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The Sun and the Weather.

By R. M. DEELEY.

MANY writers on meteorology have tried to show that there is an intimate relation between the activities of the sun, such as are exhibited by sun-spots, &c., and the variations of the weather which take place on the earth's surface, the favourite line of attack being through periodicity. Most of the attempts to correlate sun-spot activity with weather-changes have been directed to the question of temperature and rainfall changes, and it would appear that sun-spot activity is in some places associated with cold, and in some with warm conditions, in some with increased, in some with decreased rainfall.

Our meteorological charts show us the changes of atmospheric pressure which occur on the earth's surface from month to month, and also, to some extent, the anomalous conditions of pressure which obtain when the climatic conditions of particular areas are unusual, but although very great attention has been paid to the daily and hourly variations of pressure which occur, there is no agreement among meteorologists as to how the conditions obtaining at any one time are brought about.

I have attempted* to show that if the winds be considered as resulting from the heating of the upper portion of the

* *Phil. Mag.*, July 1915, April 1916, and March 1918.

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stratosphere, as well as the lower portion of the troposphere, it is possible to account for the general pressure distribution and wind directions being as they are ; but to do this it must be assumed that the stratosphere is mainly heated over the poles and the lower troposphere over the equator. Now the earth's atmosphere is warmed in two ways. The heat and light waves mainly pass through the upper atmosphere and heat the earth's surface and lower troposphere, whilst the electrons shot out by the sun are, as explained by Arrhenius, directed by the earth's magnetic field towards the poles, where they heat the upper atmosphere and cause the aurora. If such be the case the climate of the earth will be affected both by variations in the intensity of the heat rays emitted by the sun as well as by variation in the number of electrons shot out.

One way to detect changes in the number of electrons emitted from the sun from time to time would be by a study of auroral changes ; for great auroral displays resulting from the sun's electrical activities should, theoretically, be accompanied by greater heating of the upper atmosphere over the poles* than over the equator.

From a study of barometric changes I shall attempt to show that the conditions in Great Britain during the long spell of dry hot weather in 1921 have been such as may be expected when the electronic bombardment is a mild one.

Encircling the earth along the equatorial regions is a belt of low pressure towards which the winds blow from easterly directions. This low pressure belt oscillates about the equator, following the sun as it moves north and south. The circulation of the atmosphere in this region appears to be caused mainly by the heat of the vertical sun acting upon the earth's surface and the lower atmosphere. If the winds

* Even as far south as lat. 35° N. Slipher has seen the green auroral line ($\lambda 5578$). Lord Rayleigh remarks "I have succeeded in photographing the line on many nights for the past month. I do not always get it, and one of the failures has been on a fairly clear night. On the other hand, many of the successes have been on cloudy, though not, of course, extremely dark nights."

"At the present time sun-spot minimum is much nearer than during Slipher's experiments, and for this and other reasons I am inclined to think that I have been dealing with fainter auroras than he did."

"The programme in view is a systematic comparison of the auroral intensity with sun-spots and magnetic disturbances, and also a comparison of its intensities in different localities in Great Britain and elsewhere. So far as I have been able to learn, the auroral spectrum has not previously been photographed in this country." *Nature*, March 31st, 1921, p. 137.

It is to be hoped that all those who are in a position to do so will second Lord Rayleigh's efforts to obtain as complete a record as possible of auroral intensities, especially over Northern Europe, Asia and North America.—R. M. D.

[An account of Lord Rayleigh's further work in this direction is given on p. 295 of the issue for November.—ED. *Met. Mag.*]

of the earth were entirely due to the sun's heat acting in this way on the lower atmosphere and earth, the polar regions, not being so greatly affected by the sun's heat rays in summer, and being entirely in the shade during winter, would be areas of high pressure and intense cold, and the air would descend and blow towards the equator from easterly directions. But this does not take place, for over the polar areas there are great low pressure cyclones, towards which westerly winds blow. Over the Arctic regions the cyclone has what may be regarded as two low pressure eyes, one over the North Atlantic and the other over the Behring Sea, the warm seas probably assisting to cause an updraught, especially in winter. Between the polar low pressure areas and the low pressure equatorial belt, therefore, we have high pressure belts (anti-cyclonic), broken to some extent by reason of the varying temperatures of the ocean, as compared with the land. The two polar cyclones seems to be due to the heating of the upper atmosphere over the polar areas, such heating more than compensating for the comparatively thin cold layer near the ground. Now the positions of the two high pressure belts depend upon the diameters of the two polar cyclones, and if they decreased in diameter and strength the two high pressure belts would approach the poles. If this occurred in the summer, anticyclonic hot and dry conditions would travel towards the poles, but if in winter, anticyclonic and probably cold surface conditions would result. Thus decreased electrical activity on the part of the sun results in England in cold winters and warm dry summers.

During 1921 the high pressure belt covering western Europe has been much further north than usual, and consequently, over France and southern England particularly we have had exceptionally hot weather. The south-westerly winds which generally blow from the Atlantic during both winter and summer, and give us our cool summers and warm winters, are thrown far to the north, whilst France and southern England have dry warm easterly, southerly, or northerly winds. We thus have a continental summer instead of an oceanic one.

The actual climatic conditions produced by the shifting of the high pressure belts depends upon the position of the areas affected. Generally speaking, the result of decreased electrical activity is to move the hot weather and desert conditions nearer the poles in summer, but the distribution of the land areas and especially of mountain ranges exercises a considerable effect. Not only is this the case, but changes in the direction of the winds, caused by movements of the high pressure belts, modify very considerably the directions taken by the ocean currents and thereby modify the temperature and humidity of the air.

The more general rains, however, are the result of secondary or travelling cyclones causing currents of air to rise, the one over the other, and throw down moisture. Such cyclones seem to be fewer in number and of less strength when pressure is generally high and when there is a deficiency of electrical activity on the part of the sun, the chain of events in the northern hemisphere being (*a*) reduced activity of solar electronic bombardment, (*b*) increase of pressure near the pole, and northern march of the high pressure belt, (*c*) reduced frequency of westerly winds and cyclones crossing Western Europe, (*d*) reduced rainfall and hot weather especially in the northern portion of the British Isles.

Is the Propagation of Waves affected by the Rotation of the Earth?

By F. J. W. WHIPPLE, M.A.

To most people who have not had occasion to study meteorology the dynamical influence of the rotation of the earth is a scientific curiosity which is illustrated by Foucault's pendulum and by the gyrostatic compass. To the meteorologist, the tendency of moving air to bear to the right in the northern hemisphere, to the left in the southern, under the influence of "geostrophic force," is familiar, but it is only recently that the like property of moving water has been fully realised. G. I. Taylor's investigations on the tides of the Irish Sea show that it is owing to geostrophic force that the range of the tide on the Welsh coast is much greater than that on the opposite Irish coast. As the flood-tide moves northward the water is piled up on the east of the Irish Channel, and during the ebb it is thrown away from the same coast. More recently Taylor has explained the movement of the tide in the North Sea, where the tidal wave as it comes in from the north hugs the British coast and sweeps round the Low Countries to Scandinavia.

The behaviour of Ocean currents is also explained by the action of geostrophic force. Currents in deep water are only appreciable near the surface; they are due to the dragging power of the wind, but as Walfrid Ekman predicted and as has been verified by Jeffreys, the currents do not flow with the wind. Under steady conditions the direction of motion of the water close to the surface is inclined 45° to the right of the direction of motion of the air. Theory indicates that at increasing depths the direction of motion of the water bears more and more to the right. The resultant drift is at right angles to the wind, this being the condition that the resultant geostrophic force may just balance the drag of the wind.

The action of the wind in producing high water in the narrow seas has not yet been fully investigated, but instances in which the action of geostrophic force is to be detected can be found without difficulty when once the clue is given. Two recent examples were mentioned in the last issue of this Magazine. Another will be found in the *Meteorological Office Circular* No. 31, where it is stated that the highest tides at Richborough were found with northerly winds.

The question whether the propagation of ordinary waves on the surface of the water is affected by the rotation of the earth does not seem to have been discussed, in fact speculation as to the origin of the "swell" observed either on the coast or in mid-ocean is always based on the idea that waves once started will be propagated in straight lines, or rather in the great circles which are the nearest possible approach to straight lines on a globe.

In view, however, of the acknowledged importance of the rotation of the earth in the theories of the tides and of ocean currents, it may be asked whether surface waves are not also affected.

If the motion of a wave on the sea were comparable with that of a particle on a smooth rotating globe its course would be very nearly a circle; in latitude L the wave-front would rotate through two right angles in a fraction $\frac{1}{2}$ cosec L of a day. Thus, near latitude 50° waves created by a west wind and moving at 40 knots from the west would be met 15 hours later and 400 nautical miles to the south as a swell from the east. Such a notable rotation, if it took place at all, would surely be well known to seamen. It is understood that the identification of the origin of "swell" is not always easy even when daily synoptic weather charts are available, and that some smaller rotation of the direction of movement might be admitted, but nothing like a complete reversal in 15 hours.

An examination of the problem from the mathematical point of view shows, however, that no such rotation is to be expected. The analysis given below indicates that the wave-fronts move straight ahead in spite of the movements of the individual particles in the water not being confined to planes at right angles to the wave-fronts. At the crest the particles are running with the wave, and owing to the geostrophic force they will have a slight acceleration to the right. In the trough there is a like acceleration in the opposite direction.

