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SOME PROBLEMS CONNECTED WITH THE TEMPERATURE ELEMENT IN CLIMATOLOGY.

By L. C. W. BONACINA.

OF the four fundamental meteorological elements—temperature, moisture, wind, and sunshine—with which the climatologist is concerned in devising schemes for the comparison and classification of the diverse climatic regions of the Earth, temperature is the one which is given usually the foremost place in works on climatology, and it is, therefore, perhaps, specially unfortunate that it should also be the one which in its climatological significance presents more perplexing problems than any of the others. The reason is this : that the temperature element of the atmosphere which imparts to animals and plants sensations and effects of heat and cold, and is responsible for the temperatures assumed by the surface of inanimate bodies, is compounded of two separate factors. Firstly, there is what is commonly known as the temperature of the air, a definite physical condition scientifically measurable in different ways but best, perhaps, by enclosing a thermometer in some sort of shelter from radiation like the familiar Stevenson screen ; secondly, there are the sensations and effects of heat and cold attributable to direct radiation received from the sun or lost from the earth, to which must be added the various local radiations and reflections of heat which take place between body and body ; and this complexus of radiation unfortunately offers a most refractory problem in the thermal investigation of climate for the very good reason that it can not be measured in definite climatological terms, as will shortly be shown. The thermal element of climate comprises, therefore, air temperature plus radiation effects, in as much as the sense of “ hotness ” experienced by human beings, which is also an index of important consequences in the growth of plants and crops, depends on the conjoint influence of these two factors, and I propose to distinguish this thermal combination from the measurable temperature of the air conveniently by the indeterminate expression “ temperature of the atmosphere ” (using the term atmosphere in the sense of general climatic environment

without special reference to the air we breathe), meaning thereby simply that temperature which the surface of a body will assume on exposure to the air and radiation, and which will, of course, vary for the same intensity of radiation and the same air temperature with the nature and composition of the body, as well as with the amount of wind blowing over the surface of the body.

First, by way of a geographical illustration, let the climate of London be compared with that of Rome. The Italian capital has a mean annual air temperature very approximately 10° F. higher than the English, the former being almost exactly 60° F., and the latter slightly under 50° F., the latitude difference between the cities being likewise practically 10° . But the 10° difference in air temperature although a most important measure of the thermal difference between London and Rome, does not afford a full picture of the contrast between England and Italy in respect of warmth, because the greater intensity of solar radiation in latitude $41\frac{1}{2}^{\circ}$ N. than in $51\frac{1}{2}^{\circ}$ N., manifests itself directly to sensation as well as indirectly by raising the mean annual air temperature the said 10° F.

One need not, however, travel to observe the necessity of studying the two thermal factors in question, and for a second illustration let a seasonal experience be taken and the climate of April be compared with that of October. Now these two months, situated diametrically opposite one another in the earth's orbit round the sun, have each an average mean air temperature which in temperate climates does not materially differ from the mean annual temperature, so that the periods may be regarded as nodal points separating the five definitely warm months of the year from the five definitely cold months. In continental countries the mean temperatures of April and October are in fact substantially identical, though in maritime countries like England, where the seasonal maxima and minima of temperature lag longer behind the solstices, the advantage of air warmth is with October by some 2° or 3° F. So much greater, nevertheless, is the power of the sun and the length of the day in April than in October that it is the universal practice of meteorologists to place the former month by preference in the "summer half of the year"—thereby giving expression to the paradox that a month which is distinctly colder than another, as judged solely by the temperature of the air, may be indeterminately warmer when radiation influences in conjunction with air temperature are taken into account.

In these illustrations an attempt is made to visualize the two separate factors of our thermal environment, of which everyone is more or less conscious, but of which one has been neglected in meteorological thermometry simply because no satisfactory method has yet been devised for its measurement. But the importance of the question is further emphasized when, instead of confining

our attention to the variations of climate which attend change of latitude or change of season, we consider such as accompany change of altitude. Every mountaineer knows that at great altitudes the heat of the sun feels inordinately great in spite of the low temperature of the air, and in like manner he no doubt finds that the direct chill from rock radiation at night is more noticeable than it is in the denser air of lower levels. It would, perhaps, be true to say that whereas at sea-level where the air is dense the temperature of the air is of greater consequence in the physiological estimation of warmth than radiation, at high levels conditions tend to become reversed. That this is, and must be so, can, I think, be inferred by contemplating what meaning may be attached to the so-called temperature of planetary space. Whatever the precise trend of recent physical theory may be concerning "ether" as the basis of "matter," I assume that in planetary space there exists no molecular substance possessing temperature, and that consequently the phrase "temperature of space" can mean nothing more than the temperature to which some imaginary body placed beyond the confines of the Earth's atmosphere would be brought by the totality of radiation influences to which it would be subjected—which temperature would be conditioned by the nature of the body. On the surface of the moon, apparently, "temperature" means radiation exclusively, in default of any molecular gaseous envelope. If, however, a very thin atmosphere does exist on the moon, say of about 1 mm. pressure, then it is evident that objects on its surface must be in a definite molecular environment, however thin it may be, possessing a temperature of its own. But a tenuous atmosphere like that will impart its temperature to a small object immersed in it more slowly than a dense gas in as much as according to the kinetic theory the number of molecular bombardments upon unit area of surface of the object is less. Similarly one can not doubt that on the summit of Mont Rosa, 15,000 odd feet above the sea, where half the mass of the atmosphere lies below, the thermal consciousness of the Observatory officials must be governed more decidedly by the various direct radiation influences and less decidedly by the temperature of the air than is the case with ourselves in the dense atmosphere of London near sea-level where not only is solar radiation by day materially softened down, but also terrestrial radiation at night is not in the ordinary way very conspicuous to the senses except indirectly through its effect in chilling the air which surrounds us. It should hardly be necessary to point out that for the same temperate dense air *feels* colder than rare air in the case of ordinary temperatures below that of the blood, and hotter in the case of temperatures above that point, but these latter are only occasionally met with locally in hot countries.

