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The Shape of the Sky.

By HAROLD JEFFREYS, M.A., D.Sc.

IT is well known that if we attempt to estimate the angular altitude of a celestial object by eye, and afterwards determine it by means of an instrument, the former estimate is always the greater. The current explanation of this fact is that when we think we are estimating the angular distance between two points we are really carrying out a much more complex process. We suppose the points projected by perspective on some real or imagined physical object, and instead of estimating the angular distance between them, we really estimate the linear distance along the surface of this object. The sky, even in the absence of clouds, appears to many people to be a somewhat flattened vault. The projections upon it of two points with a given angular separation are further apart when the points are low down than when they are high up, and therefore, according to the theory, their angular distance is estimated to be greater when they are low down than when they are high up.

Gauss suggested that this flattening of the sky was caused by our mechanism of vision, the distances from us of all objects, real or imagined, and in particular of parts of the sky, being systematically under-estimated when we have to turn our eyes upwards to see them. This theory is followed by Pernter. Humphreys, on the other hand, holds that the apparent distances of different parts of the sky are determined by the "clearness" of those parts. In three recent papers*

* Anuario del Observatorio Central Meteorologico, Madrid. Supplemento al Tomo III., pp. 157–163, 175–210.

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H. Dember and M. Uibe advocate a further hypothesis, which has a considerable amount of experimental support. Their suggestion is that the distance of any part of the sky is determined by its luminosity; whereas in Humphreys's theory the determining cause appears to be the amount by which the colour departs from a certain standard blue, the specification of which requires investigation. Their observations decide definitely against the theory of Gauss and Pernter, but that of Humphreys is not considered.

It is clear that the issue between the theory of Gauss and the other two is capable of experimental test. If the discrepancies are due to purely physiological or psychological causes, the same observer, observing objects at equal measured altitudes, should always make the same, or nearly the same, estimate of the altitude. Different observers observing under the same conditions, however, may make different estimates. On the other hand, if an external physical cause enters into the estimate, the appearance of the sky will influence the estimates of any one observer; different observers, however, may be affected equally, and therefore make the same estimate. This test has been carried out by Dember and Uibe. The sight of a quadrant was pointed to the part of the sky whose angular elevation was estimated at 45°. The actual altitude was then read off. It was found at Teneriffe to range from 25·2° to 42·9° for the same observer. Reimann, in Germany, had previously found a considerable range in the determinations. Accordingly there must be some other cause involved than the purely physiological one.

Dember and Uibe had, up to this point, made no assumption about the form of the vault. They next tried a segment of a sphere as an approximation. In the following table ϕ is the mean of the measured altitudes of points, on different occasions, whose altitudes were estimated at 45°; k is the ratio of the distance of the sky beyond the horizon to its height in the zenith.

Illumination.	Germany.		Teneriffe.	
	ϕ	k	ϕ	k
Moonlight nights	26·5°	2·90	36·7°	1·73
Starry, moonless nights	29·9°	2·36	40·1°	1·40
Clear days	22·0°	3·55	32·0°	2·14
Cloudy days	?	?	29·0°	2·54

On the assumption that the sky is a segment of a sphere, the ratio k can be determined when ϕ is known.

It will be noticed that the flattening of the sky is less on moonless nights than on moonlight nights, on clear than on cloudy days, by night than by day, and at Teneriffe than in Germany. This summary is confirmed by an inspection of the individual observations, which shows that these differences are systematic and not accidental. The lowest value of k found at Teneriffe was 1·12, corresponding to $\phi = 43°$. The influence of optical and atmospheric conditions is plain.

As a test of the accuracy of the segment of a sphere as an approximation, the authors have found the measured altitudes of points in the sky at other estimated altitudes than 45°; this hypothesis about the form of the sky makes these calculable from ϕ, and the observed and calculated values usually agree within 1° or 2°, the greatest individual discrepancy being 7°. The agreement is quite satisfactory, and indicates that the approximation is very close.

The suggested explanation of this form is that we estimate the distance of the sky in any direction as proportional to the distance to which a body of specified size with the same surface luminosity as that part of the sky would have to be removed in order to be just visible. The apparent distance should then be proportional to the square root of the luminosity. The distribution of luminosity being determinable by observation, the form of the sky to be expected on this theory is capable of quantitative determination, and it is found to agree with that determined from ϕ to within about 4 % in the radius vector. On some occasions, however, the sky becomes markedly flatter near the horizon, though retaining the spherical form at measured altitudes of 30° and more.

The explanation, however, seems very artificial. Even if variation of luminosity is the fundamental cause of the discrepancies between measured and estimated angular distances, the assumption of a background of a definite size and shape is an extraneous hypothesis. Dember and Uibe's observations are sufficient to show that the ratio of the estimated angular distance between two objects to the measured angular distance is proportional to the square root of the luminosity of the background in the neighbourhood. This result is purely empirical, and involves no special assumption whatever. The reference to the shape of the sky, with the estimates of distances between non-existent objects on a non-existent background, involves several purely psychological assumptions, and can be tested, if at all, only by the methods of experimental psychology. It is worth while calling attention to this, in view of Dember and Uibe's insistence on the physical, not psychological, nature of their theory.

It is not improbable, indeed, that the true cause may be some other factor than the luminosity of the background, but ordinarily so closely correlated with luminosity that a correlation between the other factor and apparent size implies one between luminosity and apparent size. The colour of the clear sky, for instance, usually varies steadily from deep blue in the zenith to a bluish white near the horizon, while luminosity also steadily increases towards the horizon. The correlation between the colour of the surrounding sky and the ratio of the measured and estimated angular distances is not examined in the papers. This is unfortunate, since it renders impossible a comparison between Dember and Uibe's theory and that of Humphreys.