In the ordinary theory of long waves it is shown that the individual particles move in vertical circles in planes at right angles to the wave-fronts. When allowance is made for geostrophic force it is found that the circles described by the particles are inclined to the vertical; the tip is so small, however, that there is no possibility of detecting it by observation. We may therefore conclude that there is at present no reason to suspect any appreciable influence of the rotation of the earth on the propagation of swell.

It may not be irrelevant to mention, in conclusion, that with sound waves, where the period of oscillation of a particle is infinitesimal compared with the period of rotation of the earth, no effect of that rotation is to be expected. On the other hand, as Margules has realised, any theory of such waves as are shown in the regular diurnal changes of barometric pressure must be largely devoted to the consideration of this rotation.

Analysis.—Confining attention to the case of waves in a polar basin and taking the axes of x and y horizontal, that of z vertically downwards, the equations of motion are

$$\frac{du}{dt} - 2nv = -\frac{1}{\rho}\frac{\delta p}{\delta x}$$

$$\frac{dv}{dt} + 2nu = -\frac{1}{\rho}\frac{\delta p}{\delta y}$$

$$\frac{dw}{dt} = -\frac{1}{\rho}\frac{\delta p}{\delta z} + g$$

and the equation of continuity is

$$\frac{du}{dx} + \frac{dv}{dy} + \frac{dw}{dz} = 0$$

where u, v, w are the components of the velocity, p is the pressure, n the angular velocity of the earth, g the acceleration due to gravity and ρ the density of the water.

A solution of these equations is

$$u = \mathrm{A}e^{-mz}\cos(kx - \sigma t)$$

$$v = \frac{2n}{\sigma}\mathrm{A}e^{-mz}\sin(kx - \sigma t)$$

$$w = -\frac{k}{m}\mathrm{A}e^{-mz}\sin(kx - \sigma t)$$

$$\frac{p}{\rho} = gz + \frac{k\sigma}{m^2}\mathrm{A}e^{-mz}\cos(kx - \sigma t)$$

with the condition $\sigma^2(\sigma^2 - 4n^2) = k^2g^2$

An additional condition $\sigma^2 = mg$ is determined by the agreement between the upward velocity of the free surface with that of the water near the surface.

The existence of such a solution of the equation indicates that a series of waves can be propagated without change of direction. Moreover, since n is very small in comparison with σ the velocity of the waves is not appreciably affected by the rotation of the earth.

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OFFICIAL NOTICES.

Meteorological Office. Changes in Codes for Reports.

FROM 1st January 1922, the hourly reports issued by wireless telegraphy from the Air Ministry, primarily for the London–Continental Air Services, will be sent in the revised code adopted by the International Commissions for Weather Telegraphy and for the Application of Meteorology to Aerial Navigation at meetings held in London last September. The code will be brought into use from the same date by the French and Belgian Meteorological Services.

The revised code is shorter than the code at present in use; the specifications of the different code figures remain practically unchanged, but in the case of visibility the code has been modified to include a figure for distances of 50 kilometres and upwards. This modified code for visibility will be adopted in all British meteorological reports from 1st January.

Copies of the code and full particulars of the reports referred to may be obtained on application to the *Director, Meteorological Office, Air Ministry, W.C. 2.*

Official Publications.

British Rainfall, 1920. 9 × 6. pp. xxviii + 285. 2 plates. Fully illustrated. Price 12*s*. 6*d*. net.

THE sixtieth annual volume of *British Rainfall*, dealing with the records of the year 1920, gives evidence that the transfer of the work of the British Rainfall Organization from private to public control, a task attended with many difficulties, may now be regarded as having been successfully accomplished. The number of complete records available for the year was 5,452, an increase of 54 over 1919; this increase appears to put a period to the gradual decline in numbers which had been the natural result of the war.

An innovation introduced into the volume is the addition of a column to the general tables of rainfall, giving the number of days in the year on which ·04 in. (1·0 mm.) of rain fell at each station. This step has been taken as a result of the enquiry instituted in the volume for 1919 on the advisability of regarding ·04 in. as the unit for computing frequency of days with rain instead of ·01 in. as hitherto. The tabulation of dry and wet periods based upon the new unit has again been given side by side with the results by the older method. The advantages of the new definitions set out in 1919 have been confirmed. It is proposed, however, not to discontinue the use of the old definitions until a few years' comparative data are available.

The section dealing with Heavy Falls of Rain in 1920 contains an account of the disastrous storm at Louth on May 29th, 1920, when 22 lives were lost and damage to the extent of 100,000*l*. was done.

The statistical basis of the work has been greatly strengthened by the introduction, for the first time, of the recently computed rainfall averages for the period 1881–1915. In addition to bringing the tables into line with those published in this Magazine and in the *Monthly Weather Report*, the use of the new averages greatly improves the choice of stations for comparison with average conditions and enables the number to be increased. This affects the sections dealing with monthly and seasonal rainfall and with that of the year as a whole, and enables the maps illustrating these sections to be improved. The publication of a map showing the distribution of total rainfall during the year, on a scale of 80 miles to 1 inch, has again been possible.

The special articles include an account of the revised rainfall averages and the regional distribution which they indicate, illustrated by examples of the monthly average rainfall maps referred to in this Magazine for March 1921, p. 37, and comparing also the values for individual stations with those given by the average 1875–1909 previously used.

Another article deals with recent experiments by Mr. Wilfred Irwin on the salt-content of rain in the British Isles, suggesting a geographical distribution of considerable range and pointing out the economic bearing of the observations.

An account is also given of the development of the Nipher rain gauge shield in America and on the Continent of Europe, with suggestions for its adaptation for use in the British Isles.

British Meteorological and Magnetic Year Book, 1914, *Part V. Réseau Mondial.* Price 18s. net.

THE first volume of the Réseau Mondial to be prepared was that for 1911. Volumes for 1912 and 1913 followed and then 1910. With the resumption of international communication, it became possible to proceed with the preparation of later volumes, and that for 1914 has now been issued. For this volume the whole of the normals have been revised and a number of new values computed; it is hoped to publish these revised normals at a later date. Complete observations over Russia were unobtainable at the time, but it is hoped that they will be published eventually.

The Fernley Observatory, Southport. Report and Results of Observations for the Year 1920. By Joseph Baxendell.

IN addition to the usual full account of the weather at Southport the report of the Fernley Observatory for 1920 contains an account by Mr. Baxendell of an examination of a long series of mean winter-temperatures for London. The temperatures adopted are based on observations at various places in London with various exposures and various hours of observation, but they have been adjusted to be comparable with the means for the present exposure at the Royal Observatory, Greenwich. Mr. Baxendell finds that the five-year periodicity is well marked in these data, and that its length during the last 125 years lies nearly midway between 5·0 and 5·1 years with a slight lengthening tendency. The next minimum is due about 1921. The amplitude is nearly double that obtained by Capt. D. Brunt from whole-year temperatures, the reason being that easterly winds and clear anticyclonic weather increase the surface temperature in the summer. It is hoped that more detailed results of Mr. Baxendell's work will soon be available for publication.

Royal Meteorological Society.

THE first meeting of the session was held on Wednesday, November 16th, at the Society's new house, 49, Cromwell Road, S. Kensington.

Dr. Harold Jeffreys.—On the Dynamics of Wind.—The first paper was by Dr. Harold Jeffreys "On the Dynamics of Wind." Dr. Jeffreys sets down the general equation of motion of a fluid on a rotating globe and considers the order of magnitude of the various terms. This analysis leads to the division of winds into three main groups, according as the pressure differences between places at the same level are mainly occupied in producing acceleration relative to the ground, in guiding the wind under the influence of the earth's rotation, or in overcoming friction. In the ideal cases when these several causes predominate the winds are to be called "Eulerian," "geostrophic" and "antitriptic" respectively. The name Eulerian is in honour of Euler who was the first to give the equations of fluid motion; the word geostrophic, meaning in tune with the earth's motion, was coined by Sir Napier Shaw and has been generally adopted; the denomination antitriptic, *i.e.*, opposed to friction, has been invented by Dr. Jeffreys for the present paper. It appears that tropical cyclones and tornadoes are Eulerian; all winds of wide extent, including the winds of the travelling cyclone of temperate regions as well as the great air-currents like the monsoons and trades, are approximately geostrophic whilst sea and land breezes, mountain and valley winds are mainly antitriptic.

The part played by temperature differences in producing wind is analysed with special reference to the alternation of high and low pressure in winter and summer in central Asia, and to the production of land and sea breezes.

In the discussion on this paper Mr. Whipple insisted that though mountain-breezes directing the drainage of cold air into the valleys at night were common there was no reverse movement of the air by day; the winds that blew in the day time in the valleys were the more general currents. Mr. Whipple also pointed out that sea breezes were affected by the rotation of the earth. Observations at Aberdeen showed that the sea breeze was nearly perpendicular to the shore at first, but by sunset it was nearly parallel to the shore.

N. K. Johnson, B.Sc.—The Behaviour of Pilot Balloons at Great Heights.—Wind structure in the upper atmosphere is almost invariably determined by following a pilot balloon with a single theodolite. At a few stations the balloon is followed by two theodolites, but in the great majority of the determinations only a single theodolite is used. The reduction of observations with a single theodolite rests upon the assumption that the rate of ascent of the balloon is uniform, and therefore any departure from uniformity in the rate of ascent will give rise to errors in the computed wind velocity and direction. In the case of a pilot balloon observed with two theodolites at the ends of a base line, the actual height of the balloon is calculated from minute to minute, and no assumption is therefore needed as to the constancy of the rate of ascent. On the contrary this method affords a means of testing the accuracy of the assumption which has to be made in the single theodolite method. Evidence bearing on this point is given by observations made at Shoeburyness during 1920, and examples are given which illustrate the untrustworthy nature of the single theodolite method of observation at great heights. Balloons which had risen steadily to considerable heights developed leaks, and either drifted horizontally or began to fall. Experiments on the leakage of pilot balloons are detailed, and from these the author re-affirms that the results of single theodolite pilot balloon ascents which are carried to great heights must always be received with great caution.