(To be continued.)

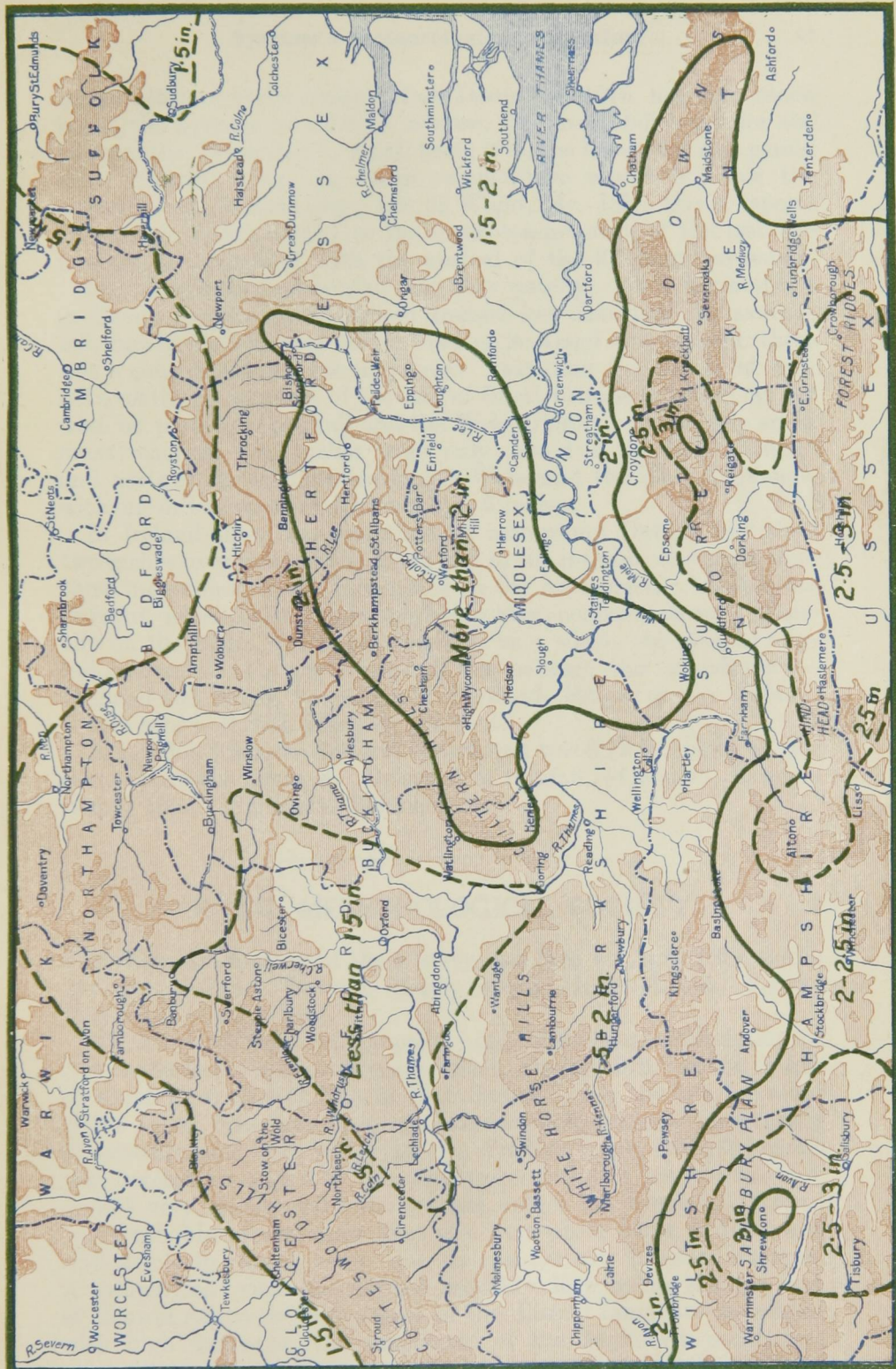
THE WEATHER OF APRIL.

THE outstanding feature of the weather of April was the very low mean temperature which was accompanied by considerable falls of snow in places. During the first eighteen days of the month the low temperatures that had prevailed without interruption since the beginning of the year continued with practically undiminished intensity, but during the last ten days a gradual rise set in which culminated in warm weather at the close.

The month opened with very low temperatures the thermometer falling to 4° in the screen at Eskdalemuir on the night of the 1st-2nd while at Bothalhaugh, Morpeth the Rev and Hon. W. Ellis reports a shade value of 3° on the lawn 90 feet above the river and of -5° lower down near the river. Other stations reporting temperatures under 10° were Rounton (Yorks., N.R.), 7° , Buxton, 8° , and Newton Rigg, 5° . Heavy falls of snow were of frequent occurrence during the first half of the month, when the British Isles were largely under the influence of shallow cyclonic disturbances moving in a northerly or easterly direction. On the 24th an anti-cyclone, whose centre had some days previously lain to the westward of Ireland, began to spread eastward, and until the end of the month this system was accompanied by relatively warm weather very generally. The only interruption in the spell of fine and dry weather occurred about the 27th, when a depression travelling eastward at some distance to the north produced strong winds and rain in the north of Scotland. At the close of the month some relatively warm days were experienced. The highest values reported on the 30th were 67° at London (Camden Square), and also at Ross-on-Wye, while as far north as Nairn a temperature of 60° was reported.

