatorii Meteorici, Rome, 1929.
- Revista de Meteorologia y Aerologia.* Vol. I. Nos. 1-6, Dec., 1929 to May, 1930. Tacubaya D.F. Mexico, 1930.
- Royal Alfred Observatory, Mauritius*; Annual Report, 1928, and Results of magnetical and meteorological observations for January to June, 1929. Port Louis, 1929.
- The climatic factor in man's physical environment.* By Prof. R. de C. Ward (Scientific Monthly, XXX, 1930, pp. 170-83).
- Meteorology in Mysore for 1928*, being the results of observations at Bangalore, Mysore, Hassan and Chitaldrug. Thirty-sixth Annual Report, Bangalore, 1929.

Obituary

Professor Herbert Hall Turner.—We regret to learn of the death of Professor Turner on August 20th, at Stockholm, where he was attending a meeting of the International Union of Geodesy and Geophysics. Though primarily an astronomer and seismologist, he was well known to many meteorologists and served for a time on the Council of the Royal Meteorological Society. Prof. Turner was born at Leeds in 1861, and educated at Leeds Modern School, Clifton College and Trinity College, Cambridge. He displayed a genius for mathematics and graduated as second wrangler in 1882. In 1884 he became chief assistant at the Royal Observatory, Greenwich, leaving in 1893 to become Savilian Professor of Astronomy and Director of the University

Observatory at Oxford. He played a very large part in forwarding the international plan for mapping the heavens; among his other astronomical work may be mentioned his analysis of the periodicity of sunspots and his theory of the formation of sunspots by a swarm of meteorites derived from the Leonids.

Prof. Turner was elected a Fellow of the Royal Society in 1896, and from 1913 to 1922 he was one of the general Secretaries of the British Association. In 1913 also, after the death of Prof. Milne, he took charge of the latter's seismological bureau at Shide. A few years later the bureau was removed to Oxford under Prof. Turner's direction as President of the Seismological Committee of the British Association. His main interest in seismology lay in the investigation of periodicities, a subject which gave his mathematical bent full play in the improvement of methods of harmonic analysis, where he was one of the first to insist on the use of exact methods. In 1913 he published "Tables for facilitating the use of harmonic analysis"; he also investigated the long-period terms in the growth of the "Big Trees" of California, and developed a theory of "discontinuities" interrupting the regular periodic course of meteorological phenomena. His three papers on the latter subject in the *Quarterly Journals of the Royal Meteorological Society* for 1915 to 1917 were at the time the subject of much discussion. It was a great loss to the Society, on the personal as well as on the scientific side, that his numerous other activities prevented him from giving more time to meteorology.

News in Brief

Following the recent successful trans-Atlantic flight from east to west of the French airmen Costes and Bellonte, it is interesting to note that in addition to decorations bestowed on the pilots by the French Government, M. André Viaut of the forecast division of the Office National Météorologique, Paris, has been made Chevalier Légion d'Honneur in recognition of his work in connexion with the flight.

Corrigendum

August, 1930, page 164, footnote for "*Edinburgh Proc. R. Soc.*" read "*Edinburgh Trans. R. Soc.*"

The Weather of August, 1930

The first three weeks of the month were unsettled and generally rather cool and wet. For the first seven days heavy local rains or thunderstorms, due to a complex depression over the British Isles, were of almost daily occurrence, the largest falls in 24 hours being 1.89in. at Campsea Ashe, Suffolk on the 3rd and