In the discussion on this paper Captain Cave expressed the opinion that the leakage of gas from a balloon was sometimes intermittent, the hole through which the gas had escaped closing when the balloon reached a lower level. Mr. Corless emphasized the importance of the highest accuracy in the construction and use of theodolites for observing balloons at great distances, especially when two theodolites were used.

C. J. P. Cave, M.A.—The Cloud Phenomenon of November 29th, 1920.—As was mentioned in the *Meteorological Magazine*, December 1920, p. 256, a cloud with a sharp-cut edge passed across the east of England on November 29th of that year. Captain Cave presented to the Society an account of this phenomenon. The cloud was observed as far north as Worksop, Notts, and as far south as Hawkhurst, Kent. It moved from the west with clear sky in front, overcast sky behind, but the maps prepared by Captain Cave show that the progress of the edge was not regular. The cloud seems to have been built up more or less continually by air rising in front of the cloud and streaming nearly parallel to the edge from north to south. A fascinating riddle!

Discussions at the Meteorological Office.

Nov. 14th. *Is the Atmosphere Warmed by Convection from the Earth's Surface?* By W. Schmidt. Meteorologisch Zeitschrift. September 1921.

THE heating and cooling of the atmosphere depend on the balance of several causes, radiation, convection, evaporation and condensation all playing their part, as well as compression and rarefaction. It is widely believed that, on the average, the direct contact of air with the ground heats the air more than it cools it. In this paper by Dr. Schmidt (which was introduced by Capt. Brunt) the results of some numerical investigations of the convective transference of heat, based on observations in India, Germany, and Hungary are discussed. Dr. Schmidt concludes that the resultant flow is downwards and averages 50 gram-calories per square centimetre per day. Objection to this conclusion, which is opposed to that of Mr. W. H. Dines* was raised by several speakers. The rate of transference of heat depends on both the eddy conductivity and on the difference between the adiabatic and actual lapse-rates of temperature. When the lapse-rate exceeds the adiabatic, the vertical exchange of mass is a much more vigorous process than when it is less. Consequently, Schmidt's use of mean values of the lapse-rate may have led him to underestimate the transference of heat upwards very considerably. On the other hand, the absence of a diurnal variation of temperature at heights of two or three kilometres indicates that these layers are not warmed appreciably from the ground.

Nov. 28th. *The Origin of Continents and Oceans.* By A. Wegener. Die Wissenschaft, Bd. 66, 1920.

THE problem of the origin of continents and oceans has received much attention but most theorists have worked with the idea that the present land masses have occupied similar relative positions since their first solidification. Dr. Wegener, whose work was explained by Dr. G. C. Simpson, allows the continents to slide over the globe, and finds evidence that parts which were in contact in past ages are now widely separated. Perhaps the best example of this separation is the case of South America and Africa. It is obvious, on the map, that these continents would fit together pretty well, and the fit becomes better if the edges of the continental shelves are considered rather than the shore-lines. Moreover, bringing the continents together brings into juxtaposition rocks of like character. The striking Glossopteris flora of Carboniferous

* *Q. J. R. Met. Soc.*, Vol. XLIII., 1917, p. 155.

age is found only in South Africa, South America, Madagascar, India and the Antarctic. Wegener suggests that the land masses of the globe were formerly all connected so that these countries were close together, and that the single continent of that period has broken up into several fragments which have separated and moved over the semi-fluid interior of the earth into their present positions. The theory avoids the assumption of several vanished continents, which is generally adopted as an explanation of the distribution of the Glossopteris flora Moreover, a shifting of the continents relative to the pole gives a possible explanation of glacial periods. A general westward movement of the land-masses is postulated, whilst resistance to this movement accounts for the curvature of the extreme south of South America and the neighbouring part of Antarctica.

So startling a theory naturally gave rise to vigorous discussion, various speakers criticising it in its dynamical, geodetic, astronomical and geological aspects. It was agreed, however, that the theory did co-ordinate a large number of facts which were not otherwise explained except by many *ad hoc* assumptions, and opened up a wide field for closer investigation.

Correspondence.

To the *Editors*, "*Meteorological Magazine.*"

The Loss of the R. 38.

NONE of the orthodox meteorologists having endeavoured to explain the reason of the destruction of the R. 38 in very thundery weather at the mouth of the Humber, permit me to give what was most probably the cause, viz.:—The airship running into a small circular storm or whirlwind. The five shocks spoken of by one of the survivors of the disaster would thus be accounted for, as the airship would have been struck fore and aft in different directions.

I have been within a few yards of one of these storms in the summer of 1893 which struck an oak tree in front of me, stripping it of twigs and leaves, the whirlwind breaking at the bank of a river 100 yards or so away from me.

I should further like to state that during the past two or three years I have been able to locate many of the big storms, and I believe the track of these storms is ascertainable beforehand.

I have been able to follow the course of one or two of these and if they start in a certain district seem to have an inclination to disperse or break up in the same place time after time. W. M. ROBERTSON.

The Longacre, Cheltenham, Oct. 28th, 1921.

[The R. 38 was the airship finished by the Air Ministry for the American Government; she crashed on August 24th, 1921, during her trial trip and fell in the Humber about 17 h. 40 m. The catastrophe has not generally been attributed to meteorological conditions but the final report of the Committee of Inquiry has not yet been issued.—ED. M.M.]

Meteor Trails and Upper Air Currents.

WITH reference to the remarks on this subject in your November issue, I believe that the relative scarcity of effective observations is due more to a lack of observers than to a lack of meteors. For every fireball whose path is well determined there are hundreds of thousands which pass unrecorded over some region of the earth's surface, but perhaps not more than one tenth of these would leave durable trails.

It is frequently the case that a large fireball travels over England, without attracting more than one person to record its flight, and some pass without any notice. If astronomers and meteorologists generally were sufficiently interested to keep careful watch and to report such objects whenever they appear we should soon accumulate a large amount of new data. At the present time there are only five or six habitual meteoric observers in the Kingdom, and in other countries there is hardly any practical attention given to the subject of meteoric drifts, so that year after year there is very little addition to our knowledge.

In *Symons's Meteorological Magazine* for March 1913, I gave some results of calculation of the velocities and directions of meteor-drifts, but most of the computations were based on incomplete or rather rough data, so that exact or detailed conclusions could not be reached with safety.

There are hundreds of descriptions of long-enduring meteor trails (streaks or trains) in the reports of the Luminous Meteor Committee of the British Association for the years 1848 to 1881, but nearly all these descriptions lack essential details and few are sufficiently accurate for critical purposes.

If by a system of rocket-firing any vaporous or gaseous clouds can be visibly formed in the higher atmosphere and enable details of the upper drifts to be suitably determined it is to be hoped that this method will soon be realised, as it will avoid the delays in awaiting natural occurrences. But the cosmic clouds generated by meteoric fireballs should also afford useful evidence, and especially if a more widespread endeavour were made to deal with them in an effective manner.

W. F. DENNING.

Bristol, Nov. 17th, 1921.

The Measurement of Snow.

THE principle that practice is better than theory applies most aptly to taking meteorological observations. I venture, as an observer for more than half a century, to offer a few remarks on "The Measurement of Snow" dealt with in the *Meteorological Magazine* for October. I have had no experience of the hot water chamber which is fitted in some gauges, although, offhand, it seems feasible. Casella refers to such a gauge with a jacketed funnel in a recent catalogue of instruments. In course of experience I have carried the funnel and inner reception can indoors, although I do not like this method.

There is no occasion to lose any of the snow, for the outer body of the gauge, which is practically the same diameter as the funnel, will serve to catch what falls while the melting is in progress, and this extra snow may be transferred finally into the inner reception can.

The method of pouring a measured quantity of hot or boiling water into the funnel of an all-metal gauge to melt the snow is, in my judgment, the best method to be adopted by an ordinary observer. I have done this for more than half a century, using generally a graduated metal milk measure to gauge the amount of water added, and subtracting an equal quantity before measuring the precipitation. I first adopted this method from a suggestion made by Mr. G. J. Symons, who was my colleague in the Meteorological Department in the early sixties. I should, personally, strongly object to applying a hot cloth to the funnel or can, as this method seems too troublesome, at any rate in a snowstorm, even if efficacious, though in fairness I may say I have never tried it.

I have seen it suggested that an allowance should be made by measuring the depth of snow as it has fallen and estimating that a foot of snow yields about an inch of rain; this is far too rough an approximation, owing to the great range in the density of the snow at different times of occurrence.

CHAS. HARDING.

2, Bakewell Road, Eastbourne, Nov. 1921.

Long-Range Forecasting.

WILL you permit me to comment very shortly on Mr. E. V. Newnham's article on "Long-Range Forecasting"?