For the British Isles as a whole the mean temperature was about 4° below the average, the greatest deficit, 5° , being recorded in the eastern and south-eastern parts of Great Britain, and the least, 3° below the average, in the Channel Islands. The mean temperature in London (Camden Square) was $43^{\circ}\cdot 1$, being the lowest during the 60 years covered by this record in the Glaisher Stand. The nearest approach was in 1860, when the mean was $43^{\circ}\cdot 9$. At Greenwich the mean temperature (mean of daily maximum and minimum) was $42^{\circ}\cdot 7$, the month being the coldest April since 1839, when the mean was $42^{\circ}\cdot 1$, but $2^{\circ}\cdot 6$ warmer than the record cold of 1837 ($39^{\circ}\cdot 5$), which seems to have been the coldest April in the London district and also at Edinburgh during the last century and a half. From information regarding April, 1917, kindly supplied by Mr. Watt, Secretary of the Scottish Meteorological Society, it appears that in the north-east of Scotland, where Gordon Castle had a mean temperature of $39^{\circ}\cdot 4$, April, 1917, was the coldest April since 1812, when the mean was $38^{\circ}\cdot 2$, but further south, at Edinburgh, April, 1879, was slightly colder than that of 1917. The

THAMES VALLEY RAINFALL, APRIL, 1917.



ALTITUDE
SCALE

Below 250 feet 250 to 500 feet 500 to 1000 feet Above 1000 feet

SCALE OF MILES

0 5 10 15 20

temperature of every month, since December, 1916, has been much below the average at Camden Square, the mean deficiency for the five months, December to April, being $3^{\circ}\cdot6$, the lowest for this period since 1890-91, when the mean temperature was $4^{\circ}\cdot0$ below the average. At Totland Bay, Isle of Wight, Mr. John Dover reports an average deficit of $4^{\circ}\cdot1$ in the mean temperature of the last five months, as compared with the normal of the 31 years preceding.

The distribution of rainfall was very patchy. At a few stations in Devon and the south-east of Ireland less than half the average fell, but in the extreme north, both of Scotland and Ireland, there was a considerable excess in places. Less than two inches of rain fell over the greater part of the east of Great Britain and even as far west as parts of Cornwall and the Welsh Border. Relatively small areas reaching four inches were only found in the Lake District and parts of the rainiest portions in Wales and the West Highlands, with one or two spots with as much as 6 inches.

In Ireland there was less than an inch round Dublin, less than two inches over most of the south and in the interior, and more than three inches only in the mountains on the west coast. An absolute drought, which has extended well into May, commenced very generally on the 19th. Over the Kingdom, as a whole, the general rainfall expressed as a percentage of the average was as follows:—England and Wales, 95 per cent; Scotland, 106 per cent.; Ireland, 85 per cent; British Isles, 95 per cent.

In London (Camden Square) the rainfall was $2\cdot19$ in., being 26 per cent. above the average. Duration of rainfall, 44 hours. Evaporation, $1\cdot18$ in. Sunshine, 149 hours.

ROYAL METEOROLOGICAL SOCIETY.

THE Monthly Meeting of the Society was held on April 18th at the Society's Rooms, Victoria Street, Major H. G. Lyons, F.R.S., President, in the Chair.

Mr. E. G. Bilham read a paper on "The Diurnal Variation of Atmospheric Pressure at Benson, Oxon., during 1915," in the course of which he remarked that he had obtained from the hourly values of the Dines' float barograph the mean monthly diurnal inequalities of pressure and analysed them in a Fourier series, with the result that, except in regard to the amplitude of the 24 hour term, they agreed very closely with the normal values for Kew and Oxford. The probable errors show that the first order term is the most susceptible to casual error due to non-periodic pressure changes. A comparison with the normal monthly Kew values showed that at Benson relatively high values of the diurnal range are associated with high values of the amplitude of the 24 hourly oscillation.

The amplitudes of the second and third order are similar at the two stations. The President and Messrs. Whipple, Bryant, Chree, Harding and Brooks took part in the discussion.

A paper by Lieut. C. D. Stewart, R.E., dealing with "Atmospheric Electrical Phenomena during Rain," was also read, in which the values of the potential gradient occurring during rain had been investigated. The maximum is in summer and the minimum in winter, but the maximum "fine weather" values occur in the later season. The form of the diurnal variation of rain potential gradient is uncertain, although it appears to have only one oscillation in 24 hours as compared with the double oscillation in fine weather. In most cases rain depresses the potential gradient and is a function of the rate of fall. The President and Messrs. Chree and Bilham took part in the discussion.

The following new Fellows were admitted, *viz.*, M. A. Giblett, Lieut. M. J. D. Mayall, J. D. North and F. A. Ward.

Correspondence.

To the Editor of Symons's Meteorological Magazine.

WATER DROPS BELOW THE FREEZING-POINT.

Referring to Dr. G. C. Simpson's interesting letter on the above in the March Magazine I may be allowed to record an instance of rain falling at a temperature below the freezing-point. At 8 a.m. on February 16th the air temperature was 30° F., and the ground was covered with dry snow. I was inside a zinc roof building when I heard a loud and sudden sound on the roof like the dropping of hailstones. I immediately went out and to my surprise found that it was a shower of real rain drops of large size, and the water was dripping from the eaves. On surveying the sky I noticed a small dark cloud just overhead with the rest of the sky quite clear. The surface wind at the time was calm or very light, but the cloud moved at a fair rate from the south-west. The base of it was about a mile high. At the time there was no mist on the neighbouring mountains (2,600 feet high), but, towards the afternoon, the temperature rose the mist descended to about 2,300 feet on the hills and a thaw set in. The shower occurred just at the transition from the cold to the mild spell of weather. The rain presumably originated in a layer of relatively warm air, and merely fell through a stratum of air which was below 32° at the time.