In Dember and Uibe's last paper the variations with altitude of the apparent sizes of the sun and moon are discussed. It is pointed out that the apparent magnification of the setting sun persists when it is looked at in an inclined mirror, which shows that the phenomenon is not affected by the direction of gaze. The authors had two discs of diameters 30 cm. and 40 cm. These were placed on the ground at the same level as the observer, and their distances adjusted till their angular diameters were estimated as equal to that of the sun. When the sun was near the horizon the measured angular diameters would naturally agree with that of the sun, but when the sun was high the discs had to be placed further away. In each case the distances necessary remained closely proportional to the actual diameters of the discs. This provided a useful check, for the discs, being of different sizes, had to be set independently, so that neither could influence the setting of the other. It was found that the ratio of the estimated angular diameters of the sun when high up and low down agreed closely with that of the projections of the horizontal diameter on the hypothetical vault.

One may doubt, however, whether this confirms the theory in the form in which the experimenters present it. The surface of the vault is not normal to the radius vector from the observer, except in the zenith. Hence the projection on the vault of the diameter of the sun in a plane passing through the zenith should be longer than that of the horizontal diameter. On this theory, therefore, the sun should almost always appear elliptical, with the long axis vertical. This is a serious objection to the assumption of a background of reference. On the other hand, if there is merely an apparent magnification or reduction of angular diameter owing to variation in the luminosity of the sky, there is no reason why the estimate of one diameter should be more in excess or defect than that of any other, and the sun should appear circular; as it actually does except when near the horizon, when it appears flattened, but in the opposite way to that required by the former theory.

To an observer at a considerable height above the earth's surface the sky appears less luminous than to another observer at the surface, but the effect of dust and water particles is practically removed. These are an important factor in causing the whiteness of the sky near the horizon, and it is not unlikely that observations from balloons and aeroplanes may be valuable in comparing the importance of luminosity and clearness.

The Deficient Rainfall.

SINCE the extremely wet July of 1920 the rainfall in the British Isles has been so generally deficient as to call for widespread comment, and the markedly small rainfall of the present year, particularly in England and Wales, has greatly accentuated the effect of the dry period as a whole.

It is not possible as yet to examine the records of the year in comparison with those of previous dry years in complete detail, but the results of a preliminary investigation are probably of sufficient interest to put on record.

Speaking generally, January and March were the only months since July 1920 with an excessive rainfall, and even during these months parts of the south-east of England failed to record their average fall; but up to and including January the general deficiency was not in any way remarkable, and we propose to confine attention to the six months February to July, inclusive. In February the rainfall reached as much as half the average only in the west of Ireland and in parts of the west coast fringe of Scotland. Over by far the greater part of Great Britain less than a quarter of the average fell, and in some districts, the most conspicuous of which comprised the counties contiguous to the Bristol Channel, less than one-tenth of the average fell. March was wet in the west, especially in Scotland, where more than twice the average fell widely, but nearly all parts of England continued dry, and less than half the average fell over part of the eastern counties. In April the deficiency was again widespread, but it was least marked in the east of England, where part of East Anglia just exceeded its average. In the south of Ireland and of Scotland, and in the south-west of England

and Wales, less than half the average fell. May was distinctly less dry, most of Scotland having a slight excess, but nearly all parts of England, Wales and Ireland had little relief from the shortage of rain, and an extremely dry June in all districts set the seal upon what had already threatened to become a very serious drought, using the term in its popular significance rather than in its technical sense. In June less than half the average was practically universal, and less than a quarter of the average fell everywhere in England, Wales and Ireland except a few very local patches affected by a thunderstorm on the 26th. The district chiefly affected by this storm was the south Midlands of Ireland, where 3·10 in. fell at Abbey Leix, in Queen's Co. The deficiency was greatest on the south coast, where less than one-tenth of the average fell, no rain at all being reported from some stations in Pembrokeshire and Sussex.

With July came relief in the west, but nearly the whole of England and about half of Wales again failed to record as much as half the average rainfall, and all parts of the south-east from the Humber to Dorset less than one quarter. In the south-east Midlands less than one-tenth of the average again fell.

In considering the period of six months as a whole it is necessary to confine attention to England and Wales, since the deficient rainfall, although remarkable elsewhere, was not sufficiently so to warrant the expenditure of time necessary to carry out a detailed comparison with previous years.

The total rainfall from February to July, inclusive, exceeded 60 per cent. of the average in England and Wales only in the extreme west and north-west. Less than half the average, representing a deficiency of an almost unprecedented nature over so protracted a period, occurred over a roughly circular area bounded by a line passing from the mouth of the Humber through the north Midlands to South Wales and Devonshire, and in the east, possibly cutting off eastern Kent. This may be regarded as defining the field over which the drought of 1921 has been extremely severe, and the district most severely affected lay in the centre, where less than 40 per cent. of the average rainfall occurred over some 15,000 square miles extending from Monmouthshire on the west to Lincolnshire on the north, and Suffolk and Sussex on the east and south. The lowest values of which any record has been received are 33 per cent., or 67 per cent. deficiency, at Wellingborough, and 34 per cent., or 66 per cent. deficiency, at Ross-on-Wye. In London there was a deficiency of 63 per cent.

In comparing the above with the records of previous long dry spells, an examination was made of the monthly rainfall at a large number of stations for the past 50 years. There have been a considerable number of instances of short periods, from one to three months, which would bear comparison with the most severe phases of the dry spell of 1921, but taking the period as a whole there appears no doubt that the only six-monthly periods worth considering as comparable with 1921 were those of the spring and early summer of 1887 and 1893. The conditions during these two years were discussed fully by Mr. Symons in the appropriate volumes of *British Rainfall* and also in *Symons's Meteorological Magazine*, and the reader is referred to these publications for fuller details.