As the originator of the system of Periodic Weather Forecasting I might mention that in 1916, when Mr. Newnham lectured on "Rainfall and Periodicity," I called his attention to the fact that all weather in this country was periodic, both as regards drought, heat and cold. At that time I had never kept a note or attempted long-range forecasting. It was only after an interview with Lieut. Grant at the Admiralty on October 2nd, 1917, and at his request, that I first issued long-range forecasts, and finding that my forecasts were generally fairly accurate, after enlisting the services of Mr. D. W. Horner, we recently published in *Simple Weather Forecasting*,* the methods we pursue. I have not the slightest doubt that if meteorologists, or even laymen, will study our theory they will find that generally accurate forecasts can be made without using any instruments. As regards the long-range forecast issued by the Meteorological Office, I wrote early on Sunday, September 25th, an article for the *Dundee Courier* pointing out that an Indian Summer was probable as wind was light north-west. This wind shifted to north-east on 26th and in that district this shift of wind usually causes some trouble and frequently denotes changes further south later on, so that I was able to warn a past President of the Royal Meteorological Society of the depression off Ireland of October 2nd, twenty-four hours beforehand. If meteorologists will purchase our book and will send me descriptions of their thunderstorms during the summer I believe that the actual direction in which these are likely to travel may be traceable, but it would be far better if the Meteorological Office would lend its assistance, as I find playing a lone hand entails an enormous amount of correspondence.

In conclusion I should like to add that the gale which proved so disastrous to the German Zeppelins was forecasted to Lieut. Grant some days beforehand for twenty-four hours later than it arrived, but warning was sent to him midday of its coming within a few hours and every airman should be instructed in my system. Certain districts in the North Sea and round our coasts in certain weather might be death traps to any novice. W. M. ROBERTSON.

The Longacre, Cheltenham, Nov. 28th, 1921.

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* *Simple Weather Forecasting for Everyone,* by Donald W. Horner and W. MacDonald Robertson. 8vo, *illus.* Tunbridge Wells: The Courier Printing and Publishing Co., Ltd., 1921.

Exceptional Visibility.

My attention has been called to a note in the *Meteorological Magazine* with reference to a statement that "the Ordnance "Surveyors were able on July 15th, 1844, with the aid of a "small glass, to see a staff about 4 inches in diameter on "Dunstable Downs," from Leith Hill 47 miles away. It is the case that observations were taken from Leith Hill in 1844, with the 36-inch theodolite; but there is no mention in the Ordnance Survey records of any staff being observed. As a fact heliostats were used; and I think that a staff "4 inches in diameter" would have been quite invisible at the distance named, through "a small glass."

C. F. Close, Colonel, Director-General, O.S.

Ordnance Survey Office, Southampton, Nov. 30th, 1921.

The Early Frost.

As evidence of the severity of the frost in this district, I may mention that on November 11th—Armistice Day—I walked across a brook 13 feet wide on ice which never even cracked. There was not much current, the stream being very low, but about a foot deep just above a weir. This is the earliest date on which I have ever known ice to bear a man, the fact that it was running water makes it still more remarkable. The exposed thermometer had been as low as 11° F. and the highest temperature reached was only 35°, there being no perceptible thaw in the shade. R. P. Dansey.

Kentchurch Rectory, Hereford, Nov. 12th, 1921.

NOTES AND QUERIES.

A Rate of Rainfall Recorder.

An interesting attempt to solve the problem of constructing an efficient instrument for recording the instantaneous rate at which rainfall occurs has been made recently by Messrs. Negretti and Zambra.

The principle adopted is that of recording the weight of water passing down an inclined surface at any given moment, the weight varying with the rate of flow. The inclined surface takes the form of a tube in the shape of a spiral, and is delicately suspended at one end of a balanced lever, the other end of which carries the pen. The angular fall of the coil is about 18° and is a compromise between a steep incline that would empty rapidly but hold too little water to work the pen, and a gradual one that would hold a lot of water and take a long time to empty, but which would bring the pen to zero after the rain had ceased. The rain is collected in a funnel 16 inches in diameter.

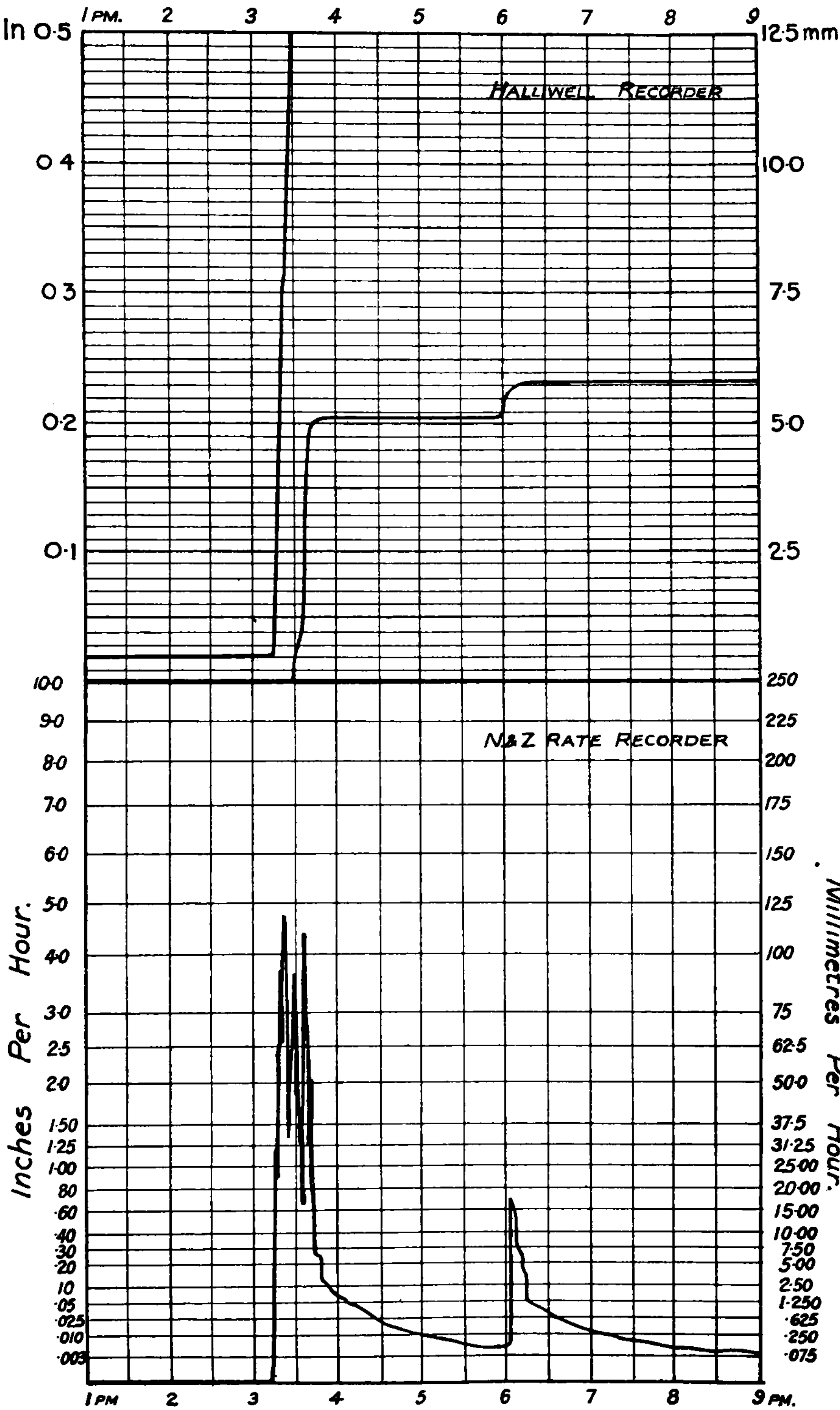
This instrument is a decided advance towards the desired end, and, though it has several defects which render it of little value for statistical purposes, its records are very interesting.

Perhaps the first criticism one may make is that the scale of the chart is not linear. For low rates of fall the scale is very open, decreasing to a minimum for falls of about 10 inches per hour. This lack of uniformity of the scale makes it almost impossible to check the records in the only really satisfactory manner, namely, by integrating the curve and comparing the result with the total fall recorded during the same period by an ordinary rain-gauge. If one knew that the record given by the instrument was a true one, uniformity of the scale value would not be so important, but unfortunately there are only too many indications that the record itself is untrue. The contraction of the scale value at the higher rates has, however, the important advantage that information as to heavy rates can be obtained without risk of the pen passing off the record sheet.

So far as the actual working of the recorder is concerned it has been noted that whenever the funnel and spiral tube are wet, the commencement of rain is marked, as one would expect, by a sharp rise of the pen until the actual rainfall rate is reached, followed by a steady or jerky trace according to the varying intensity of the rainfall. This is quite satisfactory; but if, on the other hand, the funnel and tube are dry when rain commences, the water is held up by surface tension, firstly in the funnel, and secondly, in the tube itself. The result is that until this surface tension effect is broken down by a sufficient head of water at the top of the tube, the pen is rising above the height indicating the true rate of rainfall. In the case of a gentle, steady rain this effect, although often very considerable, is perfectly obvious judging by the trace, but in showery weather in which funnel and tube have time to dry between the showers it is not always possible to tell whether the record is true or not.

Another obvious defect shown by the records depends on the fact that the draining process after the cessation of rain takes a considerable time, and, although on the average it does not appear obvious on the chart until the pen drops to the ·003 inch per hour mark, there are occasions when this process commences as high as the ·10 inch per hour mark.

Rain Gauge Records at 62 Camden Square.
Tuesday 23rd August 1921.



