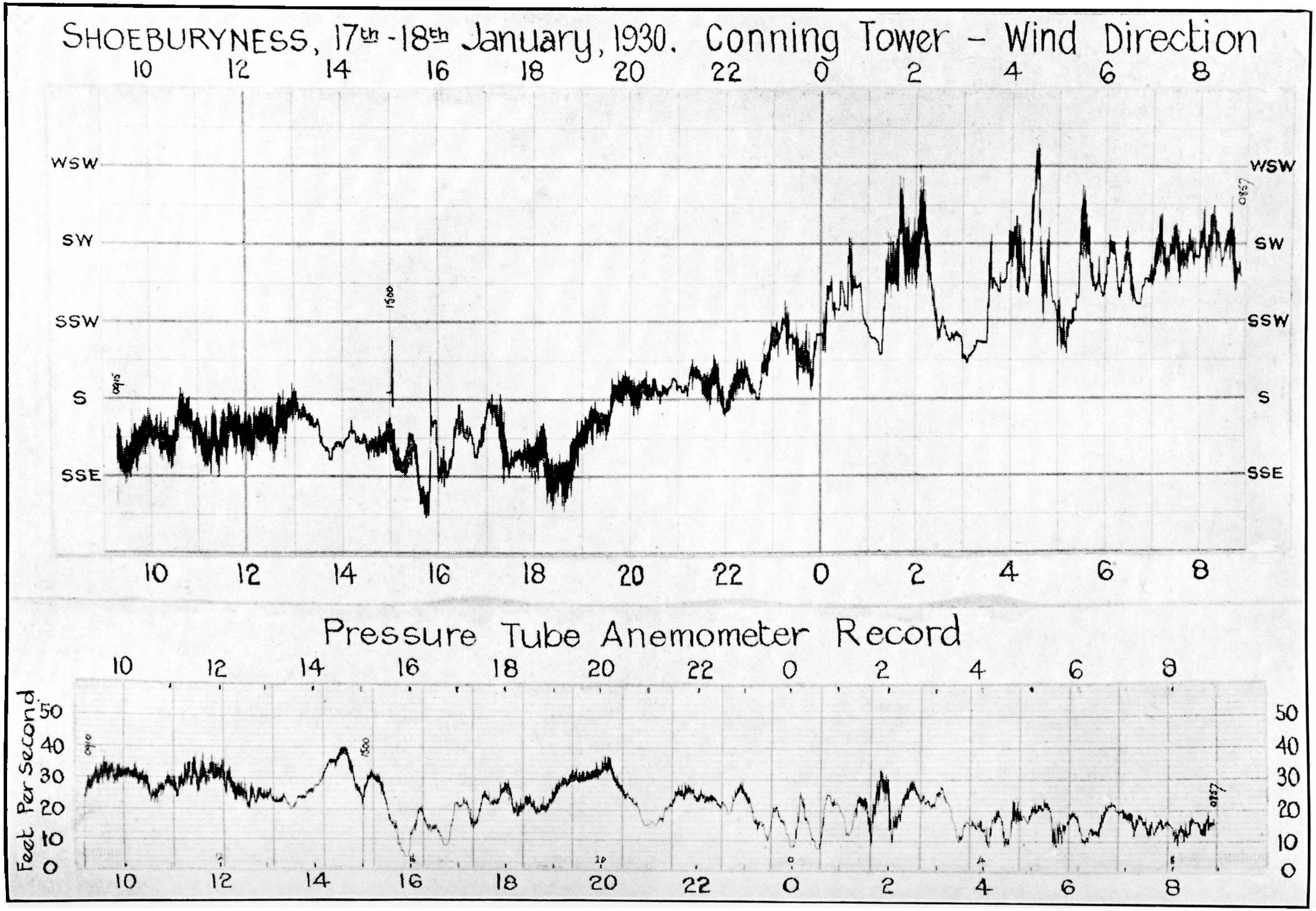

WIND RECORDS, SHOEBURYNESS, JANUARY 17TH-18TH, 1930—(*see* p. 92).

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On the Design of Raingauges for Tropical Use

By A. J. BAMFORD, M.C., M.A., B.Sc.

One of the items submitted for consideration by the recent International Conference at Copenhagen was a suggestion that it was desirable to standardise a definite form of raingauge for universal use. The implied idea that uniformity of apparatus will give comparable results in different parts of the world is at first sight a natural one. However, what we really want is comparable observations, and I submit that in order to obtain these in different parts of the world, under the very different conditions that exist, what is required is not uniformity of apparatus, but suitable variations in apparatus, to meet the various difficulties that arise under different conditions.

In a letter to the *Meteorological Magazine* in October, 1922,* I made the point that the standard 5in. gauge approved by the Meteorological Office as the most suitable for use in England underestimated in Ceylon—and I suspect would underestimate in most tropical climates. In that letter I supported my argument by figures from a number of gauges here over a period of several months, and attributed the deficit chiefly to evaporation. Comparative observations of eleven gauges have been maintained here for the last six years, so that I can now amplify the previous figures.

The standard rainfall is taken to be that from a specially

* Vol. 57, 1922, p. 240.

(89474) P.S. 14/89 1,050 5/30 M. & S. *Gp.303*

protected 8in. copper gauge with deep lip and two inner receivers, in addition to the outer cover, which itself acts as receiver if both the inner ones overflow. This outer cover is a copper cylinder of 8in. diameter. The inner receivers consist of a metal cylinder of 5in. diameter, and within it a graduated glass which overflows when the rainfall exceeds 0·65in. The rim of this gauge is 21in. above ground level and a mild windscreen is provided by its being enclosed by a fence 3 feet in height, consisting of wire netting (½in. mesh) on a wooden framework. The width of the enclosure is 14 feet. This gauge has the advantage of being read three times daily, so that in no case can water stand in it for longer than 15 hours. The close agreement between its figures and those of the self-recording (Richard) gauge is striking, but will not be discussed further here.

The main discussion in this paper turns on the relationship between the figures of six similarly situated gauges which are read only once daily. These six gauges have rims of 5in. diameter, and are arranged in line on open level ground at intervals of six feet with their rims 12in. above ground level. Of these the 1st, 3rd and 5th are of the standard London Meteorological Office type with buried conical base and metal cylindrical containers of diameter 4¾in. The inside of their funnels commences with a vertical drop of 5in., after which the cone slopes to a total depth of 7in. below the rim. These gauges are referred to below as of "M.O." type. The middle one of them has in addition a glass bottle receiver of diameter 5in. tapering to a narrow neck, which is only just large enough to receive the central vertical tube from the funnel. The 2nd, 4th and 6th gauges have funnels of the British Association type (abbreviated below to "B.A."), *i.e.*, a slope of 45° commences less than half an inch below the rim, and the 2nd and 6th have the ordinary B.A. receivers—metal cylinders of diameter 2½in. The middle one, No. 4, has a bottle similar to that in No. 3—the difference being that whereas in the case of No. 3 the bottle is in addition to the metal receiver, in the B.A. gauge it is instead of it.

Starting from the generally accepted ideas that the shallow funnel of a B.A. gauge will lose a little owing to splash, when compared with the deep lip of the M.O. standard, and that any gauge tends to underestimate if the altitude of its rim above the ground is increased, we might expect the M.O. gauges at one foot altitude to record most. The experimental facts do not follow this expectation, and as there appears to be no reason why the accepted variations due to splash and wind eddies should not be in operation here, I attribute the discrepancy between the expectation based on those causes alone and the experimental facts, to the existence of additional distorting causes, notably evaporation.

The standard 8in. gauge has the highest figures throughout, and in the table below the amounts recorded by other gauges are expressed as deficits below this amount. Looking at the grand totals first, it will be seen that on days of low rainfall (*i.e.*, less than 0·2in. or 5mm.) the M.O. gauges show an average deficit of 9 per cent., which is more than 2 per cent. greater deficit than the B.A. gauges, whose figure is 6·9 per cent. The gauges with glass receivers recorded greater amounts than those without, but again the M.O. gauge recorded less than the B.A. one, though by a smaller amount than in the previous case. This may be expressed otherwise by saying that the effect of the bottle receiver is greater in the case of the M.O. gauge, where it constitutes an addition, than in the case of the B.A. gauge, where it is simply an alternative, and where the original form does not leave so much room for improvement.

Looking next at falls of from 0·2in. to 1·0in. in 24 hours, we find that the percentage deficits are lower, but again the unmodified M.O. gauges lose more than the B.A. ones. The effect of the bottle under the B.A. rim is less than 0·1 per cent., but under the M.O. rim it is considerable and gives the smallest deficit of the whole set.