In 1887, as in 1921, the driest months were February and July, whilst May was only moderately dry. During the whole period the deficiency of rainfall was greatest in two separate areas, the north of England and the extreme south-west. The latter was the only district in which less than 40 per cent. of the average fell, and no part was so dry as the south Midlands in 1921.

In 1893 the dry period lasted from March to August, the driest months being March and April. These two months together, over England and Wales as a whole, were far drier than any two consecutive months in 1921. The latter part of the period was, however, far less remarkable, and July, though clearly falling into the dry spell as a whole, had more than its average fall. The total fall was nowhere less than half the average, but exceeded this limit by only a narrow margin over a large area extending from Pembrokeshire to Kent.

In the following summary are compared the general values of rainfall over England and Wales expressed as percentages of the average:—

GENERAL RAINFALL as Percentage of Average, 1881–1915.

ENGLAND AND WALES.

—	Feb.	Mar.	April.	May.	June.	July.	Aug.	Six Dry Months.
1887 -	36	70	70	86	31	51	—	57
1893 -	—	24	17	72	58	132	67	65
1921 -	17	81	66	79	16	35	—	49

It is inadvisable to make too hasty a judgment, but we have little hesitation in expressing the opinion that, even when a fuller examination of past records has been possible, it will prove that the six months just completed will, so far as England and Wales are concerned, have been unprecedented for widespread deficiency of rainfall for at least half a century.

The Case for the Modern Units in Meteorology.

By F. J. W. Whipple, M.A., Superintendent, Climatology Division, Meteorological Office.

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2. Pressure.

In the case of rainfall the new unit adopted in the British meteorological service is merely one which has been used as a matter of course on the Continent for a century. For pressure a unit has been chosen which is entirely a novelty in practical meteorology, and the underlying ideas are not so simple. It seems so straightforward to regard pressure as merely the reading of a mercury barometer that most people who have not had occasion to consider the matter closely are not aware of the difficulty of giving precision to the interpretation of such readings and of bringing them into connection with other physical measurements. With a mercury barometer we balance the pressure of the mercury against the pressure of the atmosphere. It is not sufficient, however, to say that the pressure is equivalent to a head of so many inches of mercury; we must know the temperature of the mercury, for two barometers in adjacent rooms and at different temperatures will give appreciably different readings on account of the fact that warming mercury makes it lighter. The practice has been to take mercury at the freezing point of water as the standard, and to apply corrections to "reduce" the readings to this standard. It will be agreed that this practice is rather artificial, especially as barometers are very seldom used in rooms at such a temperature as 32° F. With Fortin barometers graduated to read in inches there is another anomaly to allow for. The standard British yard being the length of a certain brass rod when at 62° F., it is customary to graduate barometers so that the scales read true inches at this temperature. Accordingly the specification of the conditions under which barometers would give readings requiring no corrections implies that the brass scale is to be at 62° F., whilst the mercury is at 32° F. It should be noticed, however, that in the routine of a meteorological station this curious rule of the instrument maker does not introduce any additional complication. The correction tables allow for the peculiarity in the graduation. The important point is that the corrections for temperature are large enough to matter seriously. A barometer reading of 30·000 inches, with the thermometer standing at 80° F., corresponds with only 29·861 true inches on the ideal barometer, with mercury at 32° F.

A further difficulty was introduced into the subject when it was realised that since the same "head" of mercury would not support the same pressure in different latitudes, it was not legitimate to treat barometric readings as if latitude were of no account. The gravitational attraction of the earth is greater at the poles than at the Equator, so the pressure which could be balanced by 30·000 inches of mercury at the North Pole is greater than that balanced by 30·000 inches at the same temperature at the Equator. The difference is considerable; it is about equivalent to a head of 0·156 inch of mercury. The difficulty can be met by "reducing" the readings of the barometer to latitude 45°, the meaning being that the pressure at a particular place is not expressed in terms of the head of mercury which can be supported there, but in terms of the head of mercury which could be supported by an equal pressure at a place in latitude 45° and at sea-level.

The student of meteorological literature will find that all important pressure observations he has to deal with have been reduced to 32° F., but that even close scrutiny will not always show whether the reduction to latitude 45° has been carried through. The latter correction was not introduced into the publications of the Meteorological Office until 1911. On maps drawn before that date the lines which were supposed to be isobars, *i.e.*, isopleths of pressure, were merely isopleths of head of mercury.

Enough has been said to indicate that the British unit of pressure, one inch of mercury at 32° F. in latitude 45° at sea-level, is not a very handy unit. The Continental unit, the millimetre of mercury at 32° F. in latitude 45° at sea-level, suffers from most of the same defects.

When we attempt to make a fresh start we realise that we have been slaves to our tools: mercury happened to be available as the best liquid for making pressure gauges, and so pressure was measured in terms of the weight of mercury. On the other hand, the more instructive way is to regard pressure as giving so much force over a specified area. The engineer is content to deal with so many pounds to the square inch, so many kilograms to the square centimetre, but the meteorologist wants precise and universal units, and the weight or—as I prefer to call it—gravitance of a pound is not a universal unit, since even on the earth's surface it depends on latitude. The universal unit of force on the C.G.S. system is the dyne, the force which produces an acceleration of one centimetre per second per second in a mass of one gramme. The corresponding unit of pressure is one dyne per square centimetre. To this pressure the name microbar has been given. The microbar is small compared with the pressure dealt with in ordinary meteorology. The pressure of the very rare gas in an electric-light bulb may be as low as one microbar, however. The "bar," one million microbars, is known sometimes as the C.G.S. atmosphere, since it happens that it is not far from the average atmospheric pressure at sea-level. The unit which has come into practical use is the millibar, the thousandth of a bar and one thousand times the microbar.