J. R. GETHIN JONES.

Blaen-y-Cwm, S. Wales, April 8th, 1917.

THE GREAT SNOWSTORM ON THE 1st APRIL, 1917.

THE people in East Clare will long remember Palm Sunday, 1917. A little snow fell on the night of March 31st, but it was all melted by noon on April 1st. It began to snow again at 2.45 p.m. on that day, and at 5.30 p.m. it was 9 inches deep on all the roads about Broadford. Two motor cars came to Broadford early in the afternoon and had to stay there till the morning of the 4th. The mail car left Broadford at 6.40 p.m. for Limerick, and did not get there till the evening of the 2nd. Thus taking 24 hours to do 12 miles. The direct road from Broadford to Killaloe is only 8 miles over the mountain. The first four miles of which, to the village of Kilbane, is nearly level, Kilbane being 200 feet above the sea. A mile further on the road gets to the top of the pass of Slounagalough, 892 feet above the sea. It then falls 700 feet in half-a-mile, and the last $2\frac{1}{2}$ miles to Killaloe is nearly level. On April 1st a man named James Vaughan (aged 40) and his nephew, Michael Vaughan (aged 12), who both live at Kilbane, drove a trap to Killaloe. On their way home that evening, they were caught in the snow storm. They left their trap at a farm house at the foot of the eastern side of the pass, and started to walk home, leading the horse with them. On the evening of the 2nd some men went to the top of the pass, looking for sheep that had been lost in the snow, and were much surprised to see a horse standing there with harness on him. In a short time they found the two Vaughans lying dead in the snow. There was very severe frost that night. My thermometer here went down to 16° . Only once before (viz., on February 4th) during the past very severe winter, was it so low. No doubt they were killed by the great cold, as there is not a bit of shelter to be found on the "Sap Road" as it is called locally. Very few cars ever go over this road, though I have seen a map for motorists, on which it was marked as the main road to Killaloe. And it is said that one night, some time ago, a strange motor car did actually drive over the "Sap." The driver no doubt driving by the map.

On Monday, April 2nd, Broadford was quite cut off from the outside world. No mail car came or went. All the roads being quite blocked up with snow drifts, several feet deep. The day was very fine, however, with a bright warm sun. The snow on the level ground, where it had not drifted, was 12 inches deep. But just about the rain gauge it was 18 inches deep. That is 6 inches over the rim of the gauge. Never before has the gauge been quite hid by snow, during the thirty-two years it has been here.

On Tuesday, April 3rd, it was snowing nearly all day and very cold. A mail car came from Quin railway station at 2 p.m. The road here from there being fairly level ground was not blocked with snow. But the mail car from Broadford to Scariff, which started at 2.30 p.m.,

ran into a drift two miles from here. The horse fell, and the car was smashed, and the driver had to return to Broadford. In the evening one of the motor cars tried to get to Limerick, but found the road so blocked with snow that it had to return here.

On Wednesday, April 4th, the Broadford-Limerick road was cleared by the road men. A motor bread van came to Broadford to the great pleasure of everyone.

The greatest previous snow storm I can remember here was on February 19th, 1892. Then it was generally only 5 inches deep. But a severe E. gale blew the snow off the fields into the cuttings on the roads, which were quite blocked up with very deep drifts.

Many old men about here have told me they never saw the snow so deep as it was on the morning of April 2nd.

W. A. BENTLEY, Lieut.-Col.

Hurdlestown, Broadford, Co. Clare, 11th April, 1917.

MR. DARKEN'S WEATHER FORECAST.

MR. DARKEN'S forecast of weather published in your Magazine for March is like most long distance forecasts so vague that it is difficult to test its accuracy. He gives eight periods aggregating 86 days, and varying in length from eight to fifteen days, during which he expected the British Isles to lie in the track of depressions producing strong winds and bitter weather. In two cases these periods were consecutive, in two they were separated by one day in two by two days, and in one case by three days. Thus there were nine days concerning which no prediction was made. From the Weather Reports of the Meteorological Office and other sources it is clear that the whole period was abnormally cold, but the nine days not specified do not seem to have been any warmer than the 86 days included in the prediction. On these nine days the distribution of pressure was essentially of a cyclonic type and gales mostly from the north and east or south-east occurred on six of the days, accompanied in general by snow or rain.

The first cyclonic period, January 1st to 11th, may be taken as a successful forecast, but the second January 15th to 24th was a failure, as the conditions during that time were on the whole anti-cyclonic. The third period, January 26th to February 2nd, included several days with strong winds or gales, but no depressions came near to the British Isles. This forecast was thus indeterminate.

The fourth cyclonic period, February 3rd to 16th, was a total failure, the conditions from the 5th to the 16th being markedly anti-cyclonic, but the fifth cyclonic period, February 19th to March 5th was indeterminate, depressions, mostly in the far north, or to the westward of Ireland, dominating the weather from the

20th to the 27th and from March 2nd to 7th. A marked anti-cyclone occurred from February 27th to March 1st, The sixth cyclonic period from March 8th to 18th., was, on the whole, a failure, for although there were shallow depressions on several days, they did not produce strong winds, except on the 8th, and the British Isles were largely under the influence of an anti-cyclone from the 16th to the 18th.

The seventh period, March 20th to 27th, may be cast as a success on account of a cyclone which passed well to the north of the British Isles on the 25th and 26th, while the eighth period, March 28th to April 6th, was a success as far as depressions are concerned, though these were not accompanied by strong gales.

Thus it will be observed that taking the predictions for the specified periods three appear to have been successful, two were indeterminate and three were failures. Thus Mr. Darken's system which he does not describe produced results very similar to what might be expected by mere guessing. No doubt it would be possible for a "partisan" of the system to claim more hits than misses, and for an opponent to assert that there were more misses than hits, but in my opinion if Mr. Darken had confined himself to saying that the whole period from January 1st to April 6th, would be abnormally cold, he would have made a fair case for a further consideration of his methods.