In the case of rainfalls above 1in. we cannot expect the same accuracy. An observer who could make repeated measurements of, say, 6in. using a ½in. glass, and never deviate by 0·01in. from the truth would be superhuman. For comparisons, however, we can accept six-year summaries without compunction, and the most striking thing is the lack of variation between the different gauges. With falls of over 1in. the atmospheric humidity will in general be high, liability to evaporation is less, and instrumental precautions to prevent it, that were necessary in other cases, are no longer so important. Under B.A. rims the difference between metal and glass receivers is inappreciable. Under the M.O. ones the glass receiver actually loses the most, suggesting that evaporation from the stored rain in the receiver is unimportant in this case. All the B.A. rims show less than the M.O. ones, presumably because of loss by splash, which had been masked by the evaporation effects in the case of smaller falls. It may be noted here that falls of small amount are frequently intense so far as rate of fall is concerned, so that it is unlikely that the percentage effect of splash is much greater in the case of large ones.

An incidental comment on the loss by evaporation in Ceylon is supplied by the self-recording gauges. When no rain falls, their pens draw horizontal lines at heights depending on the amount of water left in the cylinders. When an appreciable drought occurs this line gradually sinks on the charts of successive days, despite the fact that the float covers nearly all the water surface and the air in the upper part of the cylinder is stagnant. The amount of this sinkage averages about 0·025in. in a dry fort-night. The numerical result does not admit of exact interpretation, as it depends on the small amount of clearance round the float, but the fact that the loss is a measurable quantity is significant.

Thus far the discussion has been essentially on the lines of my previous letter in 1922, amplified by the longer period of observation, and the greater variety of receivers, but a further point may be considered. Instead of referring to deficits as percentages of total falls we can divide them by the number of days with rain and express them as mean deficits per observation, and here we come up against a further point with regard to the evaporation.

If we think of the loss from the collected water in a cylindrical container, the evaporating surface will be of the same extent whether the container is a quarter full, or three-quarters full. It will only be reduced if the amount of rain is insufficient to cover the whole base. If we consider this cause alone, we might expect the loss per observation to increase slightly with increased amounts of rainfall up to what is necessary to cover the whole base of the receiver, and then remain constant. Allowing for the fact that the atmosphere will in general be drier on days of little rain, we must superimpose on the above a tendency for greater loss per observation on the days of less rainfall. However, when we examine the actual deficits we find that while rainfalls of less than 0·2in. per day show a mean loss of from ·004in. to ·005in. per observation, this amount goes up to about ·010in. for the stage from 0·2in. to 1·0in. (5 to 25mm.), and to ·016in.-·018in. for the heavy falls, although the cross section of the receiver is unaltered throughout in the case of M.O. receivers, and only increases in the two outer B.A. ones when over $2\frac{1}{4}$in. have fallen. The increase does not appear to be due to direct error in the diameters of the gauges, since such an error would vary directly with the amount measured.

Thus both types show deficits, apparently due to evaporation, whose amounts per observation increase slightly with the quantity of rain, and which cannot be explained by evaporation from the water at rest in the container. This loss presumably takes place while the water is on the surface of the funnel, and in the down pipe. Clearly water does not remain for long on the surface of the funnel, but while it is there, it is spread in a thin film peculiarly susceptible to evaporation, and all the time rain is falling, the funnel has a thin film of water over it.

The deep-lipped funnel thus encourages evaporation by the mere fact that the rain has a longer journey over its surface than in the case of the shallow one. But this is not all. Rain normally reaches the earth at Colombo at a lower temperature than that of the gauge it encounters.* Consider two funnels of

* Measurements of rain temperatures have been made at Colombo for about three years.

similar design but of different thickness. The thicker one will have higher heat capacity and will take longer to cool down under the effect of the rain. During this process it will stimulate evaporation more than the lighter one. The deep lipped M.O. gauge has a vertical drop of 5in. before the sloping part of the funnel commences. The whole surface that is liable to be wet is over 100 sq. in., or about three times that of the shallow B.A. gauge. With rain falling obliquely half this area may not be wet, but even so the M.O. funnel would have a wet surface of more than half an much again as the B.A. one. This is certainly not an overestimate because one special asset, rightly claimed for the deep lip, is that it saves loss by splash, and if this saving is appreciable it means that the part of the inner surface of the funnel that is sheltered from directly falling oblique rain will yet be wet from splash. We have thus the fact that, so long as rain is in progress, both gauges provide a possible evaporating surface of greater extent than that of the still water in the receiver, and that this area is considerably greater in the M.O. gauge than it is in the B.A. one.

In the temperate zone loss due to this point is probably trivial, but a brief consideration of the quantities concerned shows that it may be expected to be appreciable here. The average evaporation as measured at Colombo is over 80in. per year (Hann puts it as 2-3 metres as a tropical generalisation!) and though evaporation is not working at this rate during heavy rain, the comparison with the English figures of less than 20in. is enough to support the idea of evaporation being altogether a more serious factor here.

It will be seen from the table that the deficits in the south-west monsoon are consistently less than those at other times of year. At first sight we may explain this by saying that the humidity is apt to be higher then, but a further point can be made from it, regarding the importance of evaporation from the funnel compared to that from the receiver. In the south-west monsoon rain may occur at any hour of the day, and on occasions water may have to stand in the container for nearly 24 hours. At other times of year there is very little rain between 8 a.m. and 4 p.m., and hence there is seldom opportunity for evaporation during the worst heat of the day. A faulty container therefore appears to have more scope during the south-west monsoon than at other periods.

Consider now losses from the surface of the funnel. Rain coming during the north-east monsoon, or inter-monsoon thunderstorms, may fall in the afternoon on to a gauge that has been standing in bright sunshine through the heat of the day and which, a few minutes before the rain commenced, was unpleasantly hot to touch. If rain occurred at the same hour during the south-west monsoon, the gauge would probably have been standing under a cloudy sky for several hours previously, and the humidity of the surface air would be high. Thus while evaporation from the funnel is postulated whenever the funnel is wet, we should expect evaporation losses due to faulty funnels

		No. of Observations.	Amount Standard Gauge.	Deficits in gauges at 12in.			
				M.O.	M.O. + bottle	B.A.	B.A. + bottle.
Falls of less than 0·2in.							
	S.W. Monsoon ...	298	19·59	1·62	1·06	1·39	·96
	N.E. & Inter-Monsoon	277	17·18	1·70	1·24	1·13	1·14
	All	575	36·77	3·32	2·30	2·52	2·10
Per-centage loss	S.W. Monsoon ...	—	—	8·3	5·4	7·1	4·9
	N.E. & Inter-Monsoon	—	—	9·9	7·2	6·6	6·6
	All	—	—	9·0	6·3	6·9	5·7
Loss per Observation	S.W. Monsoon ...	—	—	·0054	·0036	·0047	·0032
	N.E. & Inter-Monsoon	—	—	·0061	·0045	·0041	·0041
	All	—	—	·0058	·0040	·0044	·0037
Falls of from 0·2in. to 1·0in. ...							
	S.W. Monsoon ...	186	88·76	1·90	1·07	1·76	1·44
	N.E. & Inter-Monsoon	217	111·42	2·62	2·23	2·12	2·32
	All	403	200·18	4·52	3·30	3·88	3·76
Per-centage loss	S.W. Monsoon ...	—	—	2·1	1·2	2·0	1·6
	N.E. & Inter-Monsoon	—	—	2·4	2·0	1·9	2·1
	All	—	—	2·3	1·6	1·9	1·9
Loss per Observation	S.W. Monsoon ...	—	—	·0102	·0058	·0095	·0077
	N.E. & Inter-Monsoon	—	—	·0121	·0103	·0098	·0107
	All	—	—	·0112	·0082	·0096	·0093
Falls of less than 1in.							
	S.W. Monsoon ...	82	168·49	1·20	1·25	1·31	1·21
	N.E. & Inter-Monsoon	109	212·00	1·82	2·02	2·11	2·19
	All	191	380·49	3·02	3·27	3·42	3·40
Per-centage loss	S.W. Monsoon ...	—	—	0·7	0·7	0·8	0·7
	N.E. & Inter-Monsoon	—	—	0·9	1·0	1·0	1·0
	All	—	—	0·8	0·9	0·9	0·9
Loss per Observation	S.W. Monsoon ...	—	—	·0146	·0153	·0160	·0148
	N.E. & Inter-Monsoon	—	—	·0167	·0185	·0194	·0201
	All	—	—	·0158	·0171	·0179	·0178

to be relatively less marked in the south-west monsoon, and reference to the table shows this to be the case.

It must be remembered that the Observatory standard gauge, though specially made, and emptied three times a day (which is a precaution not possible at every outstation) must lose something by evaporation from the funnel. The deficits plotted are only the excess of deficit in the case of small gauges, with relatively high heat capacities. As explained above, this does not prevent the comparison between them being rigid.