There are happy accidents which make the use of the millibar very convenient. The fact which has been mentioned that one bar or 1,000 millibars is fairly close to the average pressure of the atmosphere at sea-level may rank first. It results that in balloon ascents, when pressure is 900 mb., one-tenth of the atmosphere is below the aviator, nine-tenths above, and similarly for other pressure readings. The range of sea-level pressure all over the world is almost confined between the limits 1,050 millibars and 950 millibars, so that a barograph chart may conveniently have 1,000 millibars for its middle line. To avoid misconception it should be mentioned, however, that in no part of the world is the average sea-level pressure as low as 1,000 millibars. For Greenwich the average is approximately 1,015 millibars. The standard atmosphere of the chemist, 760 millimetres of mercury at 0° C. at sea-level in latitude 45°, is 1,013·23 millibars.

Mercury barometers can be graduated to give readings in millibars, and these readings require corrections for temperature and for latitude, but on account of the difference between the ways in which the idea of measuring pressure is approached the theory of these corrections is on rather a different footing from that of the corrections to the inch barometer. The difference is that one can hardly realise the significance of the unit "one inch of mercury at 32° F. and 45 degrees of latitude" without considering the nature of barometer corrections, whilst the definition of the millibar makes no reference to mercury and the corrections of the millibar barometer are mere technical detail.

On the practical side the advantage of using a unit of pressure selected in accordance with the principles of dynamics is great. With systematised units the pressure due to the weight of a column of homogeneous liquid may be determined at once by the formula

$$p = \rho g h,$$

where p is the pressure, ρ the density, g the acceleration due to gravity and the earth's rotation, h the height of the column. For example, the pressure due to a column of water 30 feet, *i.e.*, 914·4 cms., high at 50° F. in latitude 51° is found in centimetre-gramme-second units by writing $\rho = 0{\cdot}9991$, $g = 981{\cdot}2$, $h = 914{\cdot}4$. On substitution in the formula we get $p = 896000$ nearly. So that the pressure is 896000 microbars, or 896 millibars.

Similarly with the fundamental formula of aerodynamics, $p = \frac{1}{2}\rho v^2$, which gives the extra pressure on a surface due to a stream impinging directly on it with speed v, with the fundamental formula of the theory of gases, $p = \frac{1}{3}\rho \times$ average (V^2), which connects the pressure of a gas and the speeds of the molecules, and with the fundamental formula of dynamical meteorology, $\frac{\delta p}{\delta n} = 2\,\omega\rho \sin\lambda$, by which the speed of a steady atmospheric current can be computed from the pressure gradient, in every case the use of the absolute unit of pressure makes it possible to approach special problems without reference to such irrelevant details as the density of mercury and the local value of "*g*." In fact, to the student who is trying to master the more theoretical aspects of meteorology, the use of a unit of pressure which is frankly nothing else is a decided advantage.

It is a welcome sign of the times that the instrument makers report a steadily increasing demand for barometers with the millibar graduation. Such barometers can be obtained from all the makers advertising in the *Meteorological Magazine.* On the other hand, the possessor of an old favourite aneroid can easily bring himself abreast of the times by pasting a scale of millibars on the glass of the instrument. With the barograph the change-over is even simpler, as all that is necessary is to order charts with the appropriate ruling.

Official Publications.

Professional Notes.—No. 18. Lizard Balloons for Signalling the Ratio of Pressure to Temperature. No. 19. Cracker Balloons for Signalling Temperature. By Lewis F. Richardson, F.Inst.P. *Price* 1s. net each.

DURING the year 1920 Mr. Richardson was working at Benson Observatory and found opportunity to develop new methods of upper-air research. The present notes are devoted to two of these methods.

The first note, No. 18, describes the "Lizard Balloon" and gives some account of its manufacture, the tests applied to its several parts and the theories relating to its calibration and expansion. A report of the first ascent made at Benson on April 30th, 1920, is also given.

The "Lizard Balloon" is an ordinary india-rubber balloon inflated with hydrogen within an inextensible case of chiffon. A trigger of bronze wire with an india-rubber spring is sewn to the chiffon case and the balloon drags after it a thread ending in an inverted parachute made of a small square of nainsook. The balloon is prevented by the chiffon case from expanding horizontally, so it expands vertically, ultimately pressing the trigger and releasing the tail. Hence the name "Lizard" from the habit of some of these animals to drop their tails when disturbed. The observer follows the balloon with a theodolite and the height is determined by the "tail method."

The initial and final volumes of the balloon are compared just before the ascent by weighing the corresponding total lifts. During the ascent the balloon acts as a hydrogen thermometer, expanding between known volumes; it therefore measures the ratio of pressure to temperature at the level where the tail is released, and except for the small effect of water vapour it may be said to measure density. Mr. W. H. Dines has shown that the standard deviation of density at heights between 1,000 and 5,000 metres is only 1 to 2 per cent. of its mean so that if the present instrument is to be of value it must have a standard error decidedly less than 1 per cent. Mr. Richardson aspires to attaining an accuracy of 1 in 1,000. The most serious difficulty is due to the warming of the gas in the balloon by direct sunshine; it is thought that this effect, which invalidates the assumption that the temperature of the balloon is the same as that of the free air, may introduce an error of $\frac{1}{2}$ per cent. in the computed density. With a sky either uniformly clear or uniformly overcast, the greater accuracy might be obtained.

The second note, No. 19, is similar in content to the first—it describes the "cracker-balloon" and its various parts and gives accounts of two ascents made at Benson in 1920, one with a single thermometer, the other with two thermometers.