R. C. MOSSMAN.

334, Camden Road, London, N. 7, May 9th, 1917.

DEW AND HOURLY TEMPERATURE.

ON page 10 of Vol. 50 you published some figures and remarks of my own regarding dew deposit. I have pursued the investigation of the matter through the two intervening years; but the results have been by no means more lavish. All I got in 1915 amounted to no more the .3 in.; and last year I secured only .216 in. Surely somebody in the British Isles gets more dew than I.

In the communication referred to I gave the horary value of fluctuations in temperature during the years 1913 and 1914. I herewith forward the same for two succeeding years.

| | 1915. | 1916. |
|-------------------------------------|---------|---------|
| Hours with temperature below 32° .. | 310 | 269 |
| Temperature 32° to 40° .. | 1,361 | 1,338 |
| " 40° to 50° .. | 2,971.5 | 2,726.5 |
| " 50° to 60° .. | 2,176.5 | 2,426 |
| " 60° to 70° .. | 1,281.5 | 1,452.5 |
| " 70° to 80° .. | 556 | 453.5 |
| " 80° to 90° .. | 102 | 118.5 |
| With temperature higher than 90° .. | 1.5 | .0 |

WILLIAM GODDEN.

20, Richmond Avenue, Willesden, N.W., 28th January, 1917.

RAINFALL TABLE FOR APRIL, 1917.

| STATION. | COUNTY. | RAINFALL. | | | | | | |
|-----------------------------------|------------------|--------------------------------|--------------|-----------------------------|---------------------------|----------------------|--------|-------------------|
| | | Aver. 1875— 1909. in. | 1917. in. | Diff. from Av. in. | Per cent. of Av. | Max. in 24 hours. | | No. of Days |
| | | | | | | in. | Date. | |
| Camden Square..... | London..... | 1'74 | 2'19 | + '45 | 126 | '42 | 2 | 15 |
| Tenterden..... | Kent..... | 1'77 | 1'87 | + '10 | 106 | '27 | 14 | 14 |
| Arundel (Patching)..... | Sussex..... | 1'82 | 1'84 | + '02 | 101 | '37 | 11 | 12 |
| Fordingbridge (Oaklands)... | Hampshire..... | 1'92 | 2'36 | + '44 | 123 | 1'05 | 2 | 13 |
| Oxford (Magdalen College)... | Oxfordshire..... | 1'67 | 1'27 | — '40 | 76 | '23 | 11 | 14 |
| Wellingborough(Swanspool)..... | Northampn..... | 1'78 | 1'44 | — '34 | 81 | '24 | 11, 16 | 13 |
| Bury St. Edmunds(Westley)..... | Suffolk..... | 1'62 | 1'65 | + '03 | 102 | '35 | 16 | 16 |
| Geldeston [Beccles]..... | Norfolk..... | 1'55 | 1'82 | + '27 | 118 | '36 | 2 | 19 |
| Polapit Tamar [Launceston]..... | Devon..... | 2'34 | 2'72 | + '38 | 116 | '55 | 11 | 15 |
| Rousdon [Lyme Regis]..... | "..... | 2'39 | 1'17 | — 1'22 | 49 | '23 | 1 | 12 |
| Stroud (Field Place)..... | Gloucester .. | 2'09 | 1'62 | — '47 | 78 | '39 | 1 | 14 |
| Church Stretton (Wolstaston)..... | Shropshire.. | 2'20 | 1'84 | — '36 | 84 | '35 | 5 | 13 |
| Boston..... | Lincoln..... | 1'57 | 2'01 | + '44 | 128 | '73 | 11 | 16 |
| Workshop (Hodsock Priory)..... | Nottingham..... | 1'62 | 1'46 | — '16 | 90 | '49 | 11 | 12 |
| Mickleover Manor..... | Derbyshire..... | 1'77 | 1'23 | — '54 | 69 | '24 | 1 | 13 |
| Buxton..... | "..... | 2'87 | 3'39 | + '52 | 118 | '56 | 8 | 15 |
| Southport (Hesketh Park)..... | Lancashire..... | 1'84 | 1'64 | — '20 | 89 | '43 | 17 | 13 |
| Arncliffe Vicarage..... | York, W.R..... | 3'73 | ... | ... | ... | ... | ... | ... |