The principle that in tropical raingauges all unnecessary metal in the funnel is to be avoided receives practical support from another very prosaic source. Quite apart from meteorological considerations a stout copper gauge at a lonely outstation invites theft even more than a cheaper one does! Probably most tropical services will have to depend for some of their rainfall figures on stations where this risk occurs, and at least some of the gauges must have a hasp, padlock and chain. This at once suggests rivets which are anathema—but the lesser of two evils.

Summary.

The suggestion is that to guard against evaporation the ideal funnel for a tropical gauge should have as small a surface, and be of as light weight (low heat capacity) as possible. In practice the surface area cannot be cut down beyond what is necessary to guard against splash, nor the weight below reasonable strength. In passing it is worth noting the corollary. All metal gauges underestimate slightly in the tropics.

Of standard types the English M.O. (which is a snowgauge as well as a raingauge) has a greater surface and heat capacity than is necessitated by these limits, and the B.A. one is preferable. However, where gauges are made locally and dimensions are at choice, I prefer a slightly deeper funnel than the B.A. type as an anti-splash precaution.

2. Open containers of cross section approximating to that of the rim of the funnel allow unnecessary loss by evaporation. This loss can be reduced by supplementing them by inner containers, consisting either of metal cylinders of smaller section, or glass bottles. In experiments at a fixed Observatory under close observation there is little to choose between them, but for outstation use the small metal receiver is probably better, owing to the risk of glass receivers getting broken.

3. A certain proportion of the gauges will require a hasp, padlock and chain. Dangers arising thereby from rivets must be accepted, and guarded against by inspection.

Royal Meteorological Society

The monthly meeting of this Society was held on Wednesday, March 16th, at 49, Cromwell Road, South Kensington, Mr. R. G. K. Lempfert, C.B.E., M.A., F.Inst.P., President, in the Chair.

S. K. Banerji, D.Sc.—The electric field of overhead thunderclouds.

Changes in the electric field produced by eighteen thunderclouds during their passage over the Colaba Observatory in 1929 are discussed in the paper, and these suggest that the majority of them were of the "unitary type" and had their front part negatively charged, the central part positively charged, and the rear negatively charged. A few were of the "double type" and produced changes in the field as if two thunderclouds of unitary type had passed over in succession. In those thunderclouds which caused heavy rainfall, fluctuations in the central positive field, sometimes very rapid and violent, were found to occur on account of loss of charge by rainfall or increased concentration of positive charge owing to increased vertical current, in agreement with the breaking-drop theory.

The monsoon clouds produced an electric field, which was pre-eminently negative during periods of rainfall. The observations appear to support the breaking-drop theory of the origin of electricity in non-thunderstorm rain.

F. J. W. Whipple, Sc.D.—The great Siberian meteor and the waves seismic and aerial which it produced.

On June 30th, 1908, a great meteor fell in Siberia, probably the greatest meteor which has occurred in historic times. The blast of air produced by the meteor devastated the forests over an enormous area. A Russian scientist, Leonard Kulik, explored the region in 1927 and found the numerous holes in which, it is presumed, the fragments of the original meteor are buried.

Although the descriptions of eye-witnesses are very vague, the time at which the meteor fell can be determined accurately, for the impact of the meteorites caused seismic waves which were recorded at four observatories. The most distant of these observatories was Jena. Remarkable waves recorded by sensitive barographs in England on June 30th, 1908, were discussed by Dr. W. N. Shaw at the time; the coincidence of date was noticed by Mr. C. J. P. Cave in 1929, and it is now clear that the air waves were produced by the meteor. The waves took five hours to travel from Siberia to England, the velocity being a little greater than that of the waves due to the famous eruption of Krakatoa.

In a written contribution to the discussion of Dr. Whipple's paper, Mr. Spencer Russell recalled the unusual sunset effects which were observed on the continent and in England on June 30th, 1908, and the succeeding nights. As seen from Epsom the northern sky was of a suffused red hue varying from pink to an intense crimson. On the night of July 1st and July 2nd, twilight was prolonged to daybreak and there was no real darkness.

Erratum

April 1930, page 62, Table I, at head of last column *for* "T_1''" *read* "T_{11}''."

Correspondence

To the Editor, *The Meteorological Magazine.*

Drifting of London Fog

On Easter Sunday, April 20th, I observed here (39 miles from London) what I believe to be patches of London fog carried away by a wind of small velocity. The afternoon was very dark and rain, sleet or hail fell continuously for more than seven hours from 12h. 8m. G.M.T. At 12h. 40m. the darkness became intense and the precipitation became heavier. The most interesting feature was the peculiar yellow light which suffused the sky and caused terrestrial objects to take on an unusual tint. This continued until 13h. 15m. when the light became normal, although the gloom persisted. At 14h. 40m. the phenomenon was repeated. The darkness was greatest and precipitation heaviest at the time when the yellow colour was strongest. The colour was not of uniform intensity over the whole sky. The cloud direction was easterly, but the motion was almost imperceptible. A dead calm lasted for six hours after midday, a most unusual occurrence here. The yellow colour was exactly that of a London fog and the observations have led me to conclude that a patch of high fog over London had been detached and carried away, the velocity of the wind being too small for rapid dispersion of the fog. We are 661 feet above sea level here. I can recall a similar occurrence in the spring of 1920. It would be interesting to hear whether others at a similar distance from London have seen this phenomenon. S. E. Ashmore.

Windwhistle Cottage, Grayshott, Hindhead, Surrey, April 24th, 1930.

Early Weather Record

In view of the recent establishment of an observing and forecasting centre at Cardington Airship Base, the following letter, published in Vol. LIV of the *Philosophical Transactions of the Royal Society,* may be of interest to your readers :—

"An account of the degree of cold observed in Bedfordshire, by John Howard, F.R.S., in a letter to John Canton, M.A., F.R.S., read April 12th, 1764."

Sir,

I would beg leave to acquaint you of a degree of cold that I observed at Cardington, Bedfordshire, the 22nd of November last, just before sunrise; Fahrenheit's scale, by one of Bird's thermometers, being as low as ten and a half. If it will throw any light upon the locality of cold, or think it worth the society's observation, would leave to your better judgement, and remain, with great esteem, Sir,

Your obedient Servant,

John Howard.

John Howard's meteorological zeal is further evidenced in the

16th volume of *The Gentleman's Magazine* which states " On the frost setting in, he used, during the continuance, to leave his bed at two every morning for the purpose of observing the state of a thermometer which was placed in his garden at some distance from his house," while in a letter dated April 9th, 1786, written at Malta to a maternal relative, Mr. Tatnell, John Howard says: ". . . . We lay by contrary winds several days close to Messina, Catonia, Syracuse, etc., and saw the dreadful effects of the earthquake about two years ago in Sicily. Soon after we met a sad storm, but happy for us, it lasted only four hours and we arrived here about ten days ago. . . . ."

A perusal of John Howard's biography indicates that he collected the data for prison reform, with which he was so closely connected, with great care, and it is therefore probable that his meteorological observations were similarly noted. If still in existence they would be of considerable interest, but though preliminary inquiries have not yet been successful, further attempts to trace the records are being made.

W. A. L. Marshall.

Royal Airship Works, Cardington. February 24th, 1930.

[A brief search in the libraries of the Meteorological Office and R. Meteor. Soc. failed to find Mr. John Howard's records.—Ed. *M.M.*]

Weather Lore of Normandy

A glance through a recent publication (Folk tales of Normandy, W. Branch Johnson, Chapman and Hall, 1929) reveals many interesting items dealing with weather lore. A few are given below.

Fishermen used to say that the winds dwelt in a great palace like the children of Aeolus in Homer. A popular name for the wind is Bonhomme Hardy—he who likes to go about opening windows by force. The patron saint of the wind is St. Antoine, whose aid used to be invoked by the sailors of the Pays de Caux in a curious manner—they used to plunge into the sea reciting a sort of prayer; when they wished the wind to abate they would sing soothing lullabies to the Saint. The whole proceeding has rather a magical flavour.

There is a Sussex saying that when it snows " they are plucking geese in Scotland," but this pales before the reason given by the folk of the Bay of Mont-St. Michel :—" the good God is plucking His geese to prepare them for the marriage of His daughters at Easter."

Apparently the Normans retain some fragments of the beliefs of their Norse forbears, for instance, the Norsemen said the rainbow was a bridge joining heaven and earth, the modern Normans say it is the shadow of such a bridge. It is difficult, however, to account for the idea held by sailors that the rainbow sucks up water from the sea, and should a boat happen to sail through the spot where the rainbow touches the sea, it, too, is in danger of being sucked up, as, it is said, has happened. One suspects occasions where a rainbow has been observed by sailors on a small localised thunder-shower (with perhaps a waterspout) when a boat has been wrecked. In such circumstances a boat in or near the shower might be seen by watchers at a distance to be at the foot of the rainbow.