The "cracker-balloon" carries a thermometer capable of closing an electric circuit when the temperature falls to a pre-arranged value. The electric current heats a fine wire, which in turn ignites a small charge of explosive, the cracker. This balloon, like the "lizard," has a tail of thread ending in a nainsook parachute. A larger square of nainsook is used, however, in order to prevent the falling cell from injuring anyone. As with the "lizard" balloon the height is determined by the "tail method"; the explosion of the cracker is seen through the theodolite. In case the balloon should burst and fall to the ground before the cracker has exploded, a warning label is attached, telling the finder how to dispose of the cracker harmlessly.

Mr. Richardson states that his original design was to arrange for an explosion that would be audible from the ground. Then, if the time of the explosion were noted and the rate of ascent known, the height could be obtained. Also observations would not be hindered by thick weather. But up to the present he has only used small charges of powder and their explosion has only just been audible at a direct distance of 2,200 metres, which is not sufficient. If more powerful crackers were used, further precautions to protect the finder of an unexploded cracker would be necessary. A short-lived cell is suggested as a safe device and the possibility of making a whistle or siren blown by burning cordite is also considered.

British Meteorological and Magnetic Year Book, 1910, *Part V. Réseau Mondial Charts.* Price 8s. 6*d*. net.

THIS volume contains charts illustrating the tables of the *Réseau Mondial* for 1910, which were issued last year. The charts show deviations of pressure and temperature from the normal for each month and for the year, and are in all respects similar to those of the volume for 1911, which was published in 1916.

Réseau Mondial Tables have been published for the years 1911, 1912 and 1913, but owing to the difficulty experienced during the war in obtaining the necessary data for the later years, it was decided, after the tables for 1913 had been prepared, to proceed with the volume for 1910. When the issue of charts was again taken up, this year, being the earliest of the series, was the first to be dealt with. It is hoped that the charts for 1912 and 1913 will be published in due course.

Correspondence.

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

Aerial Photography of Industrial Towns during the Coal Strike.

MIGHT I enquire if any aerial photographs were taken of the large industrial cities during the coal strike, when the dark canopy which usually enshrouds them was removed for some weeks, revealing their features with exemplary and probably unprecedented clearness?

From my point of view in Sheffield, which is some 600 ft. above sea level, I saw the details of the valley through which the Don passes, and where all the large works are situated, entirely free from smoke throughout its entire length, even so far eastwards as Rotherham, where the church spire could be distinctly discerned. It was a sight that has never been previously opened to my view, although I have occupied the same habitation for more than a quarter of a century, and it occurred to me it would be of interest generally, if we could have had some photographs from an aeroplane. This was suggested to the Corporation, but difficulties were felt in the way of doing it which could not easily be overcome, so nothing was done. Possibly some airman flying over the country may have taken a photograph of Sheffield, and if so I should be very glad to hear from him.

Our smoke canopy is confined, in the mass, to the valley of the Don, and in that district I have had for some years a sunshine recorder in the thick of the smoke. A quarter of a mile away, in the same district, but on a hill at High Hazels about 150 feet higher than the valley, I have another. The difference between the two for one year is about 30 per cent. under ordinary circumstances, Attercliffe having the smaller number of hours. During the coal strike, when all the works were down, the difference was practically nil, in fact at the three stations, Weston Park, 450 feet above sea, and about two miles away from the heavy industrial parts, High Hazels, 300 feet above sea, and Attercliffe, 141 feet above sea, the readings were practically the same, and on some days Attercliffe got more sunshine than the other two, although, being in the valley, the actual possible amount was always less.

E. HOWARTH.

Museum and Art Gallery, Sheffield, July 29th, 1921.

Descending Currents associated with Sea Breezes.

An instance of the apparent descent of air from one level to another was observed at Calshot on July 6th. A pilot balloon ascent was made at 10 h. 10 m. G.M.T., the height of the balloon at each minute being obtained by means of the "tail method." Two white balloons were used, one being inflated with hydrogen to give a rate of ascent of 500 feet per minute, while a smaller balloon was inflated with air until its diameter was approximately one half that of the other. Readings of the altitude and azimuth were made at even minutes, and micrometer readings were made at alternate half-minutes. Both balloons were observed for 23 minutes.

At the end of 8 minutes the balloons had reached a height of 3,100 feet, the mean rate of ascent being 390 feet per minute. For the next 3 minutes the rate of ascent decreased to 250 feet per minute. From the 11th to the 13th minutes the balloons rose only 40 feet, but afterwards the rate of ascent increased, the mean rate for the remaining 10 minutes being 450 feet per minute.

The weather conditions at the time were as follows :—

> Anticyclone to the SW of England; wind at surface SW by S, 18 feet per second; gradient wind WNW, 20 feet per second; cloud cirrus 7; humidity 57 °/₀ decreasing; surface temperature 70·3° F.; approximate sea temperature (derived from D.W.R.) 58° F.

The track of the balloons was almost wholly over the sea, and during the 9th to 15th minutes a loop was described the speed of the wind being very light, less than 5 feet per second.

Assuming that the resistance of the smaller balloon would decrease the rate of ascent by approximately one-fifth, *i.e.*, that the rate of ascent of the system of two balloons was 400 feet per minute, it appears that between the 11th and 13th minutes descending currents of 6·3 feet per second were encountered. The descending currents were undoubtedly real, as the micrometer readings for the 12th and 13th minutes were exceptionally low compared with the neighbouring readings.

Another ascent, made at 15 h. 15 m. G.M.T. on the same day exhibited no signs of descending currents of more than 1 foot per second. R. P. Batty.

Calshot, July 18th, 1921.