| Goldsborough Hall..... | "..... | 1'89 | 1'99 | + '10 | 105 | '28 | 5 | 15 |
| Hull (Pearson Park)..... | " E.R..... | 1'69 | 1'71 | + '02 | 103 | '24 | 16 | 16 |
| Newcastle (Town Moor)..... | North'land..... | 1'84 | 2'28 | + '44 | 124 | '57 | 2 | 14 |
| Borrowdale (Seathwaite)..... | Cumberland..... | 6'91 | 5'64 | — 1'27 | 82 | 1'95 | 14 | 15 |
| Cardiff (Ely)..... | Glamorgan..... | 2'50 | 2'16 | — '34 | 86 | '54 | 11 | 17 |
| Haverfordwest..... | Pembroke..... | 2'82 | 2'19 | — '63 | 78 | '50 | 17 | 16 |
| Aberystwyth (Gogerddan)..... | Cardigan..... | 2'48 | 2'91 | + '43 | 117 | '74 | 17 | 17 |
| Llandudno..... | Carnarvon..... | 1'79 | 1'58 | — '21 | 88 | '38 | 10 | 16 |
| Cargen [Dumfries]..... | Kirkcudbrt..... | 2'50 | 2'76 | + '26 | 110 | '95 | 10 | 13 |
| Marchmont House..... | Berwick..... | 2'28 | 2'98 | + '70 | 131 | '81 | 3 | 13 |
| Girvan (Pinmore)..... | Ayr..... | 2'81 | 3'12 | + '31 | 111 | '53 | 9 | 22 |
| Glasgow (Queen's Park)..... | Renfrew..... | 1'86 | ... | ... | ... | ... | ... | ... |
| Islay (Eallabus)..... | Argyll..... | 2'64 | 2'61 | — '03 | 99 | '51 | 17 | 21 |
| Mull (Quinish)..... | "..... | 2'98 | 2'67 | — '31 | 90 | '44 | 13 | 22 |
| Balquhiddier (Stronvar)..... | Perth..... | 4'15 | 1'95 | — 2'20 | 47 | '50 | 8 | 10 |
| Dundee (Eastern Necropolis)..... | Forfar..... | 1'93 | 1'43 | — '50 | 74 | '24 | 13 | 13 |
| Braemar..... | Aberdeen..... | 2'30 | 1'33 | — '97 | 58 | '21 | 27 | 15 |
| Aberdeen (Cranford)..... | "..... | 2'23 | 1'65 | — '58 | 74 | '45 | 1 | 19 |
| Gordon Castle..... | Moray..... | 1'74 | 2'76 | + 1'02 | 159 | ... | ... | ... |
| Drumnadrochit..... | Inverness..... | 1'85 | 2'63 | + '78 | 142 | '35 | 12 | 23 |
| Fort William..... | "..... | 3'65 | 2'53 | — 1'12 | 69 | '47 | 13 | 23 |
| Loch Torridon (Bendamph)..... | Ross..... | 4'70 | 6'45 | + 1'75 | 137 | '87 | 27 | 26 |
| Dunrobin Castle..... | Sutherland..... | 2'02 | 2'73 | + '71 | 135 | '90 | 27 | 20 |
| Killarney (District Asylum)..... | Kerry..... | 3'46 | 2'23 | — 1'23 | 64 | '46 | 10 | 18 |
| Waterford (Brook Lodge)..... | Waterford..... | 2'68 | 1'58 | — 1'10 | 59 | '62 | 1 | 10 |
| Nenagh (Castle Lough)..... | Tipperary..... | 2'54 | 2'44 | — '10 | 96 | 1'05 | 1 | 13 |
| Ennistymon House..... | Clare..... | 2'81 | 1'69 | — 1'12 | 60 | '40 | 10 | 16 |
| Gorey (Courtown House)..... | Wexford..... | 2'37 | 1'00 | — 1'37 | 42 | '20 | 5 | 10 |
| Abbey Leix (Blandsfort)..... | Queen's Co..... | 2'54 | 1'31 | — 1'23 | 52 | '37 | 2 | 12 |
| Dublin (Fitz William Square)..... | Dublin..... | 2'03 | '90 | — 1'13 | 44 | '18 | 17 | 12 |
| Mullingar (Belvedere)..... | Westmeath..... | 2'37 | 1'91 | — '46 | 81 | '30 | 18 | 14 |
| Crossmolina (Enniscooe)..... | Mayo..... | 3'13 | 3'80 | + '67 | 122 | '67 | 10 | 18 |
| Cong (The Glebe)..... | "..... | 2'98 | 2'64 | — '34 | 89 | '90 | 10 | 14 |
| Collooney (Markree Obsy.)..... | Sligo..... | 2'52 | 2'69 | + '17 | 107 | '53 | 17 | 17 |
| Seaforde..... | Down..... | 2'76 | 2'04 | — '72 | 74 | '57 | 10 | 14 |
| Ballymena (Harryville)..... | Antrim..... | 2'57 | 4'88 | + 2'31 | 190 | 1'50 | 10 | 20 |
| Omagh (Edenfel)..... | Tyrone..... | 2'50 | 2'47 | — '03 | 99 | '49 | 17 | 16 |