As in other parts of France priests are believed to have power over the elements, one priest in Lower Normandy going by the name of the Cloud Splitter. These powers are also shared by witches and shepherds, and many are the tales told by the peasants.

A poetic idea is that in the lightning the Blessed Virgin may sometimes be seen—also when a sudden light breaks through a storm cloud. Another strange notion, the origin of which is rather obscure, is that when a Pope dies, a cloud is said to bow before the cardinal whom Heaven has chosen to succeed the dead Pontiff.

CICELY M. BOTLEY.

Guildables, 17, Holmesdale Gardens, Hastings, December 21st, 1929.

NOTES AND QUERIES

"Gliding Surfaces" and Fog Formation

The interesting note from Mr. J. Durward in the April number of the magazine, dealing with fog formation in Egypt, raises certain theoretical points of some difficulty. Suppose we have a sloping surface of discontinuity, with the colder air below it, cutting the earth's surface to form a " front " roughly parallel to the isobars. Then it can readily be shown (either directly or from a formula of Margules) that the higher pressure and the steeper pressure gradient lie on the same side of the front, whether the air on that side is cold or warm. This condition is not satisfied on the isobaric chart accompanying Mr. Durward's note. It may also be noted that the centre of the anticyclone was nearer to Ismailia, where there was a calm, than to Heliopolis, where there was a wind of force 5.

The presence of sloping inversions in anticyclones has often been pointed out by Dr. Georgii and others, but the existence of downward sliding of the warm air relative to the cold air has never been proved. In the case of sluggish anticyclones such a process presents very formidable theoretical difficulties. A possible alternative explanation of the observed facts is a slow subsidence of both the cold and the warm air masses, varying somewhat with locality. This should be considered in conjunction with turbulence, radiation, horizontal movements, temperature, and humidity, including condensation and evaporation. All these factors react on each other in a complex manner, and there are few problems in synoptic meteorology in which it is legitimate to ignore any of them.

Patches of cold fog lying close to warm dry air are frequently observed in suitable conditions in England, and there is a marked tendency for calms and light winds in the foggy regions, owing to the smaller lapse rate and the correspondingly smaller amount of turbulence. These conditions are not necessarily associated with sloping surfaces of discontinuity.

C. K. M. DOUGLAS.

Rhythmic Changes in Air Movement

Vol. 57, No. 673, of the *Meteorological Magazine* contains reproductions of the wind, pressure, and temperature records obtained at Southport on January 11th, 1907, together with some remarks by Mr. J. Baxendell on their periodic character. Wind records showing similar features were obtained at Shoeburyness during the 24 hour period commencing at 9h. on January 17th, 1930, photographs of which appear as the frontispiece of this number of the magazine. The instruments used are a Baxendell recorder for wind direction, and a Dines anemograph for wind speed. The other autographic instruments in use at Shoeburyness are not sufficiently sensitive to warrant the inclusion of reproductions of the records given by them during the same period.

The wind records, unlike those of Southport, exhibit variations whose periodic nature is much more strongly marked as regards speed than direction, the effect being enhanced by the exceptionally small gustiness prevailing at the time. This is due in part, no doubt, to the peculiarities of the site of the Shoeburyness anemograph, the head of which is 100ft. above mean sea level, and about 200yds. from the sea shore which runs north-east and south-west, the surrounding country being extremely flat for many miles. This exposure rivals that of sea stations, such as the Bell Rock Lighthouse, described by Mr. Bilham in a recent number of the *Meteorological Magazine*.

The persistence between 23h. on the 17th and 6h. on the 18th of a variation in wind speed having a period of approximately half-an-hour cannot fail to be noticed; while at other times during the day similar rhythmic changes of a less pronounced character can be seen. The changes in wind direction are much less regular. It will be noticed that, even with the wind in the south-west, *i.e.*, blowing parallel to the coast, the gustiness is remarkably low.

According to Baxendell the two principal conditions favouring, but not essential to, the production of periodic changes in air movement, are a west wind and an anticyclonic protuberance.

Neither of these conditions was fulfilled in the present case. An examination of the synoptic charts shows a high pressure area centred over Poland, and a complex depression to the south of Iceland, there being no indication of an anticyclonic protuberance in the neighbourhood of the British Isles. The wind was in a southerly quarter throughout the day.

D. W. JOHNSTON.

Halos

The latest addition to the series of monographs on Cosmical Physics, published by Henri Grand, of Hamburg, is devoted to halos and allied phenomena.* The author, Professor Rudolf Meyer, of Riga, explains in the preface to the book that the subject was to have been dealt with by Erich Barkow, who, as a member of the German Antarctic Expedition, had observed many halo phenomena himself. On Barkow's death Professor Meyer undertook the task of preparing the book. The reader may regret that the personal touch is lost; we do not catch the enthusiasm of the observer who has himself seen strange things in the sky. On the other hand, we have the conscientious work of an author who has studied the literature of the subject very thoroughly and who presents impartially the theories which have been proposed in explanation of the phenomena. The general title halo phenomena is regarded by the author as covering all phenomena due to the reflection or refraction of light by ice crystals. This is, of course, in accordance with precedent. One cannot help wishing, however, that some more suitable term could be found. A sun pillar or a parhelion is not a halo, and either may occur without any halo being visible. It would be an aid to clear thinking if we could refer to these by such a term as chionismic phenomena, χιων being a Greek word meaning snow.

The book before us is in four sections: the first is devoted to descriptions and the results of observations, the second to the general explanation of halo phenomena, the third to the detailed explanation of the various individual phenomena, whilst the fourth gives instructions for observers.

In the first section Meyer emphasizes the need for more observations of a specialised character, as, for example, observations of the polarization of halos and photometric observations of their brilliance. Some standardization of observations is required so that such questions as whether the frequency of halos depends on the sunspot cycle may be settled. The appearance of the ordinary halo of 22° is popularly regarded as a sign of coming bad weather. Solberg is quoted as saying that

* Problems der Kosmischen Physik, Vol. xii, Die Haloerscheinungen, by Prof. Dr. Rudolf Meyer, Riga. Size 9 by 6 in., pp. viii+168, *Illus.*, Hamburg 1929, 11 R.M.

halos are always associated with warm fronts and have greater value as prognostics than cirrus clouds. We must agree with Meyer that confirmation of these statements by a statistical investigation is highly desirable.

Although the association of halos with ice crystals is generally admitted, there is an extraordinary lack of simultaneous observations of halo phenomena and crystals. Meyer could find only thirteen observations, mostly Dobrowolski's. They are as follows :—

Sun pillars : { Flat crystals (Plättchen) 1, Stars 2.
Flat crystals and Stars 2. }

Under-sun (the image of the sun in a cloud below the observer) : Flat crystals 1, Stars 2.

Parhelia : Flat crystals 1.

Paraselenæ : Flat crystals 1.

Ordinary halo with parhelia : Prisms 2, Prisms (some with flat crystals attached) 1.

It is mentioned that the German Antarctic Expedition of 1911-2 secured many micro-photographs of crystals together with simultaneous observations of halos, but these have not yet been published. Now that attention has been called to this omission (which may be attributed perhaps to the death of Barkow), we may hope that the observations will be found and reproduced. Observers in the aeroplanes which ascend to great heights for meteorological observations must have frequent opportunities to collect crystals from clouds in which they have seen halos, but it appears that there are hardly any records of such observations. Professor Meyer thinks that one reason for the absence of information about the forms of crystals is that the symbol ⋞— introduced by the International Meteorological Committee in 1873 for "Ice Needles" has been used indiscriminately for crystals of all shapes and sizes.

An interesting chapter is devoted to the question how many ice crystals are needed to produce an appreciable halo effect. It is assumed that in the thinnest halo-forming cloud one-fiftieth of the direct sunshine is deflected. If the crystals are flat plates one square millimetre in area, then 13,000 crystals are required in a sunbeam with cross section one square metre. On the other hand, in a thick cloud nine-tenths of the sunshine is deflected and the corresponding number of crystals is given as 1,450,000. It is estimated that 1,400 crystals, the total weight of which would be a gramme, may be found in a cubic metre, and on this basis the thickness of the cloud is found to be about a kilometre. Here again the author calls for direct observations. Perhaps such observations could be found in the works of Hilding Köhler. There is a significant passage in a paper of Köhler's in the May number of the *Meteorologische Zeitschrift*. Köhler writes that the name ice-cloud is often met with in the literature but that he has never come across any description to justify this name. Halos are formed by ice crystals; but do they develop in the formations which are usually called clouds? All the halos seen near the Haldde Observatory were developed in swarms of crystals which fell from water clouds.