[This report is of special interest as showing a descending current of air over the sea (between Hampshire and the Isle of Wight) synchronising with a sea-breeze at the observing station.—Ed. M.M.]

The Magnetic Storm of May 13th–16th: Samoa Magnetograms.

I HAVE recently received a reduced copy of the Samoa magnetograms for May 13th – 16th, 1921, showing the remarkable character of the magnetic storm then experienced. The "sudden commencement" at about 13h. 10m. G.M.T. on the 13th, with sharp rises in horizontal force and vertical force and small easterly movement in declination, was followed about six hours later by a substantial fall in horizontal force. But the disturbance on the 13th and earlier part of the 14th was overshadowed, as in Europe, by the disturbance from 22h. on the 14th to 11h. on the 15th. There was also very active disturbance during the early hours of the 16th.

The total range during the three days was only about 18′ in declination (equivalent to 180γ in the component of horizontal force perpendicular to the magnetic meridian) and 160γ in vertical force, but in horizontal force it was nearly 1,000γ. For an observatory only 14° from the Equator the disturbance is probably unprecedented. The Samoa record would be of altogether exceptional value for a complete study of the great storm.

It is sincerely to be hoped that the continuance at Samoa of an observatory capable of producing such satisfactory records will be secured. C. CHREE.

July 22nd, 1921.

Thermometer Exposure at Kew Observatory, Richmond.

I NOTICE from page 138 of the *Meteorological Magazine* for June that the minimum temperature at Kew Observatory for December last is given as 21° F.

On the night of December 12th–13th last a frost of exceptional severity was experienced over the south-east of England and low readings were recorded in the screen, even in the London District, Croydon reporting a minimum of 10° F., Camden Square 12° F., Greenwich and even Kensington Palace 16° F. It would seem, therefore, that the figure of 21° F. recorded at Kew was exceptionally high and not in accordance with the readings registered in surrounding districts. The fact that a minimum reading of 10° F. was registered at Kew on the same night on the surface of the snow would indicate that the sky was as clear as elsewhere, and therefore there is no apparent reason for this divergent screen reading.

In this connection I have very frequently noted relatively high minima recorded at Kew Observatory on cold nights compared with the other London stations, but have never before noticed such a great divergence as on the occasion mentioned, and I am unable to account for this.

Another peculiarity about Kew which I have frequently observed is not only the fact that the maxima recorded there in hot weather are often lower than at other London stations (either central or outlying), but that they are reached later in the day, in clear, hot weather the 6 p.m. (G.M.T.) reading often approaching the highest reading for the day.

HAROLD FREIR.

Bylock Hall, Ponders End, Middlesex, July 2nd, 1921.

[The use of different methods for exposing thermometers makes the comparison of observations difficult. At Kew Observatory the thermometers used for all the official reports are exposed in the large thermograph screen on the north wall of the building, and 10 feet above ground. There is a Stevenson screen (double size) on the lawn.

For the night in question, December 12th–13th, 1920, the lowest temperatures recorded were :—

North wall screen ordinary minimum thermometer	20° F.
,, ,, ,, photo-thermograph - - -	20° F.
Stevenson screen - - - . - -	15° F.
Grass minimum thermometer - - - -	10° F.

For the first ten days of December 1920 the minimum by the Stevenson screen averaged 1·0° F. lower than that in the north wall screen, whilst the maximum in the Stevenson was the higher by 0·5° F., so that the difference of range was about 1·5° F. According to a comparison made at Kew Observatory in the years 1879–81 (Q.W.R. 1880, App. II.) the average differences in winter were :—

Maximum Stevenson higher than north wall by	0·42° F.
Minimum ,, lower ,, ,, ,, ,,	1·80° F.

The use of the more modern pattern of Stevenson screen provided with a double roof and a nearly closed bottom has presumably made the present Stevenson screen readings more nearly represent the temperature of the free air.

It should be mentioned that the comparability of London observations is also affected by the use at Greenwich Observatory and at Camden Square of Glaisher stands instead of Stevenson screens. On the Glaisher stand the thermometer is sheltered from direct radiation from the sun, but it can exchange radiation with the ground, &c. These exceptional methods of thermometer exposure have been maintained for historical reasons.—ED. M.M.]

Cloud Nomenclature.

My experience is that seven of the principal types of cloud are readily recognised from their definition, according to the international classification. The difficulty arises when alto-stratus, stratus or nimbus clouds prevail. The distinction between stratus and nimbus clouds is not very clear to most observers, unless rain is falling, when the clouds are called nimbus. According to the *Meteorological Glossary*, p. 65, "it should be noted that rain, hail or snow only fall from nimbus or cumulo-nimbus clouds, except the slighest and most transient showers, which may sometimes fall from alto-cumulus or strato-cumulus clouds." This statement is either incorrect, or otherwise on quite 40 per cent. of the occasions when rain is reported, the cloud type is wrong. Observers frequently report "continuous moderate rain," "heavy showers," etc., with a cloud-type stratus.

The only means of distinguishing stratus from alto-stratus by the definitions proposed by Dr. Brooks is "by whether or not it appears to be lower than 1,000 metres above the surface," but with this distinction only, greater confusion between the two types of cloud is certain to arise. Estimating the height of a cloud is very difficult and deceiving, as people with flying experience will testify.

The question of precipitation from various types of clouds other than nimbus arises in Dr. Brooks's definition of alto-stratus where he says "steady rain or snow may fall for hours from alto-stratus."

To bring about a better uniformity among cloud observations, some clear statement about precipitation from various types of clouds should be added to the definitions in the international classification. C. C. Newman.

Kingston-on-Thames, July 27th, 1921.

The Design of Rain Gauges.