The distortion of the trace thus produced is a characteristic of the instrument, and one cannot be sure to what extent this process goes on whilst rain is falling as well as after its cessation. Any checking by comparison with an ordinary gauge is also effectively prevented by this distortion.

The extreme sensitiveness of the balance of the lever, brought about by the special design of its fulcrum, to some extent defeats its own object. It makes the instrument so liable to accidental errors in registration that their magnitude is often greater than the variations which it is trying to record. Apart from the enormous effect of initial hold-up, smoothing out of variations in the process of draining, and of final draining, the slightest jar to the instrument, such as opening the lid, or sometimes only walking past it, will produce a jump on the trace which, if the chart were examined by anyone not familiar with the facts, or at a later date than the time of occurrence, would be quite indistinguishable from an actual shower trace. In practice such a disability is serious.

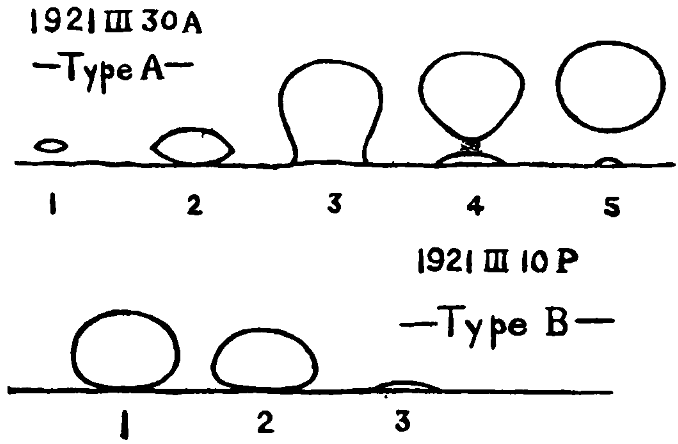
The records reproduced on p. 331 were obtained at Camden Square on the occasion of the thunderstorm of August 23rd. The initial rise in this record appears to be a true one, although no confirmatory evidence can be given that the rate of 4·5 inches per hour was actually reached. The fall between 3 and 4 p.m. is officially quoted as ·68 inch (17·3 mm.) in 26 minutes, that is, the mean rate of fall was 1·57 inches per hour. At South Kensington the total fall was 12 mm. (·47 inch), and careful measurements of the Halliwell Recorder trace gave the fastest mean rates of fall for 1 mm. as 60 mm. (2·36 inches) per hour, and for 5 mm. as 50 mm. (1·97 inches) per hour. From these results it therefore seems quite possible that the rate of rainfall did actually attain the value 4·50 inches per hour for short periods. It appears probable that in this instance the rate was high enough to mask any initial hold-up which may have occurred. The draining process is clearly marked at the cessation of both downpours, commencing just above the ·10-inch line in the first case and at the ·05-inch line in the second. It will be noted from the record that the pen did not reach the base line even after two to three hours draining.

In conclusion, one may say that the instrument will probably record faithfully rainfall rates exceeding ·10 inch per hour, but below that limit, the draining process and the initial hold-up are sufficiently marked to vitiate the records. In justice to the makers it must be pointed out that in producing this instrument they are doing valuable pioneer work. The only rate of rainfall recorders in use hitherto appear to be those described (in Japanese) in the Journal of the Meteorological Society of Japan, Vol. 24, June 1905 and Vol. 28, May 1909, and the new instrument aims at much greater precision.

N. H. SMITH.

The Duration of Sunrise and Sunset.

Nature of October 13th, 1921, contains an interesting letter by Mr. Willard J. Fisher of Cambridge, Mass., on the duration of sunrise and sunset. The observations were made with



a view to comparing observed and computed duration. The observed duration is the interval between the time at which the lower edge of the sun appears to be in contact with the horizon and the time at which the upper edge is just seen. The computed duration is determined on the hypothesis that refraction may be ignored* entirely. Seventy-nine observations were taken, mostly with marine horizons, the view-point varying from the sea-beach up to an elevation of 1512 metres. There seem to be two types of marine sunrise and sunset. With type A., which is about twice as frequent as the other and which is accompanied by horizon mirage, there is a slight excess of observed duration over the computed duration, amounting in 44 cases to 0·55 per cent.; a few cases give small deficiencies. Type B., however, always gives excess, sometimes even as large as 2 mins., or 68 per cent., with an average excess for 22 cases of 12·3 per cent.

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* In the *International Meteorological Tables* the times of sunrise and sunset are determined as the times at which the centre of the sun appears to be on the horizon, the centre being raised 34 minutes of a degree by refraction.

Mr. Fisher points out that such observations are almost non-existent and that amateur observers in as many places as possible are desirable. The subject is meteorological not astronomical, since the duration of sunrise and sunset depends on temperature distribution in the atmosphere.

A useful table of the duration of sunset for 1922 has been computed by Mr. Fisher and is published in *Nature* of December 1st.

Meteorology in Brazil.

We learn from *Auto-Propulsão* of September 1st, 1921, that the National Observatory of Morro do Castello, at present the headquarters of the Brazilian Meteorological Department,* has initiated an ambitious programme under the leadership of Dr. Sampaio Ferraz. The first aerological soundings to be made in Brazil were carried out with some ceremony in the presence of the Minister for Agriculture. They reached 21,760 metres (wind, north), and 8,000 metres (wind, north-west), respectively. Three kite-balloon stations and 18 pilot-balloon stations are to be established within a year. The new Meteorological Department will continue the climatological work instituted in 1909, standardising the methods of all the meteorological institutions throughout Brazil, and publishing the results of the last ten years. A Forecast Service will also be established for the whole of Southern Brazil, and an Agricultural Meteorological Service will study the influence of weather on crops, a Maritime Service will be established with a special section for rain and floods, and provision has been made for research, including long-range forecasting.

We are glad to be able to announce that Dr. Sampaio Ferraz has arranged to telegraph each month for publication in this Magazine an official summary of the weather in Brazil.

The summary for October, which was received too late for inclusion in the November Magazine is as follows:—

> The pressure distribution over the Southern States was generally irregular during October; the weather was rather cooler than usual over the South and Centre, and abnormal cloudiness was experienced over the whole country. Rainfall was deficient in the north, especially in Ceara, Pernambuco and Parahyba, and the rains in Central Brazil were so much retarded that the coffee plantations in Spaulo were sensibly affected, and agriculture and dairy work in general suffered.

The summary for November will be found on p. 339.

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* *Meteorological Magazine*, Sept. 1921, p. 225.

Meteorology in Russia.

METEOROLOGISTS will learn with interest that steps have been taken to re-organise the Russian Meteorological Services. All independent services have been absorbed in the organization based on the Central Physical Observatory, a return to pre-war conditions. In order to co-ordinate the work of different organizations carrying out meteorological or geophysical research, a committee has been formed consisting of representatives of the government departments interested, the Director of the Central Observatory being president.

Regional and provincial meteorological bureaus are to be established so that all districts in the Republic may receive forecasts in good time. A radio-station for receiving messages from meteorological stations in western Europe and in Russia is to be established at headquarters; meteorological messages are to take precedence of all others at telegraph offices and the Central Observatory is to be allowed the use of the telephone line from Petrograd to Moscow for ten minutes daily. Moreover a legal liability is to be imposed on any one who fails to take the necessary steps for the urgent transmission of meteorological information. The Supreme Council of Public Economy is to transform the workshops of the Central Observatory into a fully-equipped factory for the manufacture of meteorological instruments and to provide for the printing and publishing of reports and other literature.

Meteorological Stations.

Weston, Newtownbarry.—A climatological station has been instituted at Weston, Newtownbarry, co. Wexford, by Mr. G. T. Lewis, and a summary of the first return of the observations has been published in the *Monthly Weather Report* for October. This station fills a gap in an otherwise unrepresented district in south-east Ireland.

The Symons Medal.

THE Council of the Royal Meteorological Society has awarded the Symons Memorial Gold Medal for 1922 to Col. Henry George Lyons, F.R.S., for distinguished work in connection with meteorological science.

The medal, which is awarded biennially, will be presented at the Annual General Meeting on January 18th, next.

Shall Climatological Data be published for a "Climatic" rather than a Calendar Year?

THE United States Weather Bureau has instituted an inquiry into the desirability of publishing climatological data for a year beginning on September 1st or October 1st instead of or in addition to the calendar year. The chief argument for the change is that the transition from one year to the next would take place at a time of minimum precipitation, at any rate for California, the state from which the proposal originates. It has already been adopted by the Water Resources Branch of the U.S. Geological Survey. A *questionnaire* is being circulated on the subject, and all users of the precipitation data of the Weather Bureau are invited to communicate their views.

The Seasonal Aneroid.

IN the *Meteorological Magazine* for January, 1921, Vol. 55, page 279, reference was made to Dr. Chapman's "Seasonal Aneroid." We learn that the maker of this instrument is Mr. F. Darton, of 142, St. John Street, E.C. 1, who is issuing a pamphlet dealing with it.

News in Brief.

The *Journal of Hygiene*, Vol. 20, p. 248, contains a paper by Dr. Matthew Young on the "Regional Distribution of Rheumatic Fever." Dr. Young states that acute rheumatic infection is more common in the north and west of England than in other districts and that it is associated with high rainfall and low temperature. He finds a positive correlation between the death-rate from rheumatic fever and the mean annual rainfall, and a negative correlation between this death-rate and the mean annual temperature.