2·60in. at Chewton Mendip, Somerset on the 6th; the temperature was considerably below the average, many places having maxima of 55-60°F. and minima below 45°F. The weather continued generally unsettled, although on the 10th and 11th the south-east of England had several maximum temperatures over 70°F.; on the 14th strong squally winds and local gales occurred in the rear of a deep depression which crossed northern Scotland. After this a temporary improvement set in and on the 16th good sunshine records were obtained, Harrogate having 14·3 hours of bright sunshine and Ross-on-Wye 13·9 hours. After a further period of unsettled weather with local thunderstorms, a vigorous secondary depression caused gales and heavy rain on the 20th and 21st. Several stations recorded over 2in. on the 20th and at Llyn Fawr Reservoir, Glamorgan, 3·51in. fell; at Borrowdale, Cumberland, 2·97in. fell in the 20th and 3·37in. on the 21st. During the last week of the month a great change took place, southerly winds bringing warm air from the western Mediterranean and giving rise to high temperatures. On the 27th maximum temperatures of over 80°F. were recorded inland over an area extending from Edinburgh and Dumfries to the south coast. For three consecutive days (27th-29th) temperatures rose above 90°F. in parts of London and on the 28th and 29th temperatures over 90°F. were recorded in other parts of England (see p. 177). The minimum temperature of 67°F. at Kew Observatory on the 30th is a record for the last ten days of August. Severe thunderstorms, accompanied by hail occurred in Scotland and northern England on the 28th and 29th (see pp. 178 and 184) and thunderstorms were experienced over a wide area in the night of the 29th-30th (see pp. 178 and 185).

The distribution of bright sunshine was as follows:—

	Total (hrs.)	Diff. from normal (hrs.)		Total (hrs.)	Diff. from normal (hrs.)
Lerwick	136	+ 5	Liverpool	204	+18
Aberdeen	154	+ 4	Ross-on-Wye	196	+22
Dublin	133	— 29	Falmouth	184	—27
Birr Castle	99	— 43	Gorleston	220	+14
Valentia	106	— 49	Kew	221	+34

Pressure was below normal over the British Isles, about normal over Sweden and was above normal over southern and central Europe and over an area extending from Iceland to Spitsbergen, the greatest excess being 5·9mb. at Spitsbergen. Temperature was above normal at Spitsbergen, London, Sweden and in Portugal, and was below normal in Switzerland. Rainfall was above normal in Spitsbergen, northern Europe and Switzerland; in Sweden it was generally about normal, but only half the normal in southern Scania and double the normal in eastern Gothaland. Unusually big falls in a single day were rather common in southern Sweden.

Severe storms occurred over many parts of France on the 3rd and again on the 6th, doing much damage to the vineyards and the harvest and causing floods near Chambéry. In several of the northern, central and Black Soil districts of Russia heavy rain during the early part of the month retarded the harvest. Heavy rainstorms were experienced near Innsbruck about the 13th. A thunderstorm accompanied by a whirlwind swept over Naples on the morning of the 14th and several persons were injured. At Lisbon a shade temperature of about 100°F. was recorded on the 15th. Rain fell in Berlin on most days during the first part of the month. During the greater part of the month cool weather was experienced generally over Europe but about the 25th there was a sudden rise in temperature over the whole of the central and southern regions, maximum temperatures exceeding 100°F. in Spain and reaching 93°F. at Paris and 86°F. at Berlin. Several deaths due to the heat were reported. A violent thunderstorm occurred over Paris on the 30th.

Severe and widespread floods occurred in Hondo (Japan) during the first days of the month following two typhoons off the northern coast. The rains were almost continuous for three days. Great heat occurred in Iraq about the 9th when a temperature of over 120°F. was reported. Floods occurred in the region between Tientsin and Mukden during the week ending the 11th. A typhoon swept across south-eastern Japan and the Sea of Japan on the 12th causing considerable damage. The Sind floods reported in last month's magazine continued throughout August and also extended over a wider area. Altogether 500 sq. miles on the west bank of the Indus were submerged. By the 25th the northern floods were believed to have reached their farthest limit and the southern floods were beginning to subside.

The special message from Brazil states that the rainfall in the northern and central regions was scanty with averages 1.54in. and 0.6in. below normal respectively, while in the southern regions it was plentiful. Seven anticyclones passed across the country. There were general and frequent frosts in the three southern states. Important crops suffered from the continued lack of rain, especially coffee, cotton, tobacco and sugar cane. At Rio de Janeiro pressure was 1.3mb. below normal and temperature 1.3°F. above normal.