I have read with great interest the article in the *Meteorological Magazine* for July, entitled "The Design of Rain Gauges," and it would be an excellent thing if all rain gauges conformed to the specification given. I would suggest an amplification of essential feature No. 5 something like this, "Simplicity of construction and avoidance of the use of unsoldered joints in any place where a leak may cause loss of collected rainfall."

There are many ways, other than rivetting, of making a leaky joint, such as screwing, bolting or folding without soldering, and Dr. Mill many times impressed on me the importance of having solder over any joint however it might be held together mechanically. F. L. Halliwell.

17, Brockenhurst Gardens, Mill Hill, July 22nd, 1921.

Somerset—A Year of Drought.

A VERY hot and dry July has greatly aggravated a situation which was bad enough before, and completed a very dry twelve months.

July yielded ·71 in. of rain on 7 days, against an average of 2·47 in. on 13·2 days.

The aggregate fall for 1921 thus far is 9·19 in. on 75 days, against a previous lowest 10·94 in. in 1911, and against 85 days in 1899 and in 1911. The averages for 24 years are 16·84 in. on 107 days.

For the 12 months now ended we have 18·81 in., against a previous lowest of 25·43 in the corresponding months of 1904–5, and against a 24 years' average of 32·32 in., that is 74 per cent. of the previous least and 55 per cent. of the average. H. A. BOYS, F.R.Met.Soc.

North Cadbury Rectory, Somerset, August 2nd, 1921.

The Rainfall of June 26th at Limerick.

A FEW facts connected with the abnormal rainfall here on June 26th may be of interest.

Sunday morning and afternoon were bright and hot; about 4 p.m. clouds began to roll up from the north-west. There was at first distant thunder, it came nearer, and about 4.45 p.m. a perfect "cloud burst" occurred, the rain coming down in sheets. On measuring the rain at 6.45 p.m., I found slightly over 1·50 ins. in the gauge. The rain had ceased slightly although it was still raining hard. It continued practically all night, but its great strength was over. The gauge at 9 a.m. on the 27th registered for the 24 hours 1·88 ins. which, as far as I know, was a record in this district.

My records have been carefully kept since 1890 inclusive.

Another gauge at my factory, Upper William Street, Limerick (on the opposite side of the River Shannon), only read 1·06 for the 27th. Of course a cloud-burst causes an unequal distribution of rainfall, and I have reason to think that within 20 miles of Derravoher there were places in which the rainfall was not one-third of what we had. In fact, I have heard, but I cannot verify it, that there were places that afternoon in which there was no rain at all.

A. W. SHAW.

Mulgrave Street, Limerick, July 13th, 1921.

NOTES AND QUERIES.

Optical Phenomena at Aberdeen, June 13th, 1921.

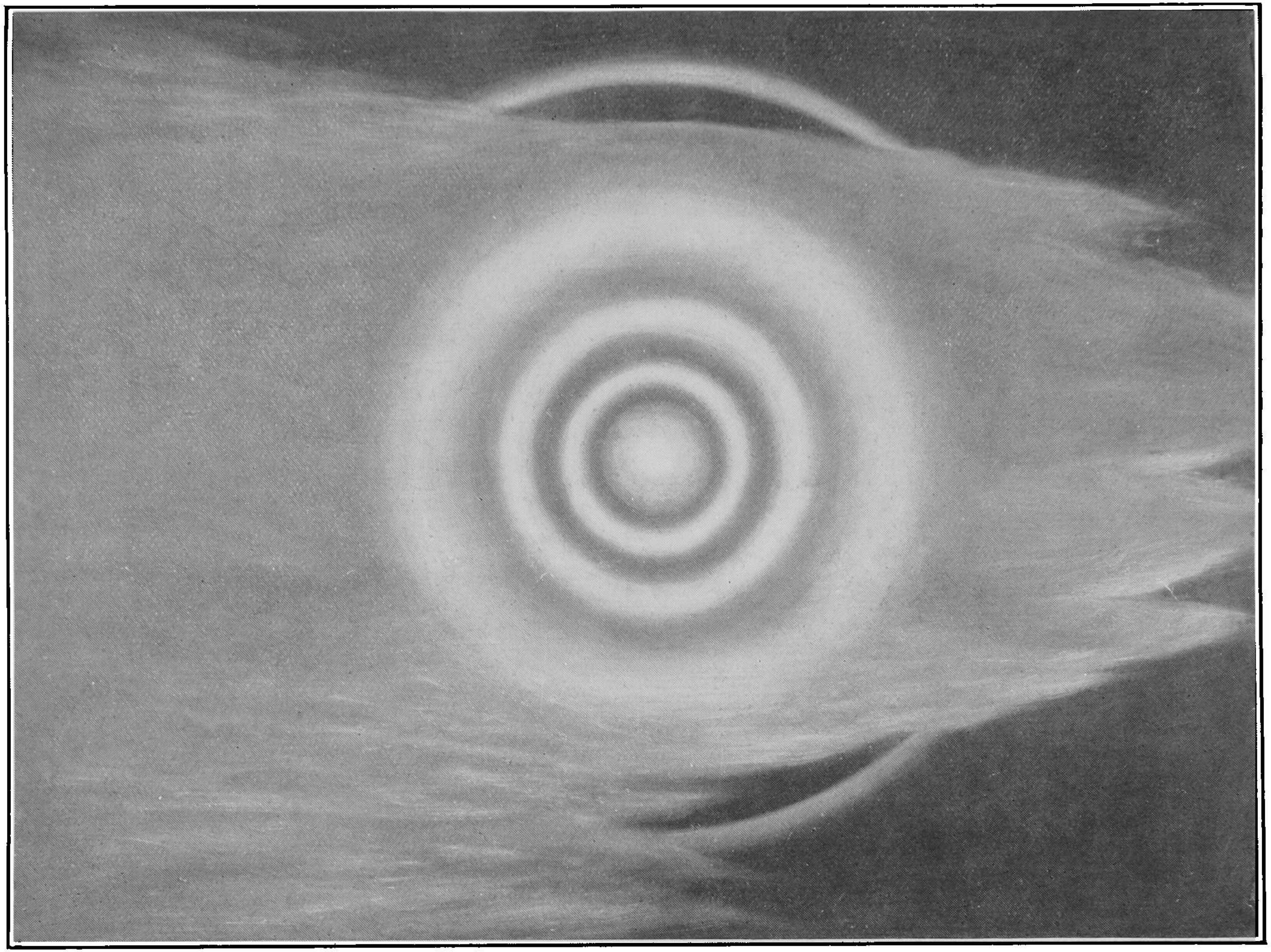
Simultaneous Halo and Corona.