"Everyone is interested in the weather" is one of the mottoes of Messrs. Negretti and Zambra's price list "for December 25th." Among other suggestions for gifts are shewn aneroids, barographs, and the patent forecaster. According to a statement in a recent number of this Magazine "instrument makers report a steadily increasing demand for barometers with the millibar graduation," but the Philistines will rejoice to find that all the barometers and all the barograph charts shewn in this list shew inches only.

THAMES VALLEY RAINFALL — NOVEMBER, 1921.

ALTITUDE SCALE

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

SCALE OF MILES
0 5 10 15 20

Watershed of River Thames above Teddington and River Lea above Feildes Weir.

Isohyetals.

H.M.Stationery Office Press, Kingsway W.C.2.

On December 2nd, a " Geophysical Discussion " was held in the rooms of the Royal Astronomical Society. The discussion, which was opened by Dr. H. Jeffreys was on " Certain Geological Consequences of the Cooling of the Earth." Dr. Jeffreys elaborated the hypotheses set out in his recent paper in the *Proceedings of the Royal Society*, A. Vol. 100, 1921. Sir Jethro Teall was in the chair, and Dr. J. W. Evans, Col. E. H. Grove-Hills, Mr. R. D. Oldham, Prof. W. G. Duffield, and Dr. G. C. Simpson took part in the discussion.

On November 18th the Association of Economic Biologists held a discussion on "Meteorological Conditions and Diseases " which was opened by Dr. E. J. Butler.

On December 5th, Col. E. Gold lectured on "The Application of Meteorology to Aviation" before the Scottish Branch of the Royal Aeronautical Society, at the Royal Technical College, Glasgow.

On December 6th, Sir David Wilson-Barker read a paper on "Weather at Sea, including Clouds, Waves, &c.," before the Institute of Marine Engineers.

On December 12th, Dr. Owens gave a demonstration on " Dust in Expired Air" before the Medical Society of London.

The Weather of November, 1921.

After the first week in November, which was unsettled everywhere with high winds and considerable precipitation, the weather of north-western Europe with the exception of the extreme western districts can be summarized as quiet, cold, generally frosty and dry. The absence of wind together with the cold produced somewhat frequent fogs especially near industrial centres. Sunshine was above the average amount in eastern and southern England.

The extreme western districts, Ireland for most of the month and the west coast of Norway at times, were within a warm equatorial current. Temperature and rainfall were distinctly above and sunshine below the normals for the month in Ireland.

On the first day of the month a deep depression was centred over Scandinavia causing north-westerly gales on the Norwegian and Danish coasts and in the north of Scotland. The effect of these gales in causing high tides in the Thames was mentioned in the last issue of the *Meteorological Magazine.* From Bornholm there was reported a wind of force 11 on the Beaufort scale blowing continuously for 12 hours. Wrecks with accompanying loss of life occurred in the North Sea. Rain fell heavily in the wake of this depression and local showers of sleet or hail occurred in Scotland. As this depression moved away in an easterly direction a complex, rapidly varying, pressure distribution took its place over north-western Europe with generally unsettled weather.

A depression which appeared off the coast of Ireland on Saturday evening (the 5th) crossed the centre of England deepening very considerably as it moved and causing gales and heavy continous rain over England during Sunday. Cross-Channel services were delayed, telegraphic communication was cut, and a number of wrecks occurred in the North Sea and the English Channel. A minor effect of these high winds noticeable in the London area was the stripping of the trees which up to November 5th had lost very few of their leaves. On the 7th and 8th the disturbance with its violent cyclonic weather passed over the North Sea and the south of Denmark to north Germany. Behind this depression the temperature fell considerably and sleet or snow showers occurred throughout Scandinavia, Scotland and eastern England. The somewhat early immigration of wild geese to our northern and eastern shores during this period was hailed as an infallible sign of a hard bitter winter to come. In the frost which followed there was quoted (probably by the same prophets)—

> " Ice in November to carry a duck,"
> " Will bring nothing after but slush and muck."

The morning of the eighth saw an elongated area of high pressure off the west of Scotland. The movements and meanderings of this system have been the determining factor in the weather of north-western Europe throughout the rest of the month. On the evening of Tuesday, the 8th, the central region lay over England and severe frosts with local falls of snow were experienced. During the next two or three days the " high " extended from south-east England in a north-easterly direction so that the south-east of England, France, Belgium and Germany were getting their air supply from the north-east, chilled also by its passage over the radiation-cooled land, resulting in fine, frosty, wintry weather. Heavy snow to a depth of a foot fell in Switzerland. Skating was enjoyed in many parts of England.

On the other hand the west of the British Isles was getting air from a southern region. This caused a typical winter distribution of isotherms over the British Isles with the lines of equal temperature running north and south—a complete and sudden change from the typically summer distribution of isotherms of the middle of October.

By the 13th the highest pressure had moved to northern Russia and from the 13th to 17th a series of small disturbances caused considerable rain and strong winds in the south-west of the British Isles. The anticyclone then became very intense and extended its influence to the whole of the British Isles causing an easterly type of weather, cold, with a good deal of cloud and rain on our east coasts.

On the 21st a depression over the Azores began to influence the western districts, causing a south wind and higher temperature while the "high" over northern Europe began to move south and decrease in intensity. These changes, however, were very slow and very constant weather conditions prevailed from the 21st to the end of the month. Over central Europe and eastern England quiet, dry, cold but generally fair weather prevailed with thick fogs locally especially in places where smoke is poured into the atmosphere. London suffered severely, particularly on Sunday 27th and Monday 28th. In the western parts of the British Isles a southerly current brought warmer weather with a moderate rainfall. A succession of depressions passing from Iceland to the north of Scandinavia caused unsettled weather with strong winds and much snow in these parts. R. A. W.

On the night of the 17th two tornadoes occurred in different parts of Arkansas, probably in the south-east quadrant of a depression which passed across Texas on that day. Twelve persons were killed and over thirty injured. On the 24th a storm over Lake Ontario caused the wreck of the cargo-steamer *City of New York* off Stoney Point, Lake Ontario, with the loss of nine lives. A telegram dated the 11th states that timely rains have somewhat checked the bush fires in New South Wales, which have been very serious during the drought.

The special message from Brazil states that during November unusual frequency of high pressure was associated with cold winds from the south over the Southern States. Drought affected seriously the crops in the centre and south, especially cotton, rice, sugar, and maize, and reduced sensibly the estimates of the coffee crop for next year.

(*Continued on* p. 344.)

Rainfall Table for November 1921.

STATION.	COUNTY.	Aver. 1881—1915. in.	1921. in.	1921. mm.	Per cent. of Av.	Max. in 24 hrs. in.	Max. in 24 hrs. Date.	No. of Rain Days.
Camden Square	*London*	2·36	2·01	51	85	·51	2	10
Tenterden (View Tower)	*Kent*	3·02	1·91	49	63	·43	5	11
Arundel (Patching Farm)	*Sussex*	3·56	2·20	56	62	·64	16	11
Fordingbridge (Oaklands)	*Hampshire*	3·42	2·27	58	66	·85	16	14
Oxford (Magdalen College)	*Oxfordshire*	2·21	2·02	51	91	·48	2	13
Wellingborough (Swanspool)	*Northampton*	2·15	1·56	40	73	·47	2	11
Hawkedon Rectory	*Suffolk*	2·27	1·55	39	68	·48	2	7
Norwich (Eaton)	*Norfolk*	2·57	1·84	47	72	·41	5, 6	12
Launceston (Polapit Tamar)	*Devon*	4·24	3·67	93	87	·93	13	18
Sidmouth (Sidmount)	"	3·12	3·65	93	117	·95	30	19
Ross (County Observatory)	*Herefordshire*	2·53	1·81	46	72	·39	16	14
Church Stretton (Wolstaston)	*Shropshire*	2·94	3·04	77	113	·74	5	16
Boston (Black Sluice)	*Lincoln*	2·00	1·30	33	65	·32	2	12
Worksop (Hodsock Priory)	*Nottingham*	1·96	1·63	41	83	·46	2	10
Mickleover Manor	*Derbyshire*	2·23	1·85	47	83	·77	2	11
Southport (Hesketh Park)	*Lancashire*	3·14	2·61	66	83	·76	2	13
Harrogate (Harlow Moor Ob.)	*York, W. R.*	2·70	2·49	63	92	1·25	5	15
Hull (Pearson Park)	" *E. R.*	2·19	1·74	44	79	·56	5	19
Newcastle (Town Moor)	*North'land*	2·42	2·52	64	104	1·02	5	13
Borrowdale (Seathwaite)	*Cumberland*	13·58	5·65	143	42	..	..	..
Cardiff (Ely Pumping Stn.)	*Glamorgan*	4·17	3·38	86	81	·54	13	22
Haverfordwest (Gram. Sch.)	*Pembroke*	5·02	5·32	135	106	1·72	14	15
Aberystwyth (Gogerddan)	*Cardigan*	4·72	2·80	71	59	·98	2	10
Llandudno	*Carnarvon*	3·09	2·39	61	77	·61	2	13
Dumfries (Cargen)	*Kirkcudbrt.*	4·52	3·05	77	67	·80	5	16
Marchmont House	*Berwick*	3·00	2·19	56	73	·52	18	14
Girvan (Pinmore)	*Ayr*	5·32	3·96	101	74	·91	5	17
Glasgow (Queen's Park)	*Renfrew*	3·73	2·49	63	67	·47	16	14
Islay (Eallabus)	*Argyll*	5·38	4·30	109	80	·68	22	18
Mull (Quinish)	"	6·17	2·90	74	47	·78	13	13
Loch Dhu	*Perth*	8·69	6·30	160	72	1·70	13	15
Dundee (Eastern Necropolis)	*Forfar*	2·44	2·09	53	86	·39	22	14
Braemar (Bank)	*Aberdeen*	3·89	2·60	66	67	·48	18	15
Aberdeen (Cranford)	"	3·22	2·03	52	63	·24	7	17
Gordon Castle	*Moray*	2·88	1·65	42	57	·35	3	15
Fort William (Atholl Bank)	*Inverness*	8·07	2·85	72	35	·75	22	15
Alness (Ardross Castle)	*Ross*	4·02	1·62	41	40	·40	4	13
Loch Torridon (Bendamph)	"	9·27	2·79	71	30	·56	4	15
Stornoway	"	5·83	3·23	82	55	·67	4	21
Loch More (Achfary)	*Sutherland*	8·55	2·87	73	34	·80	3	16
Wick	*Caithness*	3·14	1·95	50	62	·45	4	14
Glanmire (Lota Lodge)	*Cork*	4·30	5·21	132	121	·80	15	24
Killarney (District Asylum)	*Kerry*	5·61	4·35	111	78	·52	22	27
Waterford (Brook Lodge)	*Waterford*	3·78	5·53	141	146	1·34	15	17
Nenagh (Castle Lough)	*Tipperary*	4·02	4·04	103	101	·75	15	19
Ennistymon House	*Clare*	4·65	..	..	..	..	..	..
Gorey (Courtown House)	*Wexford*	3·49	4·28	109	123	·94	13	17
Abbey Leix (Blandsfort)	*Queen's Co.*	3·34	3·91	99	117	·63	15	18
Dublin (FitzWilliam Square)	*Dublin*	2·67	2·57	65	96	·47	1	18
Mullingar (Belvedere)	*Westmeath*	3·41	3·71	94	109	·80	15	20
Woodlawn	*Galway*	4·01	3·67	93	92	·55	1	23
Crossmolina (Enniscoe)	*Mayo*	5·86	4·46	113	76	1·17	1	23
Collooney (Markree Obsy.)	*Sligo*	4·23	3·75	95	89	·58	1	20
Seaforde	*Down*	3·79	6·15	156	162	1·12	13	19
Ballymena (Harryville)	*Antrim*	4·05	4·14	105	102	·88	5	23
Omagh (Edenfel)	*Tyrone*	3·80	3·80	97	100	·83	5	22