Rainfall, August, 1930.—General Distribution

England and Wales	124	} per cent of the average 1881-1915.
Scotland	...	...	167
Ireland	...	...	153
British Isles	...	...	<u>142</u>

...

Rainfall: August, 1930: England and Wales

Co.	STATION	In.	Per- cent- of Av.	Co.	STATION	In.	Per- cent- of Av.
<i>Lond.</i>	Camden Square.....	2.94	133	<i>Leics.</i>	Belvoir Castle.....	2.07	79
<i>Sur.</i>	Reigate, Alvington....	3.37	137	<i>Rut.</i>	Ridlington.....	2.80	...
<i>Kent.</i>	Tenterden, Ashenden...	3.69	161	<i>Linc.</i>	Boston, Skirbeck.....	2.73	114
"	Folkestone, Boro. San..	2.60	...	"	Cranwell Aerodrome...	2.19	81
"	Margate, Cliftonville...	3.37	175	"	Skegness, Marine Gdns	2.26	93
"	Sevenoaks, Speldhurst	3.66	...	"	Louth, Westgate.....	2.31	82
<i>Sus.</i>	Patching Farm.....	3.86	153	"	Brigg, Wrayby St....	3.66	...
"	Brighton, Old Steyne..	3.83	176	<i>Notts.</i>	Worksop, Hodsock....	2.91	119
"	Heathfield, Barklye....	4.31	160	<i>Derby.</i>	Derby, L. M. & S. Rly.	2.26	87
<i>Hants.</i>	Ventnor, Roy. Nat. Hos.	3.01	151	"	Buxton, Devon Hos....	5.67	129
"	Fordingbridge, Oaklnds	4.81	183	<i>Ches.</i>	Runcorn, Weston Pt...	4.36	121
"	Ovington Rectory.....	3.28	121	"	Nantwich, Dorfold Hall	3.26	...
"	Sherborne St. John....	2.40	99	<i>Lancs.</i>	Manchester, Whit. Pk.	4.51	131
<i>Berks.</i>	Wellington College....	...	...	"	Stonyhurst College....	7.43	147
"	Newbury, Greenham...	2.92	111	"	Southport, Hesketh Pk	5.93	171
<i>Herts.</i>	Welwyn Garden City...	3.16	...	"	Lancaster, Strathspey	6.23	...
<i>Bucks.</i>	High Wycombe.....	3.53	152	<i>Yorks.</i>	Wath-upon-Dearne....	2.23	93
<i>Oxf.</i>	Oxford, Mag. College..	1.85	82	"	Bradford, Lister Pk...	4.20	155
<i>Nor.</i>	Pitsoford, Sedgebrook...	2.39	99	"	Oughtershaw Hall....	8.70	...
"	Oundle.....	1.70	...	"	Wetherby, Ribston H.	3.16	116
<i>Beds.</i>	Woburn, Crawley Mill	2.44	106	"	Hull, Pearson Park....	2.97	102
<i>Cam.</i>	Cambridge, Bot. Gdns.	1.55	66	"	Holme-on-Spalding....	4.47	...
<i>Essex.</i>	Chelmsford, County Lab	2.00	92	"	West Witton, Ivy Ho.	5.51	...
"	Lexden Hill House....	1.94	...	"	Felixkirk, Mt. St. John	2.90	102
<i>Suff.</i>	Hawkedon Rectory....	2.64	102	"	Pickering, Hungate...	2.93	...
"	Haughley House.....	3.35	...	"	Scarborough.....	3.07	110