The chapter on the detailed explanations of halo phenomena is notable for the exclusion of mathematics. Those who want to follow the analysis will find ample references to the original authorities. Occasionally one feels that the author might have examined these authorities more closely and given the reader the benefit of his criticism. This is notably the case with Visser's theory of the effect of diffraction in producing the colours of the ordinary halo. Visser claims to explain the rare halos with radii less than 22° by diffraction and Meyer appears to favour this view. The explanation of these halos as due to refraction through pyramidal crystals is mentioned but there is no reference to the work of Besson and of Humphreys on this subject.

In the last chapter will be found descriptions of simple apparatus for the measurement of angles and also some useful hints for photography. It is recommended that special forms should be prepared for noting the development of halos and also that charts drawn on the stereographic zenithal projection should be kept in readiness for sketching the observed phenomena.

The author may be congratulated and thanked for a valuable addition to the literature of Meteorological Optics.

F. J. W. Whipple.

Experiments with Wet-Bulb Thermometers

In connection with Dr. Whipple's articles dealing with this matter, it may be of interest to mention that the arrangements in use for several years and probably at present at Eskdalemuir Observatory are such that water drips from the bulbs of the standard eye-reading and photographic-recording wet-bulb thermometers. The latter are similar to those in use at Kew, but are exposed in a louvred hut in the grounds of the Observatory. I believe that the arrangements referred to were adopted by Dr. L. F. Richardson some fifteen years ago, but I do not know if the dripping of water from the bulbs was planned deliberately.

The water supply is contained in a vessel designed by Dr. Richardson to be proof against damage from frost. The container, which has admirably satisfied the latter condition, is made of copper and in the form of a shallow frustum of a pyramid of square or rectangular section, the sides sloping upwards and outwards from the base. A lid is provided. This container is supported at a convenient distance from the thermometers, and each stranded wick before descending to the bulb rests in a narrow and shallow copper gutter about six inches long fixed to an upper edge of the container. The level of the water in the container is higher above the bottom of the thermometer bulb than is recommended in Dr. Whipple's earlier article. The rate of dripping may possibly be somewhat greater than is necessary.

As to the water which is used: apparently at one time water was drawn from a tap immediately above the container, the water being part of the Observatory supply which is led in from a hill spring about a mile distant. I think, however, that in recent years rain water—of which there is usually no dearth at Eskdalemuir—was used.

H. W. L. Absalom.

An Early Episode in the Meteorological Employment of Kites

It may be of interest to call attention to the following extract from the *Philosophical Magazine*, vol. 31, 3rd series, September, 1847, which is liable to be forgotten, though it describes one of the earliest experiments in this country in the use of kites for meteorological purposes.

"*Experiments made at the Kew Observatory on a new Kite-apparatus for Meteorological Observations or other purposes.*

Mr. W. R. Birt (on the 14th of this month) took some kites, etc., to the Kew Observatory, for the purpose of endeavouring to ascertain how far it might be practicable to measure the force of wind at various elevations by their means, and (in the mere manipulations of his experiments) was assisted by Mr. Ronalds. After several trials, etc., they agreed that the sudden variations, horizontal and vertical, in the position of the kite, the great difficulty of making a kite which should present and preserve a tolerable approximation to a plane, that of measuring, with sufficient accuracy, at any required moment, its inclination, and lastly, the influence of the tail, would tend always to render the observations somewhat unsatisfactory. Mr. Ronalds then proposed to try the following method of retaining a kite in a quasi-invariable given position. Three cords were attached to an excellent hexagonal kite of Mr. Birt's construction: one in the usual manner and one on each side (or wing). The kite was then raised as usual; the two lateral cords were hauled downwards by persons standing at the apices of a large equilateral triangle (described upon the ground) until the ascending tendency became considerable (even when the force of the wind was at its minimum), and the three cords were made fast to stakes or held in the hand. He had entertained no expectation of the favourable result of this simple and obvious contrivance. The pace of the kite did not seem to vary so much as one foot in any direction, and it really appears to him probable that a very large kite or kites might be employed in this kind of manner often and very cheaply as a substitute for a captive balloon in meteorological inquiries, or even (on a very extensive scale) for other requirements in military science, etc. An anemometer, a thermometer, an hygrometer, etc., of some registering kinds, etc., might be hauled up and lowered at pleasure (like a flag) by a person standing in the centre of the triangle (above referred to) and by means of a line passing through a little block attached to the kite. The cords and kite should of course be of pure silk, for the sake of lightness, combined with extreme strength, and the size and thickness in some measure adapted to the breeze or lighter air. The silk might be advantageously covered with a very light coat of elastic varnish. (Communicated by Mr. Ronalds)."

Reviews

Einführung in die Geophysik II. Erdmagnetismus und Polarlicht, Wärme-und Temperaturverhältnisse der obersten Bodenschichten, Luftelektrizität. Berlin, 1929.

What strikes one most on reading such a book as this is the advantage that German students have over those in England in the matter of early and easy cultivation of an interest in geophysical subjects. Though specialist interest and intensity of investigational fervour in the physics of the earth are as strong here as in any country, it is in the main true that the general level of knowledge of the subject is unsatisfactorily low. Many honours students can leave the university without being more than dimly aware of the meaning of a regular diurnal variation in the magnetic elements or the potential gradient over the earth or the important influence of the geological structure and vegetational covering on the major relations between the temperature of its surface and its atmosphere; much less the more abstruse aspects of their interpretation. If, discovering his lack, the student has an inward urge to inform himself he must glean what snippets he may from a variety of uncomfortable chapters or appendices in such general text-books as condescend to mention their existence.

Against this, the fortunate German student is presented with such books as the "Einführung in die Geophysik" in close succession to the excellent Handbuchs and Lehrbuchs which have recently appeared. Here from the pens of acknowledged authorities he is offered usefully complete accounts of the existing bodies of knowledge on the subjects of the three sections; terrestial magnetism with its allied topics of earth currents and aurora by Prof. Nippoldt, temperature relationships between the earth's surface layers and the atmosphere by Dr. Keränen and atmospheric electricity by Prof. Schweidler. In those chapters which admit of the help, the facts are presented with a happy admixture of tables, diagrams and pictures: modern hypotheses and lines of further investigation in each department are instructively discussed. The total effect is to produce an eminently readable and even entertaining volume. Perhaps if university graduates in this country were furnished with such volumes, the London Meteorological Office would speedily be inundated with applications to serve at its various observatories.

As only to be expected from the inclusion of three such comprehensive subjects within 375 pages, and as consistent with the object of the volume to be an introduction for non-specialists, there has been a varying amount of sacrifice in the compilation. Except in Dr. Keränen's section the amount of mathematics is negligible and details of instrumental technique are omitted, though the underlying principles are outlined. For those who want more details there are the abundant references in the book as well as the other Handbuchs. The modern problems at present guiding fresh research are clearly kept in view, and very recent results in all the fields covered are discussed. The matter in each section is, naturally, reliable and as comprehensive as the pages will allow; the contributions are written in easy German and printed with accuracy. In a general reading no serious misprints have been noticed. Prof. Nippoldt seems to have been at special pains to add to the gaiety of his section by cutting photographic reproductions from a variety of difficult sources. His chapter on the aurora is specially decorated and thereby has an added interest for readers whose opportunities for viewing the real thing are limited. There are extensive name and subject indexes: the former contains about 400 names with over 1,000 page-references, giving an average of 2½ references per name; Dr. A. Schmidt (Prof. Nippoldt's predecessor at Potsdam Observatory) has 41, Dr. Keränen 30, and Prof. Nippoldt himself 22.

J. M. Stagg.

Nilflutstudien, Beziehungen zwischen den Luftdruck-, Zirkulations-und Temperaturverhältnissen auf der Nordhemisphäre und den Nilfluten. By Fritz Groissmayr. (Ann. Hydrogr., Berlin, LVI, 1928, pp. 6-14), and *Die Nilflut und der Temperaturcharakter des Folgewinters in Leipzig*. By Fritz Groissmayr. (Leipzig, Ber. Sächs. Akad. Wissen, LXXX, 1928, pp. 326-333.)

In the first paper the Nile is correlated with preceding, contemporary and succeeding weather, mainly in the North Atlantic area. The data stop short in 1908 in most cases, but on the other hand go back as far as 1846 in the case of Iceland, or to 1850 in many other instances. It is interesting to note that the existence of a weak North Atlantic circulation following a high Nile is confirmed by these earlier years.

The second paper deals with the relationship of the Nile to the succeeding winter in Europe. A high Nile tends to be followed by a severe winter, and in the case of Leipzig the temperature of December to February has a correlation coefficient with the Nile, July to October, of −0·52, the number of years on which it is based being 57.