Supplementary Rainfall, November 1921.

Div.	STATION.	RAIN. in.	RAIN. mm.	Div.	STATION.	RAIN. in.	RAIN. mm.
II.	Ramsgate	1·74	44	XII.	Langholm, Drove Rd.	2·97	75
„	Sevenoaks, Speldhurst	1·91	49	XIII.	Ettrick Manse	2·65	67
„	Hailsham Vicarage...	1·96	50	„	North Berwick Res....	1·96	50
„	Totland Bay, Aston ..	1·97	50	„	Edinburgh, Royal Ob.	2·55	65
„	Ashley, Old Manor Ho.	1·86	47	XIV.	Biggar..............	1·29	33
„	Grayshott...........	2·45	62	„	Leadhills	3·29	84
„	Ufton Nervet........	2·37	60	„	Maybole, Knockdon ...	2·49	63
III.	Harrow Weald, Hill Ho.	1·62	41	XV.	Dougarie Lodge.......	3·94	100
„	Pitsford, Sedgebrook..	1·83	47	„	Inveraray Castle......	4·25	108
„	Chatteris, The Priory.	1·26	32	„	Holy Loch, Ardnadam	6·32	161
IV.	Elsenham, Gaunts End	1·87	47	„	Tiree, Cornaigmore....	..	..
„	Lexden, Hill House ..	1·37	35	XVI.	Loch Venachar	4·85	123
„	Aylsham, Rippon Hall	2·09	53	„	Glenquey Reservoir ...	3·20	81
„	Swaffham...........	1·41	36	„	Loch Rannoch, Dall...	2·33	59
V.	Devizes, Highclere ...	2·01	51	„	Blair Castle	2·49	63
„	Weymouth..........	2·35	60	„	Coupar Angus....... .	2·42	61
„	Ashburton, Druid Ho.	5·58	142	„	Montrose Asylum	2·52	64
„	Cullompton	4·31	109	XVII.	LogieColdstone,Loanh'd	2·48	63
„	Hartland Abbey	4·04	103	„	Fyvie Castle..........	3·17	81
„	St. Austell, Trevarna .	5·55	141	„	Grantown-on-Spey ...	1·30	33
„	Crewkerne Merefield Ho	3·05	77	XVIII.	Cluny Castle	1·82	46
„	Cutcombe, Wheddon Cr.	3·28	83	„	Loch Quoich, Loan ...	3·90	99
VI.	Clifton, Stoke Bishop.	2·05	52	„	Fortrose	·76	19
„	Ledbury, Underdown.	1·91	49	„	Faire-na Squir........	1·75	44
„	Shifnal, Hatton Grange	2·13	54	„	Skye, Dunvegan	5·23	133
„	Ashbourne, Mayfield .	1·85	47	„	Glencarron Lodge.....	2·86	73
„	Barnt Green, Upwood	1·80	46	„	Dunrobin Castle	2·02	51
„	Blockley, Upton Wold	2·03	52	XIX.	Tongue Manse	2·14	54
VII.	Grantham, Saltersford	1·30	33	„	Melvich Schoolhouse ..	2·28	58
„	Louth, Westgate	1·69	43	XX.	Dunmanway Rectory..	8·09	205
„	Mansfield, West Bank	1·81	46	„	Mitchelstown Castle...	4·06	103
VIII.	Nantwich, Dorfold Hall	1·93	49	„	Gearahameen	9·50	241
„	Bolton, Queen's Park.	3·76	95	„	Darrynane Abbey	6·22	158
„	Lancaster, Strathspey.	2·16	55	„	Clonmel, Bruce Villa ..	4·73	120
IX.	Rotherham, Moorgate.	1·86	47	„	Cashel, Ballinamona...	4·33	110
„	Bradford, Lister Park.	2·36	60	„	Roscrea, Timoney Pk..	3·27	83
„	West Witton.........	2·42	61	„	Foynes..............	3·60	91
„	Scarborough, Scalby..	3·44	87	„	Broadford, Hurdlesto'n	4·67	119
„	Middlesbro', Albert Pk.	2·09	53	XXI.	Kilkenny Castle.......	3·44	87
„	Mickleton...........	1·90	48	„	Rathnew, Clonmannon	4·70	119
X.	Bellingham	2·23	57	„	Hacketstown Rectory .	4·63	118
„	Ilderton, Lilburn	2·05	52	„	Balbriggan, Ardgillan .	3·73	95
„	Orton..............	2·46	63	„	Drogheda	3·27	83
XI.	Llanfrechfa Grange ..	2·12	54	„	Athlone, Twyford	3·78	96
„	Treherbert, Tyn-y-waun	6·91	175	XXII.	Castle Forbes Gdns....	3·91	99
„	Carmarthen Friary ..	4·66	118	„	Ballynahinch Castle...	7·23	184
„	Llanwrda, Dolaucothy	4·19	106	„	Galway Grammar Sch.	2·69	68
„	Lampeter, Falcondale	3·86	98	XXIII.	Westport House	4·63	118
„	Cray Station	4·90	125	„	Enniskillen, Portora...	3·85	98
„	B'ham W.W., Tyrmyndd	5·10	129	„	Armagh Observatory ..	2·81	71
„	Lake Vyrnwy.......	5·32	135	„	Warrenpoint	3·99	101
„	Llangynhafal, P. Drâw	2·67	68	„	Belfast, Cave Hill Rd..	4·09	104
„	Oakley Quarries	4·83	123	„	Glenarm Castle	5·81	148
„	Dolgelly, Bryntirion..	5·04	128	„	Londonderry, Creggan.	3·48	88
„	Snowdon, L. Llydaw.	9·47	241	„	Sion Mills...........	3·24	82
„	Lligwy	2·11	54	„	Milford, The Manse ...	4·32	110
XII.	Stoneykirk, Ardwell Ho.	4·24	108	„	Narin, Kiltoorish	4·69	119
„	Carsphairn, Shiel.....	5·94	151	„	Killybegs, Rockmount .	5·08	129