<i>Norfol.</i>	Norwich, Eaton.....	2.39	101	"	Middlesbrough.....	3.38	123
"	Wells, Holkham Hall	1.60	67	"	Baldersdale, Hury Res.	5.43	...
"	Little Dunham.....	3.55	132	<i>Durh.</i>	Ushaw College.....	5.33	183
<i>Wilts.</i>	Devizes, Highclere....	3.30	114	<i>Nor.</i>	Newcastle, Town Moor	5.02	172
"	Bishops Cannings.....	2.96	95	"	Bellingham, Highgreen	4.23	...
<i>Dor.</i>	Evershot, Melbury Ho.	4.03	128	"	Lilburn Tower Gdns....	4.19	...
"	Creech Grange.....	3.42	...	<i>Cumb.</i>	Geltsdale.....	6.69	...
"	Shaftesbury, Abbey Ho.	2.46	84	"	Carlisle, Scaleby Hall	7.01	171
<i>Devon.</i>	Plymouth, The Hoe...	3.87	125	"	Borrowdale, Seathwaite	15.15	131
"	Polapit Tamar.....	4.08	128	"	Borrowdale, Rosthwaite	15.74	...
"	Ashburton, Druid Ho.	5.76	154	"	Keswick, High Hill....	8.56	...
"	Cullompton.....	4.12	135	<i>Glam.</i>	Cardiff, Ely P. Stn....	5.88	136
"	Sidmouth, Sidmount...	3.12	111	"	Treherbert, Tynywaun	10.11	...
"	Filleigh, Castle Hill...	5.40	...	<i>Carm.</i>	Carmarthen Friary....	4.86	105
"	Barnstaple, N. Dev. Ath.	4.07	123	"	Llanwrda.....	5.37	98
<i>Corn.</i>	Redruth, Trewirgie....	6.23	182	<i>Pemb.</i>	Haverfordwest, School	4.84	116
"	Penzance, Morrab Gdn.	4.78	151	<i>Card.</i>	Aberystwyth.....	4.67	...
"	St. Austell, Trevarna...	6.76	187	"	Cardigan, County Sch.	3.17	...
<i>Soms.</i>	Chewton Mendip.....	7.22	161	<i>Brec.</i>	Crickhowell, Talymaes	5.90	...
"	Long Ashton.....	5.17	...	<i>Rad.</i>	Birm. W. W. Tyymynydd	7.09	131
"	Street, Millfield.....	3.17	...	<i>Mont.</i>	Lake Vyrnwy.....	5.09	98
<i>Glos.</i>	Cirencester, Gwynfa...	...	...	<i>Denb.</i>	Llangynhafal.....	3.70	...
<i>Here.</i>	Ross, Birchlea.....	3.45	135	<i>Mer.</i>	Dolgelly, Bryntirion...	8.92	158
"	Ledbury, Underdown..	2.88	110	<i>Carn.</i>	Llandudno.....	3.20	106
<i>Salop.</i>	Church Stretton.....	2.85	88	"	Snowdon, L. Llydaw 9	17.56	...
"	Shifnal, Hatton Grange	2.29	81	<i>Ang.</i>	Holyhead, Salt Island	4.81	151
<i>Worc.</i>	Ombersley, Holt Lock	2.68	100	"	Lligwy.....	5.20	...
"	Blockley.....	2.63	...	<i>Isle of Man</i>			
<i>War.</i>	Farnborough.....	1.98	73	"	Douglas, Boro' Cem....	6.24	164
"	Birmingham, Edgbaston	3.17	117	<i>Guernsey</i>			
<i>Leics.</i>	Thornton Reservoir...	2.74	98	"	St. Peter P't. Grange Rd.	3.42	145