E. W. BLISS.

Veröffentlichungen des Forschungs-Institutes der Rhön-Rossitten Gesellschaft e.V Nr. 2 and 3. 1929.

The Rhön-Rossitten Company exists to promote gliding flight, which is carried out over the Rhön hills near Frankfort, and over the sand dunes at Rossitten on the Baltic coast. The publication under review was issued by the Research Institute of the Company, under the directorship of Dr. Walter Georgii, and contains a number of interesting articles dealing with aeronautical and meteorological subjects. The observations of the tracks of " no lift " balloons over the dunes and the hills should prove of great value for the detailed study of atmospheric turbulence. One volume (No. 3) is entirely filled with aerological data, extending up to over 5 kilometres in many cases.

Obituary

We regret to learn of the death on January 3rd, 1930, at the age of 75, of Dr. Kiyoo Nakamura, Director of the Central Meteorological Observatory of Japan from 1895 to 1923.

News in Brief

Mr. Richard Inwards, who served on the Council of the Royal Meteorological Society for many years, and as President in 1894 and 1895, attained his 90th birthday on April 22nd and we hope that he will long retain the excellent health which he still enjoys. Mr. Inwards is well known to all meteorologists as a scientific amateur of the best type; his special hobby has been the collection of weather lore, and his book on the subject is the best account in the English language. He has also been a Fellow of the Royal Astronomical Society for many years.

The Weather of April, 1930

Dull unsettled weather with cold northerly or north-easterly winds during most of the later part of the month prevailed generally, except in north-west Scotland and northern Ireland, where the weather was mainly fair and sunny. Owing to a deep depression off our western coasts the opening days of the month were unsettled and stormy with local gales in the west and north on the 1st, 2nd, 3rd and 4th. Rain occurred generally on those days with thunderstorms in northern England and the

Midlands on the 2nd, and snow or sleet showers in east Scotland and east England and the Midlands on the 4th. Among the larger falls may be mentioned 1·45in. at Tynywaun (Glamorgan) and 1·38in. at Dungeon Ghyll (Westmorland) on the 1st. By the 5th the wind had dropped and the weather improved generally. Much sunshine was experienced in the north and west on the 5th and 6th, *e.g.*, 12·7hrs. on the 6th and 12·6hrs. on the 7th at Tiree, and in the south-west on the 7th. The 8th and 9th were cloudy and unsettled with heavy rain in the west, but on the 10th and 11th anticyclonic conditions prevailed and over 10hrs. bright sunshine was recorded at numerous places. By the 12th a depression centred to the north-west was moving eastwards, and in its rear cold north-westerly winds veering north were experienced, with local rain or showers accompanied by thunder and hail on the 14th. These cold winds persisted until the 21st so that the Easter holiday period (18th-21st) was cold throughout the country. It was also dull in many parts of England, but fine and sunny in Scotland and Ireland. Snow and sleet were experienced in Scotland and northern England on the 17th and 19th. A ridge of high pressure was situated over the British Isles on the 21st and 22nd, and sunshine records were excellent in the north on the 21st and in the south on the 22nd, *e.g.*, 13·0hrs. at Rothesay on the 21st and 12·9hrs. at Falmouth on the 23rd. There followed a period of variable weather. On the 25th it was sunny generally, but slight thunderstorms occurred in the Midlands and eastern England and heavy rain in Ireland, *e.g.*, 2·09in. at Delphi Lodge (Mayo). The highest temperatures of the month were reached on this day, when 72°F. was recorded at Greenwich and 71°F. at Norwich. On the 26th an anticyclone over the Atlantic began to spread over the British Isles from the north, giving a general improvement. The last two days of the month were dry, sunny and warm, temperature rising to 70°F. in the south-west and many places enjoying more than 12hrs. bright sunshine; Aspatria had 14·0hrs. on the 30th. Rainfall was generally above normal in England and east Scotland, and below in Ireland and west Scotland. Severe ground frosts were experienced frequently between the 6th and 23rd and on the 30th. The distribution of bright sunshine was as follows :—

	Total (hrs.)	Diff. from normal (hrs.)		Total (hrs.)	Diff. from normal (hrs).
Stornoway	185	+31	Liverpool	104	—54
Aberdeen	100	—58	Ross-on-Wye	110	—40
Dublin	166	+ 1	Falmouth	185	+ 1
Birr Castle	146	— 8	Gorleston	132	—52
Valentia	134	—26	Kew	104	—53

Pressure was below normal over south-western, western and central Europe, the greatest deficit being 6·7mb. at Brest and Bayonne, and above normal over north-western Europe, Spitsbergen, most of the North Atlantic, Bermuda and Newfoundland, the greatest excess being 9·1mb. at Spitsbergen. Temperature was above normal generally, except in Portugal and the west of Ireland, being as much as 8·9°F. in excess at Spitsbergen. Rainfall was also mainly above normal except in northern Scandinavia; the excess amounted to as much as 50 per cent. in south-eastern Gothaland.

Gales were experienced in north-west Spain on the 2nd. Snow fell abundantly in northern and central Italy about the 15th, and heavy rain and storms were reported from many other parts of Italy about the same time, doing much damage to the crops. The Po and other rivers were in flood. Snow also fell in the mountains in Switzerland down to the level of 1,500 ft. about the 20th. Severe frost in France and Switzerland between about the 19th and 23rd did much damage to the orchards and vineyards. After the 24th the weather became warm and sunny generally in Italy.

The floods in Tanganyika had subsided by the 19th. Floods occurred on the river at Voi in Kenya on the 20th, damaging the Mombasa-Nairobi railway there.

A typhoon (unexpected at this time of year) swept across the island of Leyte in the Philippines on the 18th devastating 14 towns and killing and injuring many people. The steamer *Condor* was sunk in the Pabna river, Bengal, with most of the passengers and crew during a cyclone on the 27th.

Ice jams on the Assiniboine River, Manitoba, caused floods in the neighbourhood early in the month. Temperature was above normal generally in the United States during the first three weeks of the month especially in the Missouri Valley, where it was as much as 18°F. above normal at Valentine for the week ending the 15th. The maximum at Chicago on the 10th and 11th was 90°F. After the 22nd there was a big drop in temperature and snowstorms were experienced generally. For the first three weeks the rainfall had been below normal.

The special message from Brazil states that the rainfall was scarce everywhere being 0·91in., 0·55in. and 0·28in. below normal in the northern, central and southern regions respectively. Fewer anticyclones than usual passed across the country. The scarcity of rain has proved harmful to the crops especially the cotton. At Rio de Janeiro pressure was 1·1mb. above normal and temperature 0·7°F. below normal.

Rainfall, April, 1930.—General Distribution

England and Wales	139	per cent. of the average 1881-1915.
Scotland	85	
Ireland	75	
British Isles	112	