SUPPLEMENTARY RAINFALL, APRIL, 1917.

| Div. | STATION. | Rain inches. | Div. | STATION. | Rain inches |
|-------|-------------------------------|-----------------|--------|-------------------------------|----------------|
| II. | Warlingham, Redvers Road . | 2.96 | XI. | Lligwy | 3.20 |
| „ | Ramsgate | 1.48 | „ | Douglas, Isle of Man | 2.13 |
| „ | Hailsham | 1.55 | XII. | Stoneykirk, Ardwell House... | 1.63 |
| „ | Totland Bay, Aston House... | 2.70 | „ | Carsphairn, Shiel | 3.18 |
| „ | Stockbridge, Ashley | 2.40 | „ | Langholm, Drove Road | 3.31 |
| „ | Grayshott | 2.75 | XIII. | Selkirk, The Hangingshaw.. | 3.46 |
| III. | Harrow Weald, Hill House... | 2.28 | „ | North Berwick Reservoir... | 1.56 |
| „ | Pitsford, Sedgebrook..... | 1.50 | „ | Edinburgh, Royal Observaty. | 1.20 |
| „ | Woburn, Milton Bryant..... | 1.64 | XIV. | Biggar..... | 2.66 |
| „ | Chatteris, The Priory..... | 1.13 | „ | Maybole, Knockdon Farm ... | 1.78 |
| IV. | Harrowham, Gaunts End | 2.05 | XV. | Buchlyvie, The Manse | ... |
| „ | Shoeburyness | 1.68 | „ | Ballachulish House | 3.36 |
| „ | Colchester, Hill Ho., Lexden | 1.85 | „ | Oban..... | 2.28 |
| „ | Ipswich, Rookwood, Copdock | 1.51 | „ | Campbeltown, Witchburn .. | 2.54 |
| „ | Aylsham, Rippon Hall | 2.29 | „ | Holy Loch, Ardnadam | 2.79 |
| „ | Swaffham | 1.79 | „ | Tiree, Cornaigmore | 1.56 |
| V. | Bishops Cannings | 1.75 | XVI. | Dollar Academy | ... |
| „ | Wimborne, St. John's Hill ... | ... | „ | Glenlyon, Meggernie Castle.. | 1.72 |
| „ | Ashburton, Druid House | 1.80 | „ | Blair Atholl | 1.09 |
| „ | Cullompton | 1.68 | „ | Coupar Angus | 1.20 |
| „ | Lynmouth, Rock House | 2.11 | „ | Montrose, Sunnyside Asylum. | .97 |
| „ | Okehampton, Oaklands..... | 3.04 | XVII. | Alford, Lynturk Mansef..... | ... |
| „ | Hartland Abbey..... | 1.74 | „ | Fyvie Castle | 2.91 |
| „ | St. Austell, Trevarna | 1.62 | „ | Keith Station .. | 3.28 |
| „ | North Cadbury Rectory..... | 1.85 | XVIII. | Rothiemurchus | 2.60 |
| VI. | Clifton, Stoke Bishop | 1.90 | „ | Loch Quoich, Loan | 8.40 |
| „ | Ledbury, Underdown..... | 1.32 | „ | Skye, Dunvegan | 2.36 |
| „ | Shifnal, Hatton Grange..... | 1.56 | „ | Lochmaddy, Bayhead | ... |
| „ | Droitwich | 1.31 | „ | Fortrose | 2.17 |
| „ | Blockley, Upton Wold..... | 1.57 | „ | Glencarron Lodge | 5.35 |
| VII. | Grantham, Saltersford..... | 1.37 | XIX. | Altnaharra | ... |
| „ | Market Rasen | 2.21 | „ | Melnich | 2.73 |
| „ | Bawtry, Hesley Hall | 1.44 | „ | Loch More, Achfary | 8.62 |
| „ | Whaley Bridge, Mosley Hall | 2.78 | XX. | Dunmanway, The Rectory .. | 1.14 |
| „ | Derby, Midland Railway..... | .95 | „ | Glanmire, Lota Lodge..... | 1.05 |
| VIII. | Nantwich, Dorfold Hall | 1.71 | „ | Mitchelstown Castle..... | 1.67 |
| „ | Chatburn, Middlewood | ... | „ | Darrynane Abbey..... | 1.75 |
| „ | Lancaster, Strathspey | 1.36 | „ | Clonmel, Bruce Villa | 1.72 |
| IX. | Langsett Moor, Up. Midhope | 1.75 | „ | Broadford, Hurdlestown..... | 2.50 |
| „ | Scarborough, Scalby | 3.08 | XXI. | Enniscorthy, Ballyhyland... | 1.30 |
| „ | Ingleby Greenhow | 2.96 | „ | Rathnew, Clonmannon | .76 |
| „ | Mickleton | 1.40 | „ | Ballycumber, Moorock Lodge | 1.55 |
| X. | Bellingham, High Green Manor | 2.32 | „ | Balbriggan, Ardgillan | 1.47 |
| „ | Ilderton, Lilburn Cottage ... | 3.03 | „ | Castle Forbes Gardens..... | 1.94 |
| „ | Keswick, The Bank | 3.12 | XXII. | Ballynahinch Castle | 2.55 |
| XI. | Llanfrechfa Grange | 1.23 | „ | Woodlawn | 1.62 |
| „ | Treherbert, Tyn-y-waun | 4.15 | „ | Westport, St. Helens ... | 2.56 |
| „ | Carmarthen, The Friary | 2.41 | „ | Dugort, Slievemore Hotel ... | 4.10 |
| „ | Fishguard, Goodwick Station. | 2.11 | XIII. | Enniskillen, Portora | 2.09 |
| „ | Crickhowell, Tal-y-maes | 2.00 | „ | Dartrey [Cootehill] | 2.57 |
| „ | New Radnor, Ednol | 1.92 | „ | Warrenpoint, Manor House .. | 1.36 |
| „ | Birmingham WW., Tyrmynydd | 3.42 | „ | Belfast, Cave Hill Road | 2.77 |
| „ | Lake Vyrnwy | 2.48 | „ | Glenarm Castle | 2.75 |
| „ | Llangynhafal, Plas Drâw..... | 2.71 | „ | Londonderry, Creggan Res... | 4.03 |
| „ | Dolgelly, Bryntirion..... | 5.20 | „ | Dunfanaghy, Horn Head ... | 3.76 |
| „ | Bettws-y-Coed, Tyn-y-bryn... | 4.98 | „ | Killybegs | 3.98 |

Climatological Table for the British Empire, November, 1916.