Erratum: Birm. W. W., Tyymynydd, July, for 6.88/167 read 6.38/155.

Rainfall : August, 1930 : Scotland and Ireland

Co.	STATION	In.	Per- cent of Av.	Co.	STATION	In.	Per- cent of Av.
<i>Wigt.</i>	Pt. William, Monreith	5·00	...	<i>Suth</i>	Loch More, Achfary...	9·64	165
"	New Luce School.....	...	...	<i>Caith</i>	Wick.....	5·57	202
<i>Kirk</i>	Carsphairn, Shiel.....	10·86	...	<i>Ork</i>	Pomona, Deerness.....	4·17	145
<i>Dumf.</i>	Dumfries, Crichton, R.I	7·07	186	<i>Shet</i>	Lerwick	4·36	145
"	Eskdalemuir Obs.....	8·08	157	<i>Cork</i>	Caheragh Rectory.....	5·90	...
<i>Roxb</i>	Branxholm	6·22	193	"	Dunmanway Rectory...	5·56	118
<i>Selk</i>	Ettrick Manse.....	8·98	...	"	Ballinacurra.....	4·69	126
<i>Peeb</i>	West Linton.....	5·74	...	"	Glanmire, Lota Lo.....	5·65	155
<i>Berk</i>	Marchmont House.....	4·70	142	<i>Kerry</i>	Valentia Obsy.....	7·96	166
<i>Hadd</i>	North Berwick Res....	4·70	149	"	Gearahameen.....	8·80	...
<i>Midl</i>	Edinburgh, Roy. Obs.	5·17	167	"	Killarney Asylum.....	5·48	124
<i>Ayr</i>	Kilmarnock, Agric. C.	5·44	139	"	Darrynane Abbey.....	7·85	181
"	Girvan, Pinmore..	6·62	149	<i>Wat</i>	Waterford, Brook Lo...	4·29	112
<i>Renf</i>	Glasgow, Queen's Pk.	5·37	152	<i>Tip</i>	Nenagh, Cas. Lough...	5·41	137
"	Greenock, Prospect H.	6·82	125	"	Roscrea, Timoney Park	5·65	...
<i>Bute</i>	Rothsay, Ardenraig.	8·09	166	"	Cashel, Ballinamona...	6·26	176
"	Dougarie Lodge.....	5·81	...	<i>Lim</i>	Foynes, Coolnanes.....	5·07	131
<i>Arg</i>	Ardgour House	10·78	...	"	Castleconnel Rec.....	5·69	...
"	Manse of Glenorchy...	8·74	...	<i>Clare</i>	Inagh, Mount Callan...	7·22	...
"	Oban.....	8·06	...	"	Broadford, Hurdlest'n.	6·21	...
"	Poltalloch	8·32	170	<i>Wexf.</i>	Gorey, Courtown Ho...	4·50	135
"	Inveraray Castle... ..	12·44	189	<i>Kilk</i>	Kilkenny Castle.....	6·06	174
"	Islay, Eallabus.....	8·93	205	<i>Wic</i>	Rathnew, Clonmannon	5·17	...
"	Mull, Benmore.....	20·00	...	<i>Carl</i>	Hacketstown Rectory..	7·95	196
"	Tiree .....	...	...	<i>Leix</i>	Blandsfort House.....	6·42	162
<i>Kinr</i>	Loch Leven Sluice.....	6·45	168	"	Mountmellick.....	5·73	...
<i>Perth</i>	Loch Dhu.....	8·95	133	<i>Off'ly</i>	Birr Castle.....	5·71	150