Rainfall: April, 1930: England and Wales

Co.	Station	In.	Per-cent of Av.	Co.	Station	In.	Per-cent of Av.
Lond .	Camden Square	1·86	121	*Leics* .	Belvoir Castle	2·64	173
Sur .	Reigate, Alvington	1·83	110	*Rut* .	Ridlington	3·19	...
Kent .	Tenterden, Ashenden	1·62	100	*Linc* .	Boston, Skirbeck	2·24	166
,, .	Folkestone, Boro. San.	1·93	...	,, .	Cranwell Aerodrome	3·16	240
,, .	Margate, Cliftonville	1·28	95	,, .	Skegness, Marine Gdns	2·70	202
,, .	Sevenoaks, Speldhurst	1·70	...	,, .	Louth, Westgate	2·70	162
Sus .	Patching Farm	2·30	132	,, .	Brigg, Wrawby St.	2·35	...
,, .	Brighton, Old Steyne	1·73	107	*Notts* .	Worksop, Hodsock	2·78	189
,, .	Heathfield, Barklye	2·12	115	*Derby* .	Derby, L. M. & S. Rly.	2·73	167
Hants .	Ventnor, Roy. Nat. Hos.	2·90	173	,, .	Buxton, Devon Hos.	3·00	102
,, .	Fordingbridge, Oaklnds	2·46	134	*Ches* .	Runcorn, Weston Pt.	2·07	120
,, .	Ovington Rectory	...	...	,, .	Nantwich, Dorfold Hall	3·06	...
,, .	Sherborne St. John	2·07	117	*Lancs* .	Manchester, Whit. Pk.	1·63	85
Berks .	Wellington College	2·04	127	,, .	Stonyhurst College	2·17	80
,, .	Newbury, Greenham	2·52	138	,, .	Southport, Hesketh Pk	2·72	147
Herts .	Welwyn Garden City	2·57	...	,, .	Lancaster, Strathspey	1·89	...
Bucks .	High Wycombe	1·98	126	*Yorks* .	Wath-upon-Dearne	2·86	181
Oxf .	Oxford, Mag. College	2·06	134	,, .	Bradford, Lister Pk.	3·28	163
Nor .	Pitsford, Sedgebrook	2·27	148	,, .	Oughtershaw Hall	4·30	...
,, .	Oundle	2·26	...	,, .	Wetherby, Ribston H.	3·23	183
Beds .	Woburn, Crawley Mill	1·60	107	,, .	Hull, Pearson Park	1·90	122
Cam .	Cambridge, Bot. Gdns.	2·08	153	,, .	Holme-on-Spalding	2·15	...
Essex .	Chelmsford, CountyLab	2·05	160	,, .	West Witton, Ivy Ho.	4·30	...
,, .	Lexden Hill House	1·96	...	,, .	Felixkirk, Mt. St. John	4·25	254
Suff .	Hawkedon Rectory	2·93	190	,, .	Pickering, Hungate	3·99	...
,, .	Haughley House	1·63	...	,, .	Scarborough	2·82	181
Norf .	Norwich, Eaton	2·13	125	,, .	Middlesbrough	1·96	143
,, .	Wells, Holkham Hall	...	...	,, .	Baldersdale, Hury Res.	3·04	...
,, .	Little Dunham	2·42	149	*Durh* .	Ushaw College	2·01	106
Wilts .	Devizes, Highclere	2·79	147	*Nor* .	Newcastle, Town Moor	1·55	95
,, .	Bishops Cannings	3·07	152	,, .	Bellingham, Highgreen	1·81	...
Dor .	Evershot, Melbury Ho.	3·56	151	,, .	Lilburn Tower Gdns.	2·21	...
,, .	Creech Grange	2·72	...	*Cumb* .	Geltsdale	1·96	...
,, .	Shaftesbury, Abbey Ho.	2·00	94	,, .	Carlisle, Scaleby Hall	1·65	85
Devon .	Plymouth, The Hoe	3·16	139	,, .	Borrowdale, Seathwaite	4·12	55
,, .	Polapit Tamar	2·44	104	,, .	Borrowdale, Rosthwaite	3·01	...
,, .	Ashburton, Druid Ho.	...	...	,, .	Keswick, High Hill	1·54	...
,, .	Cullompton	3·88	171	*Glam* .	Cardiff, Ely P. Stn.	2·41	95
,, .	Sidmouth, Sidmount	3·98	187	,, .	Treherbert, Tynywaun	5·75	...
,, .	Filleigh, Castle Hill	3·15	...	*Carm* .	Carmarthen Friary	2·68	98
,, .	Barnstaple, N. Dev. Ath.	2·89	136	,, .	Llanwrda	3·39	103
Corn .	Redruth, Trewirgie	3·49	121	*Pemb* .	Haverfordwest, School	3·08	118
,, .	Penzance, Morrab Gdn.	2·36	97	*Card* .	Aberystwyth	1·58	...
,, .	St. Austell, Trevarna	3·17	112	,, .	Cardigan, County Sch.	1·62	...
Soms .	Chewton Mendip	...	...	*Brec* .	Crickhowell, Talymaes	3·60	...
,, .	Long Ashton	2·70	...	*Rad* .	BirmW.W.Tyrmynydd	4·39	119
,, .	Street, Millfield	2·85	...	*Mont* .	Lake Vyrnwy	4·65	154
Glos. .	Cirencester, Gwynfa	2·50	134	*Denb* .	Llangynhafal	4·64	...
Here .	Ross, Birchlea	3·11	164	*Mer* .	Dolgelly, Bryntirion	3·12	85
,, .	Ledbury, Underdown	3·70	203	*Carn* .	Llandudno	2·68	148
Salop .	Church Stretton	3·50	162	,, .	Snowdon, L. Llydaw 9	7·70	...
,, .	Shifnal, Hatton Grange	2·17	129	*Ang* .	Holyhead, Salt Island	2·11	101
Worc .	Ombersley, Holt Lock	2·35	155	,, .	Lligwy	1·85	...
,, .	Blockley	3·78	..	*Isle of Man*			
War .	Farnborough	2·55	130		Douglas, Boro' Cem.	2·65	109
,, .	Birminghm, Edgbaston	2·70	155	*Guernsey*			
Leics .	Thornton Reservoir	3·57	210		St. PeterP't. GrangeRd.	3·83	190

Rainfall : April, 1930 : Scotland and Ireland

Co.	Station	In.	Per-cent of Av.	Co.	Station	In.	Per-cent. of Av.
Wigt .	Stoneykirk, Ardwell Ho	...	...	*Suth* .	Loch More, Achfary...	2·97	61
,, .	Pt. William, Monreith	1·79	...	*Caith* .	Wick....................	2·12	107
Kirk .	Carsphairn, Shiel.......	3·21	...	*Ork* .	Pomona, Deerness......	2·19	106
,, .	Dumfries, Cargen......	...	...	*Shet* .	Lerwick..................	2·17	95
Dumf.	Eskdalemuir Obs.......	2·35	69	*Cork* .	Caheragh Rectory......	1·89	...
Roxb .	Branxholm..............	1·23	65	,, .	Dunmanway Rectory...	2·36	57
Selk .	Ettrick Manse...........	2·04	...	,, .	Ballinacurra.............	1·78	69
Peeb .	West Linton............	1·60	...	,, .	Glanmire, Lota Lo......	1·88	67
Berk .	Marchmont House......	2·18	108	*Kerry*.	Valentia Obsy..........	3·07	84
Hadd.	North Berwick Res.....	1·25	89	,, .	Gearahameen............	6·90	...
Midl .	Edinburgh, Roy. Obs.	1·17	85	,, .	Killarney Asylum......	...	...
Ayr .	Kilmarnock, Agric. C.	1·69	82	,, .	Darrynane Abbey.......	3·14	91
,, .	Girvan, Pinmore..	2·15	72	*Wat* .	Waterford, Brook Lo...	1·75	69
Renf .	Glasgow, Queen's Pk. .	·92	47	*Tip* .	Nenagh, Cas. Lough...	2·12	84
,, .	Greenock, Prospect H.	2·53	67	,, .	Roscrea, Timoney Park	2·91	...
Bute .	Rothesay, Ardencraig.	3·06	103	,, .	Cashel, Ballinamona...	1·90	76
,, .	Dougarie Lodge.........	2·58	...	*Lim* .	Foynes, Coolnanes......	1·98	81
Arg .	Ardgour House.........	3·49	...	, .	Castleconnel Rec.......	1·71	...
,, .	Manse of Glenorchy...	2·64	...	*Clare* .	Inagh, Mount Callan...	3·09	...
,, .	Oban......................	1·96	...	,, .	Broadford, Hurdlest'n.	1·93	...
,, .	Poltalloch...............	2·46	81	*Wexf*.	Newtownbarry	...	...
,, .	Inveraray Castle...	2·44	53	,, .	Gorey, Courtown Ho...	2·73	125
,, .	Islay, Eallabus...	3·05	106	*Kilk* .	Kilkenny Castle.........	1·59	73
,, .	Mull, Benmore.........	4·50	...	*Wic* .	Rathnew, Clonmannon	1·47	...
,, .	Tiree	2·48	...	*Carl* .	Hacketstown Rectory..	3·01	113
Kinr .	Loch Leven Sluice......	1·61	84	*Leix* .	Blandsfort House......	2·04	78
Perth.	Loch Dhu...............	2·65	56	,, .	Mountmellick...........	1.85	...
,, .	Balquhidder, Stronvar	1·43	...	*Off'ly* .	Birr Castle..............	...	...
,, .	Crieff, Strathearn Hyd.	1·40	64	*Dubl* .	Dublin, FitzWm. Sq...	1·06	56
,, .	Blair Castle Gardens...	1·73	82	,, .	Balbriggan, Ardgillan.	1·12	57
,, .	Dalnaspidal Lodge.....	...	...	*Me'th* .	Beauparc, St. Cloud...	1·40	...
Angus.	Kettins School.	1·75	105	,, .	Kells, Headfort.........	1·52	60
,, .	Dundee, E. Necropolis	2·23	131	*W.M.*	Moate, Coolatore......	1·30	...
,, .	Pearsie House...........	2·89	...	,, .	Mullingar, Belvedere..	1·10	46
,, .	Montrose, Sunnyside...	2·49	137	*Long* .	Castle Forbes Gdns......	1·82	76
Aber .	Braemar, Bank...	2·41	102	*Gal* .	Ballynahinch Castle...	2·98	84
,, .	Logie Coldstone Sch....	2·12	105	,, .	Galway, Grammar Sch.	2·26	...
,, .	Aberdeen, King's Coll.	3·09	165	*Mayo* .	Mallaranny..............	3·03	...
,, .	Fyvie Castle............	3·34	...	,, .	Westport House.........	1·58	59
Moray.	Gordon Castle...........	1·66	95	,, .	Delphi Lodge...........	5·96	...
,, .	Grantown-on-Spey......	...	...	*Sligo* .	Markree Obsy...........	2·13	80
Nairn.	Nairn, Delnies	1·20	80	*Cav'n* .	Belturbet, Cloverhill...	1·66	72
Inv .	Kingussie, The Birches	1·08	...	*Ferm* .	Enniskillen, Portora...	1·41	...
,, .	Loch Quoich, Loan.....	6·95	...	*Arm* .	Armagh Obsy...........	1·52	72
,, .	Glenquoich...............	4·48	69	*Down* .	Fofanny Reservoir......	2·55	...
,, .	Inverness, Culduthel R.	1·06	...	,, .	Seaforde.................	1·38	53
,, .	Arisaig, Faire-na-Squir	1·89	...	,, .	Donaghadee, C. Stn...	1·31	65
,, .	Fort William...........	1·99	...	,, .	Banbridge, Milltown...	1·49	...
,, .	Skye, Dunvegan........	3·10	...	*Antr* .	Belfast, Cavehill Rd...	1·80	...
R & C.	Alness, Ardross Cas ...	1·81	75	,, .	Glenarm Castle.........	2·42	...
,, .	Ullapool.................	1·65	...	,, .	Ballymena, Harryville	2·21	84
,, .	Torridon, Bendamph...	2·55	49	*Lon* .	Londonderry, Creggan	1·97	77
,, .	Achnashellach..........	3·13	...	*Tyr* .	Donaghmore............	2·51	...
,, .	Stornoway...............	1·99	66	,, .	Omagh, Edenfel.........	2·06	78
Suth .	Lairg......................	1·34	...	*Don* .	Malin Head.............	1·86	...
,, .	Tongue....................	·96	37	,, .	Dunfanaghy............	2·33	...
,, .	Melvich..................	1·20	...	,, .	Killybegs, Rockmount.	2·76	77