| STATIONS. (Those in italics are South of the Equator.) | Absolute. | | | | Average. | | | | Absolute. | | Total Rain | | Aver. |
|--|-----------|-------|----------|-------|----------|------|---------------|-----------|-----------------|-------------------|------------|-------|-------|
| | Maximum. | | Minimum. | | Max. | Min. | Dew Point. | Humidity. | Max. in Sun. | Min. on Grass. | Depth. | Days. | |
| | Temp. | Date. | Temp. | Date. | | | | | | | | | |
| | ° | | ° | | ° | ° | ° | 0-100 | ° | ° | inches | | |
| London, Camden Square | 58·4 | 11 | 26·2 | 28 | 50·1 | 39·1 | 41·1 | 89 | 91·5 | 25·2 | 4·67 | 12 | 7·1 |
| Malta | 75·9 | 21 | 54·7 | 24 | 71·7 | 59·5 | ... | 75 | 123·0 | ... | 3·26 | 10 | 2·7 |
| Lagos | 90·4 | 19 | 70·5 | 24 | 87·4 | 74·4 | 74·3 | 78 | 153·0 | 69·0 | 5·29 | 10 | 6·5 |
| Cape Town | 92·4 | 16 | 48·4 | 10 | 75·3 | 56·9 | 53·8 | 63 | ... | ... | ·36 | 5 | 3·4 |
| Johannesburg | 84·8 | 15 | 40·3 | 12 | 74·6 | 52·6 | 48·4 | 61 | ... | 39·6 | 4·23 | 13 | 5·0 |
| Mauritius | 85·0 | 29 | 57·0 | 1 | 81·8 | 66·6 | 63·3 | 70 | ... | 51·1 | 1·33 | 17 | 5·4 |
| Bloemfontein | 90·8 | 14 | 41·8 | 12 | 82·2 | 54·4 | 51·5 | 62 | .. | ... | ·68 | 6 | 3·2 |
| Calcutta... .. | 86·8 | 1 | 60·7 | 22 | 81·7 | 66·7 | 65·4 | 75 | ... | 51·2 | 1·07 | 2 | 2·3 |
| Bombay... .. | 88·5 | 15 | 73·4 | 22 | 86·5 | 75·6 | 72·5 | 76 | 140·3 | 68·1 | ·72 | 1 | 2·8 |
| Madras | 92·8 | 3 | 68·8 | 22 | 85·5 | 73·7 | 72·9 | 84 | 164·3 | 67·2 | 14·17 | 18 | 4·9 |
| Colombo, Ceylon | 87·4 | 21 | 69·1 | 7 | 85·3 | 72·1 | 71·7 | 83 | 159·4 | 63·4 | 8·04 | 17 | 6·9 |
| Hongkong | 82·6 | 8 | 47·0 | 29 | 73·5 | 62·4 | 55·8 | 63 | ... | ... | ·08 | 1 | 3·4 |
| Sydney | ... | ... | ... | ... | ... | ... | ... | ... | ... | ... | ... | ... | ... |
| Melbourne | 85·5 | 20 | 40·1 | 14 | 67·3 | 51·3 | 48·5 | 67 | 147·0 | 32·7 | 6·71 | 20 | 7·3 |
| Adelaide | 88·1 | 30 | 44·5 | 14 | 69·3 | 52·3 | 48·8 | 63 | 157·8 | 39·0 | 2·84 | 17 | 6·6 |
| Perth | 95·7 | 15 | 50·7 | 4 | 77·0 | 57·3 | 52·2 | 58 | 155·8 | 41·1 | 2·78 | 8 | 3·9 |
| Coolgardie | 97·8 | 16 | 47·0 | 4 | 81·2 | 57·3 | 46·0 | 39 | 158·0 | 40·0 | 2·04 | 5 | 3·0 |
| Hobart, Tasmania | 72·0 | 11 | 42·4 | 15 | 61·4 | 48·5 | 45·2 | 68 | 141·6 | 32·8 | 7·07 | 20 | 7·7 |
| Wellington | 73·5 | 14 | 41·0 | 2 | 64·2 | 53·5 | 51·2 | 76 | 147·5 | 27·5 | 5·98 | 15 | 6·8 |
| Auckland | ... | ... | ... | ... | 67·2 | 56·3 | ... | ... | ... | ... | 7·74 | 22 | ... |
| Jamaica, Kingston | 88·5 | 6 | 65·8 | 28 | 84·1 | 71·5 | 71·3 | 89 | ... | ... | 11·27 | 16 | 6·5 |
| Grenada | 86·0 | 1 | 70·0 | 4 | 83·0 | 73·0 | ... | 80 | 134·0 | ... | 15·10 | 23 | 4·5 |
| Toronto | 64·0 | 8 | 12·0 | 26 | 44·5 | 30·7 | 30·6 | 83 | 104·0 | 9·0 | 1·64 | 14 | 5·4 |
| Fredericton | 66·0 | 9 | —5·0 | *15 | 38·9 | 20·8 | 24·5 | 86 | ... | ... | 2·37 | 7 | 6·4 |
| St. John, N.B. | 54·0 | 24 | 9·0 | 17 | 40·0 | 27·0 | 29·8 | 77 | 104·0 | ·0 | 2·55 | 8 | 5·6 |
| Victoria, B.C. | 52·0 | 8 | 29·0 | 12 | 46·4 | 38·1 | 37·0 | 84 | 108·0 | 19·0 | 2·26 | 17 | 5·9 |

* 17,

Malta.—A cyclone passed over the east of the Island, doing some damage to property
Johannesburg.—Bright sunshine, 222·8 hours.

Mauritius.—Mean temp. 1°·3 and dew point 0°·7 below, average. R ·25 in. under, average.

COLOMBO, CEYLON.—Mean temp. 78°·7, or 0°·8 below, dew point 1°·2 below, and R 3·54 in. below, averages. Mean hourly velocity of wind 3·9 miles. TS on 4 days.

HONGKONG.—Mean temp. 67°·8; mean hourly velocity of wind 10·7 miles. Bright sunshine 231·8 hours.

Melbourne.—Mean temp, 2°·0 below, and R the highest for November for 61 years, and the total for year up-to-date is highest for 61 years. Pressure very low,

Adelaide.—Mean temp. 6°·3 below, and R 1·69 in. above, averages. Coldest November on record for 59 years, and the cloud, highest on record.

Coolgardie.—Rainfall fully 1·00 in. above, averages.

Hobart.—Temp. 2°·3 below, and R 4·57 in. above averages. The wettest year to date on record.

Wellington.—Mean temp. 2°·0 above, and R 2·60 in., above, averages. Bright sunshine 177·5 hours.

JAMAICA.—Rainfall more than twice the average over the Island.