"	Balquhider, Stronvar	5·66	...	<i>Kild'r.</i>	Monasterevin	5·26	...
"	Crieff, Strathearn Hyd.	5·94	141	<i>Dubl</i>	Dublin, FitzWm. Sq...	5·04	166
"	Blair Castle Gardens...	5·79	171	"	Balbriggan, Ardgillan.	4·64	136
"	Glen Bruar, Bruar Ldg.	6·51	...	<i>Me'th</i>	Beauparc, St. Cloud...	6·18	...
<i>Angus.</i>	Kettins School.	6·13	185	"	Kells, Headfort.....	6·08	147
"	Dundee, E. Necropolis.	6·09	180	<i>W.M.</i>	Moate, Coolatore.....	5·69	...
"	Pearsie House.....	7·21	...	"	Mullingar, Belvedere..	6·47	155
"	Montrose, Sunnyside...	5·81	208	<i>Long</i>	Castle Forbes Gdns.....	5·76	141
<i>Aber</i>	Braemar, Bank... ..	5·38	158	<i>Gal</i>	Ballynahinch Castle...	9·62	175
"	Logie Coldstone Sch...	5·73	181	"	Galway, Grammar Sch.	4·59	...
"	Aberdeen, King's Coll.	5·95	217	<i>Mayo</i>	Mallaranny.....	9·85	...
"	Fyvie Castle.....	7·17	...	"	Westport House.....	5·78	143
<i>Moray.</i>	Gordon Castle.....	5·11	161	"	Delphi Lodge.....	11·08	...
"	Grantown-on-Spey.....	4·68	146	<i>Sligo</i>	Markree Obsy.....	7·29	167
<i>Nairn.</i>	Nairn, Delnies	5·20	216	<i>Cav'n.</i>	Belturbet, Cloverhill...	5·28	142
<i>Inv</i>	Kingussie, The Birches	3·17	...	<i>Ferm</i>	Enniskillen, Portora...	...	...
"	Loch Quoich, Loan....	12·35	...	<i>Arm</i>	Armagh Obsy.....	5·85	162
"	Glenquoich	11·87	140	<i>Down</i>	Fofanny Reservoir.....	10·40	...
"	Inverness, Culduthel R.	4·07	...	"	Seaford.....	6·57	175
"	Arisaig, Faire-na-Squir	7·49	...	"	Donaghadee, C. Stn...	5·12	154
"	Fort William.....	7·95	...	"	Banbridge, Milltown...	6·05	...
"	Skye, Dunvegan.....	7·32	...	<i>Antr</i>	Belfast, Cavehill Rd...	6·52	...
<i>R & C.</i>	Alness, Ardross Cas ...	7·05	239	"	Glenarm Castle.....	8·17	...
"	Ullapool	7·08	...	"	Ballymena, Harryville	7·69	180
"	Torridon, Bendamph...	10·14	154	<i>Lon</i>	Londonderry, Creggan	8·12	175
"	Achnashellach.....	9·80	...	<i>Tyr</i>	Donaghmore	7·87	...
"	Stornoway	4·80	121	"	Omagh, Edenfel.....	6·90	162
<i>Suth</i>	Lairg.....	6·68	...	<i>Don</i>	Malin Head.....	5·37	...
"	Tongue	5·86	183	"	Dunfanaghy.....	4·85	...
"	Melvich.....	...	...	"	Killybegs, Rockmount.	7·07	126