Erratum : Inagh, Mount Callan, March, *for* 5·34 *read* 4·80 inches.

Climatological Table for the British Empire, November, 1929.

STATIONS	PRESSURE		TEMPERATURE									PRECIPITATION			BRIGHT SUNSHINE	
			Absolute		Mean Values				Mean							
	Mean of Day M.S.L.	Diff. from Normal	Max.	Min.	Max.	Min.	½ max. and min.	Diff. from Normal	Wet Bulb	Relative Humidity.	Mean Cloud Am'nt	Am'nt	Diff. from Normal	Days	Hours per day	Percentage of possible
	mb.	mb.	°F.	°F.	°F.	°F.	°F.	°F.	°F.	%	0—10	in.	in.			
London, Kew Obsy.	1007·4	— 7·2	59	28	50·9	39·2	45·1	+ 1·1	41·7	91	6·8	4·83	+ 2·61	19	2·2	25
Gibraltar	1019·2	+ 1·2	74	46	67·4	51·5	59·5	— 1·0	51·9	81	4·2	2·10	— 4·29	7	..	..
Malta	1015·6	— 0·9	74	49	66·6	57·9	62·3	— 1·6	59·8	88	5·4	4·88	+ 1·31	14	5·8	57
St. Helena	1012·7	+ 1·4	..	54	..	55·2	..	..	56·1	94	9·7	0·70	— 0·98	11	..	..
Sierra Leone	1012·2	+ 1·3	88	68	85·8	73·7	79·7	— 1·5	76·2	82	5·0	6·32	+ 1·20	8	..	..
Lagos, Nigeria	1008·9	— 1·9	91	70	87·0	74·3	80·7	— 0·7	77·2	83	7·6	4·10	+ 1·52	7	..	..
Kaduna, Nigeria	1015·2	+ 3·9	94	..	89·6	..	..	..	70·5	75	1·0	0·00	— 0·12	0	..	..
Zomba, Nyasaland	1006·6	— 2·3	94	59	88·5	68·8	78·7	+ 3·1	..	51	3·2	2·92	— 2·16	8	..	..
Salisbury, Rhodesia	1008·6	— 0·7	95	56	84·1	62·1	73·1	+ 2·4	61·2	45	4·5	4·77	+ 1·07	10	7·7	60
Cape Town	1015·7	— 0·1	89	51	73·2	56·3	64·7	+ 0·3	58·2	69	5·0	0·60	— 0·49	7	..	..
Johannesburg	1011·2	— 0·3	88	44	75·3	55·4	65·3	+ 1·8	57·5	69	4·5	2·93	— 2·03	15	7·6	57
Mauritius	1015·4	— 0·7	90	63	83·5	67·8	75·7	+ 0.2	70·3	59	6·0	0·47	— 1·11	12	9·0	69
Bloemfontein	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..
Calcutta, Alipore Obsy.	1013·2	— 0·1	87	58	83·6	65·0	74·3	+ 1·2	65·9	83	2·0	0·00	— 0·66	0*	..	..
Bombay	1010·7	— 1·3	95	68	91·8	74·4	83·1	+ 2·6	71·9	74	2·6	0·22	— 0·23	1*	..	..
Madras	1010·7	— 0·6	88	69	84·4	73·0	78·7	— 0·2	74·6	85	6·5	15·07	+ 0·82	12*	..	..
Colombo, Ceylon	1010·1	0·0	89	71	85·1	73·2	79·1	— 0·6	76·4	79	6·5	9·32	— 2·47	22	6·2	53
Hongkong	1018·7	+ 1·1	79	56	72·2	63·7	67·9	— 1·7	60·7	63	5·3	1·37	— 0·30	4	6·3	57
Sandakan	..	..	90	74	87·3	75·1	81·2	+ 0·4	77·2	84	..	19·92	+ 5·26	20	..	..
Sydney, N.S.W.	1009·1	— 4·6	89	51	71·5	58·0	64·7	— 2·4	60·2	64	6·8	3·09	+ 0·28	14	7·2	52
Melbourne	1010·8	— 3·4	88	45	68·0	51·9	59·9	— 1·4	53·7	64	8·1	2·92	+ 0·70	17	4·4	31
Adelaide	1012·8	— 2·3	98	45	75·5	54·2	64·9	— 2·0	54·7	43	6·9	0·96	— 0·20	9	7·9	57
Perth, W. Australia	1013·6	— 1·7	86	52	73·7	57·0	65·3	— 0·7	58·5	59	5·4	1·12	+ 0·33	9	9·4	68
Coolgardie	1011·7	— 1·4	100	47	82·2	55·3	68·7	— 2·1	56·8	45	4·4	1·46	+ 0·78	6	..	..
Brisbane	1010·1	— 4·4	100	54	84·1	64·2	74·1	+ 0·5	65·6	52	3·7	1·25	— 2·41	10	9·3	69
Hobart, Tasmania	1007·8	— 1·6	72	39	61·5	47·0	54·3	— 2·9	50·1	64	7·1	3·14	+ 0·62	22	5·4	37
Wellington, N.Z.	1006·6	— 5·5	66	39	60·3	50·4	55·3	— 1·6	53·4	78	8·2	3·30	— 0·22	12	5.7	40
Suva, Fiji	1008·9	— 2·2	88	70	84.9	73·7	79·3	+ 2·1	75·1	78	6·7	14·23	+ 4·72	18	6·8	53
Apia, Samoa	1007·4	— 2·1	88	72	85·5	75·1	80·3	+ 1·6	77·4	77	4·2	9·43	+ 0·14	14	6·8	54
Kingston, Jamaica	1012·1	— 0·3	89	66	86·4	70·6	78.5	— 0·8	69·6	89	4·9	1·74	— 1·29	10	7·2	64
Grenada, W.I.	1008·8	— 1·5	89	72	87·7	74·6	81·1	+ 1·8	75·3	78	4·1	9·75	+ 1·36	21	..	..
Toronto	1015·9	— 0·9	61	6	43·3	32·4	37·9	+ 1·6	33·1	77	7·5	3·47	+ 0·52	16	2·8	29
Winnipeg	1017·5	+ 0·8	45	—19	24·5	13·0	18·7	— 2.1	..	..	6·2	0·69	— 0.27	9	2·7	30
St. John, N.B.	1015·3	+ 1·4	52	6	42·5	29·9	36·2	— 0·5	32·0	79	6·4	3·60	— 0·81	14	3·9	41
Victoria, B.C.	1026·9	+11·4	55	35	48·7	40·9	44·8	+ 0·4	42·5	87	7·3	1·91	— 4·55	11	3·3	35

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