Climatological Table for the

STATIONS	PRESSURE		TEMPERATURE							
			Absolute				Mean Values			
	Mean M.S.L.	Diff. from Normal	Max.	Date	Min.	Date	Max.	Min.	½ max. and min.	Diff. from Normal
	mb.	mb.	° F.		° F.		° F.	° F.	° F.	° F.
London, Kew Observatory	1021·8	+5·6	85	25	42	19	69·8	50·5	60·2	+1·0
Gibraltar	1017·0	+1·2	85	29	56	5	77·5	62·4	69·9	−0·4
Malta	1014·6	0·0	80	3, 28	62	25	75·7	65·0	70·3	−1·7
Sierra Leone	1011·8	−0·9	89	6, 12	65	2, 8, 18	85·7	68·5	77·1	−3·3
Lagos, Nigeria	1012·4	−0·5	88	5	70	23	85·7	75·5	80·6	+2·0
Kaduna, Nigeria	1013·8	+2·5	90	5	61	2	84·3	66·9	75·6	−0·4
Zomba, Nyasaland	1015·6	−1·8	82	11, 12	48	26	75·1	53·8	64·5	+2·0
Salisbury, Rhodesia	1016·5	−3·7	80	13	36	27	72·9	42·9	57·9	+1·5
Cape Town	1014·3	−6·0	77	3	39	12	61·7	50·1	55·9	+0·1
Johannesburg	1020·5	−2·6	70	28	30	23	61·8	41·8	51·8	+1·1
Mauritius	..	..	..	..	..	..	..	..	..	..
Bloemfontein	..	..	69	29	21	23	60·7	32·4	46·5	−1·1
Calcutta, Alipore Obsy.	998·3	−1·4	96	8	73	25	90·8	79·6	85·2	+0·1
Bombay	1003·4	−0·8	94	7	74	20	89·0	80·5	84·7	+0·8
Madras	1002·5	−1·4	107	1	78	13	100·5	82·1	91·3	+1·4
Colombo, Ceylon	1008·1	−0·2	88	13	75	27	87·0	78·9	82·9	+1·0
Hong Kong	1004·5	−1·6	89	23	72	3	85·2	77·8	81·5	0·0
Sandakan	..	..	91	6, 8, 14	73	28	88·7	75·2	81·9	+0·2
Sydney	1020·4	+2·5	75	10	43	21	66·2	49·0	57·6	+3·3
Melbourne	1020·1	+1·8	65	11	33	27	57·7	46·3	52·0	+1·6
Adelaide	1019·9	+0·8	69	13	37	27	62·9	47·9	55·4	+2·0
Perth, Western Australia	1018·1	+0·1	71	8	40	29	66·5	51·7	59·1	+2·7
Coolgardie	1019·1	0·0	72	12	35	30	65·0	45·0	55·0	+2·3
Brisbane	1020·1	+2·1	80	1	46	19	71·2	56·6	63·9	+3·9
Hobart, Tasmania	1014·9	+0·6	61	21	36	8	55·9	43·9	49·9	+3·1
Wellington, N.Z.	1016·6	+2·3	62	18	31	29	55·6	45·6	50·6	+0·9
Suva, Fiji	1014·3	+0·7	89	6	63	28	83·9	69·1	76·5	+1·6
Kingston, Jamaica	1013·1	−0·9	93	22	72	3	87·9	73·3	80·6	−0·7
Grenada, W.I.	1012·7	−0·6	87	7	70	2	83·4	74·0	78·7	−0·1
Toronto	1015·4	+1·1	91	23	45	6	79·9	57·1	68·5	+5·9
Winnipeg	1011·9	−0·6	94	30	32	3	78·9	56·6	67·7	+5·5
St. John, N.B.	1011·6	−2·4	80	24	42	5	63·9	48·3	56·1	−0·4
Victoria, B.C.	1015·1	−1·8	70	25	46	15	63·2	49·6	56·4	−0·6

LONDON, KEW OBSERVATORY.—Mean speed of wind 7·9 mi/hr; 2 days with thunder heard.

MALTA.—Prevailing wind direction NW. Hours of observation from this month are 7 h. and 16 h. 1 day with thunder heard, 1 day with fog.

SIERRA LEONE.—Prevailing wind direction morning NE, evening SW ; 8 days with thunder heard.

MADRAS.—13 days with thunder heard.

British Empire, June 1921.

TEMPERATURE Mean	TEMPERATURE Absolute	Relative Humidity	Mean Cloud Am't	PRECIPITATION Amount		PRECIPITATION Diff. from Normal	PRECIPITATION Days	BRIGHT SUNSHINE Hours per day	BRIGHT SUNSHINE Percentage of possible	STATIONS
Wet Bulb.	Min. on Grass									
° F.	° F.	%	0–10	in.	mm.	mm.				
54·5	?29	60	6·1	0·22	6	− 49	3	7·4	45	London, Kew Observatory.
63·9	51	73	1·8	0·20	5	− 7	2	..	..	Gibraltar.
64·6	56	65	2·8	0·00	0	− 2	0	11·1	77	Malta.
75·3	..	75	6·0	15·31	389	−104	22	..	..	Sierra Leone.
78·4	68	87	5·7	15·34	390	− 93	18	..	..	Lagos, Nigeria.
71·9	..	90	..	5·59	142	− 83	13	..	..	Kaduna, Nigeria.
..	..	80	2·9	0·08	2	− 13	1	..	..	Zomba, Nyasaland.
51·6	30	57	2·5	0·00	0	− 1	0	..	..	Salisbury, Rhodesia.
51·9	..	74	7·1	7·93	201	+ 88	17	..	..	Cape Town.
39·8	28	54	1·1	0·00	0	− 3	0	9·3	89	Johannesburg.
..	..	..	..	..	..	..	..	..	..	Mauritius.
36·6	..	71	2·2	0·00	0	− 12	0	..	..	Bloemfontein.
81·4	72	75	8·1	14·27	362	+ 72	14	..	..	Calcutta, Alipore Obsy.
78·8	72	74	6·8	26·79	680	+211	16	..	..	Bombay.
76·4	..	58	6·1	0·65	17	− 31	5	..	..	Madras.
78·4	72	73	8·3	1·50	38	−154	13	..	..	Colombo, Ceylon.
77·2	..	81	8·0	14·74	374	− 24	25	5·2	39	Hong Kong.
76·4	..	82	..	7·39	188	+ 3	14	..	..	Sandakan.
53·8	36	74	3·9	0·89	23	−107	8	6·2	63	Sydney.
49·2	31	78	6·9	1·56	40	− 14	15	..	..	Melbourne.
51·1	27	74	5·5	2·05	52	− 27	11	5·0	52	Adelaide.
55·8	30	77	6·1	6·51	165	− 5	19	..	..	Perth, Western Australia.
52·3	32	63	3·5	1·31	33	+ 2	8	..	..	Coolgardie.
60·6	42	77	6·2	7·98	203	+136	15	..	..	Brisbane.
46·5	29	76	6·4	1·55	39	− 17	14	..	..	Hobart, Tasmania.
47·6	22	79	7·4	3·36	85	− 36	17	3·5	37	Wellington, N.Z.
72·5	..	89	..	5·03	128	− 28	14	..	..	Suva, Fiji.
..	..	73	7·3	2·21	56	− 49	6	..	..	Kingston, Jamaica.
75·6	..	79	6·2	9·81	249	+ 30	27	..	..	Grenada, W.I.
60·1	41	66	3·4	2·15	55	− 15	7	..	..	Toronto.
64·0	..	73	4·0	1·56	40	− 43	10	..	..	Winnipeg.
51·6	32	78	6·0	1·46	37	− 46	14	..	..	St. John, N.B.
51·9	39	82	6·9	1·24	31	+ 7	12	..	..	Victoria, B.C.

COLOMBO, CEYLON.—Prevailing wind direction WSW ; mean speed 7·0 mi/hr.

HONG KONG.—Prevailing wind direction SE ; mean speed 10·7 mi/hr ; 10 days with thunder heard.

SYDNEY.—Mean max. temp. highest on record.

BRISBANE.—Mean temp. highest on record for June.

GRENADA, W.I.—Prevailing wind direction E ; 2 days with thunder heard.

The rainfall of the month was in excess of the average (1881–1915) over four distinct areas lying across the centre of the British Isles, viz., locally along the coast of Durham and Northumberland, a narrow strip from Cheshire to Worcestershire, near Sidmouth, and over the whole of the eastern half of Ireland extending to the extreme west of South Wales. The amount in excess was usually not large, although in co. Down more than 50 per cent. above the average was recorded. The areas with deficiency were much wider, and in Scotland less than half the average fell generally north of a line from about Mull to Elgin, the greater part of the area receiving less than 40 per cent. of the average. In England less than 60 per cent. fell locally along the south-east coast and in Cumberland, where Seathwaite recorded only 42 per cent. of the average. Less than 25 mm. (1 in.) for the month occurred locally in the neighbourhood of the Wash and the Moray Firth, while the area over which more than 200 mm. (8 in.) fell was much smaller than usual and confined entirely to Kerry and Connemara.

The general rainfall for November, expressed as a percentage of the average, was:—England and Wales, 75; Scotland, 55; Ireland, 106; British Isles, 75.

November adds yet another month to the series of consecutive months since January with rainfall less than the average in the south of England. The dryness of November in the north of Scotland has helped to counterbalance the wetness of March and May, so that for the period February to November the only district with as much as the average rainfall was a very small area in Argyll. In these 10 months less than half the average rainfall has fallen over considerable areas along the south and east coasts from about Weymouth to Canterbury, less than 60 per cent. of the average being confined to the south of a line from about the Bristol Channel to the Wash. The only considerable area in England and Wales with more than 80 per cent. of the average lies in the neighbourhood of Newcastle-on-Tyne. In Scotland less than 60 per cent. has occurred in eastern Aberdeenshire, but the Western Highlands have mainly received over 90 per cent. of the average. In Ireland the percentage varies from a little over 70 per cent. in the centre to rather more than 90 per cent. in Wexford and Down.

In London, Camden Square, the mean temperature for November was 39·4° F. or 4·0° F. below the average. Duration of rainfall, 43·5 hours; evaporation, 0·19 inch.

Errata.—On p. 292 of the issue for November, in the last line of the note on Mr. Dansey's letter: *for* 13 h. *read* 18 h.

On p. 294, in the paragraph immediately preceding the table: *for* $\frac{1}{2}$ (Mean Max. + Mean Min.) *read* $\frac{1}{4}$ (Mean Max. + Mean Min. + 9 h. + 21 h.)