Climatological Table for the British Empire, March, 1930.

STATIONS	PRESSURE		TEMPERATURE						Mean Cloud Am't	PRECIPITATION			BRIGHT SUNSHINE		
	Mean of Day M.S.L.	Diff. from Normal	Absolute		Mean Values			Am't		Diff. from Normal	Days	Hours per day	Per-cent- age of possi- ble		
			Max.	Min.	Max.	Min.	1/2 max. and 1/2 min.							Diff. from Normal	
	mb.	mb.	° F.	° F.	° F.	° F.	° F.	in.		in.					
London, Kew Obsy.	1011.3	-2.1	58	26	49.8	36.7	43.3	+0.9	37.8	7.5	1.48	0.21	18	3.9	33
Gibraltar	1016.9	-0.1	73	44	66.5	50.5	58.5	+1.0	50.8	4.8	1.77	3.02	8	8.3	70
Malta	1015.1	+0.3	72	47	62.6	52.7	57.7	+0.6	53.1	6.2	0.31	1.17	3	..	..
St. Helena	1011.6	+2.1	..	59	..	..	..	..	61.7	7.7	3.31	1.63	15	..	..
Sierra Leone	1012.5	+1.8	90	69	85.9	72.3	79.1	-3.3	73.1	3.9	0.92	0.24	2	..	..
Lagos, Nigeria	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..
Kaduna, Nigeria	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..
Zomba, Nyasaland	1009.6	-0.1	85	61	77.8	64.4	71.1	-0.2	..	7.6	5.74	3.34	18	..	..
Salisbury, Rhodesia	1010.2	-0.1	85	53	76.1	58.6	67.3	-0.9	60.8	7.1	3.75	0.75	11	5.3	43
Cape Town	1015.1	+0.6	104	51	80.2	59.8	70.0	+1.9	60.7	4.2	0.47	0.41	8	..	..
Johannesburg	1015.1	+0.1	84	43	73.0	51.9	62.5	-0.8	54.0	4.6	2.80	1.64	9	8.0	65
Mauritius	1012.9	+0.9	87	66	84.4	71.1	77.7	-0.3	73.6	4.7	1.44	7.93	18	8.3	68
Bloemfontein	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..
Calcutta, Alipore Obsy.	1009.3	-0.6	99	63	93.4	70.8	82.1	+2.0	71.1	3.6	0.43	1.01	2*	..	..
Bombay	1009.9	-1.0	94	69	86.9	72.2	79.5	0.0	70.9	1.0	0.00	0.02	0*	..	..
Madras	1010.1	-0.8	94	67	90.2	72.7	81.5	+0.4	75.4	4.2	0.01	0.18	0*	..	..
Colombo, Ceylon	1010.2	-0.2	92	72	88.8	74.1	81.5	+0.2	76.6	6.5	2.67	2.00	7	7.9	65
Hongkong	1016.7	+0.6	77	47	68.8	60.1	64.5	+1.2	59.1	8.1	7.23	4.44	12	3.9	32
Sandakan	..	..	90	73	87.9	74.6	81.3	+0.2	77.1	..	3.68	4.37	7	..	..
Sydney, N.S.W.	1020.0	+3.8	83	55	73.8	62.5	68.1	-1.2	63.6	6.4	4.23	0.56	15	6.0	49
Melbourne	1020.7	+3.7	99	42	76.2	56.3	66.3	+1.8	58.1	4.9	0.46	1.80	6	6.9	54
Adelaide	1020.0	+2.9	106	49	85.3	60.5	72.9	+3.1	59.1	3.9	0.05	1.00	2	8.6	70
Perth, W. Australia	1016.4	+0.1	99	55	85.4	66.2	75.8	+4.7	65.6	4.1	0.32	0.46	5	9.1	74
Coolgardie	1016.6	+1.8	107	55	86.0	62.7	74.3	+2.6	62.4	5.7	1.49	0.75	8	..	..
Brisbane	1017.8	+3.4	87	60	80.5	64.7	72.6	-1.7	67.2	5.5	2.85	2.71	20	7.8	63
Hobart, Tasmania	1019.6	+5.6	86	41	69.7	51.0	60.3	+0.9	54.0	5.5	0.62	1.08	7	7.2	58
Wellington, N.Z.	1020.4	+3.2	70	43	64.9	52.3	58.6	-1.9	55.9	6.0	0.41	2.92	3	7.9	64
Suva, Fiji	1009.3	+0.8	92	70	86.4	75.5	80.9	+0.8	76.6	6.6	14.20	0.50	23	5.7	47
Apia, Samoa	1009.0	-0.2	89	72	86.4	75.5	80.9	+1.6	77.8	4.1	7.13	6.41	16	7.4	61
Kingston, Jamaica	1013.5	-1.4	87	65	85.5	69.4	77.5	+0.4	67.9	2.3	0.96	0.06	4	8.2	68
Grenada, W.I.	1010.4	-2.3	89	72	87.5	73.8	80.7	+3.0	73.8	3.4	2.25	0.49	12	..	..
Toronto	1009.4	-7.6	51	15	37.3	24.8	31.1	+2.2	25.8	6.2	3.20	0.56	17	4.5	38
Winnipeg	1016.0	-2.8	39	-13	28.5	9.8	19.1	+4.7	..	4.2	0.98	0.13	8	6.1	51
St. John, N.B.	1004.8	-9.4	48	4	37.3	23.2	30.3	+1.9	25.2	5.0	5.17	0.63	13	5.8	49
Victoria, B.C.	1018.8	+3.0	66	32	51.2	39.7	45.5	+2.3	40.6	7.8	2.25	0.30	13	5.3	45

* For Indian stations a rain day is a day on which 0.1 in. or more rain has fallen.