A REMARKABLE display of various optical phenomena occurred at Aberdeen between 15 h. and 18 h. G.M.T. on June 13th, 1921.

At 15 h. the sky was covered with a film of cirro-nebula, which was structureless and scarcely sufficed to dim the blue colour of the sky. A very fine halo of 22° was visible, showing the reddish-orange very strongly, and the yellowish-green quite plainly, though not intensely. Beyond the green the colour was a white, or bluish-white, merging into, and probably tinted by, the bluish-white of the sky. The halo-ring seemed somewhat narrower than usual.

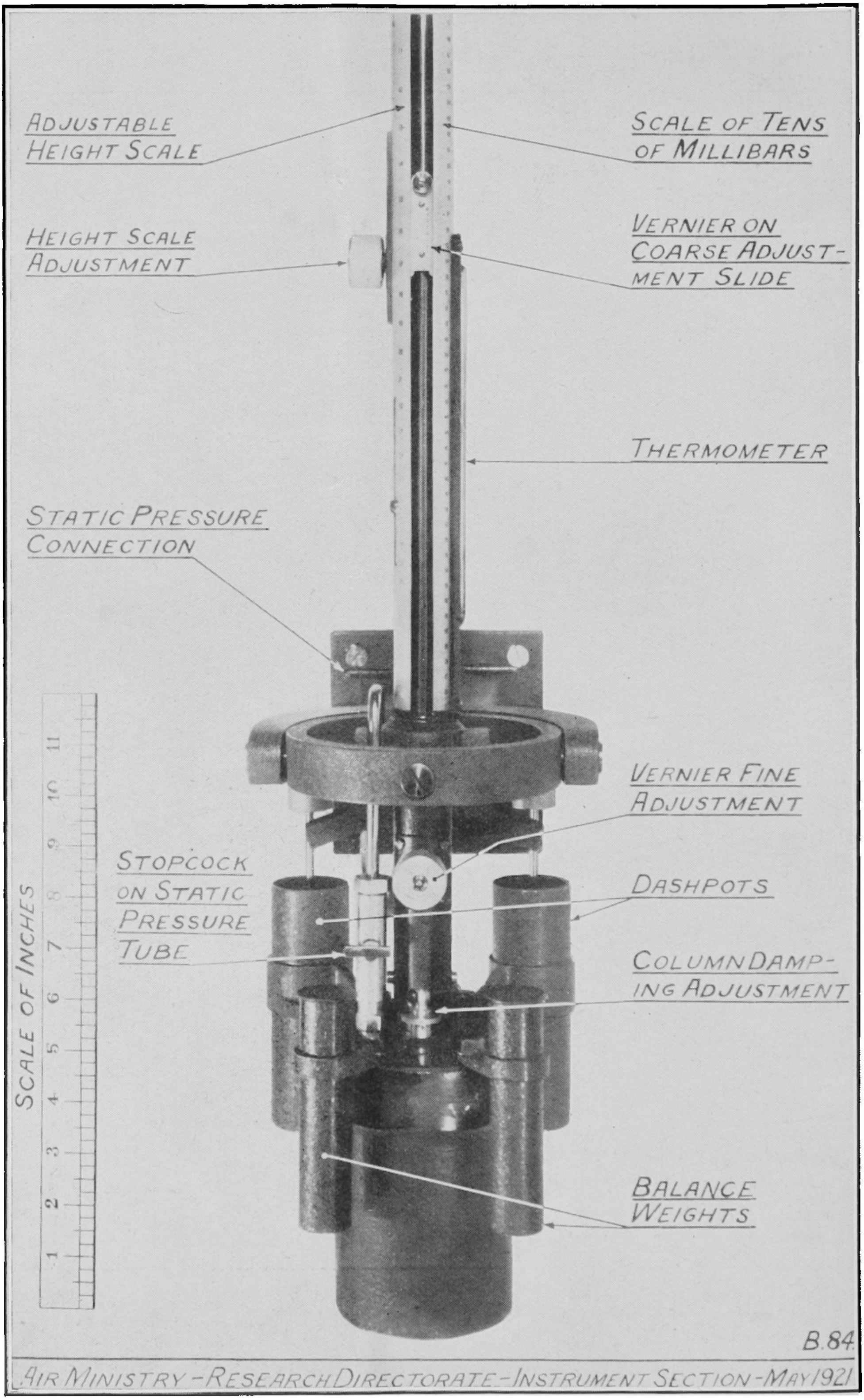
Shortly after 15 h. some sheets of very thin cirro-cumulus exhibiting double undulation formed very rapidly and went through a series of rapid changes of form and also of internal structure. Trains of waves were seen to form and to be obliterated by other trains crossing them at angles of 60° or 70°. One of these sheets was situated between the sun and the observer, and in it there formed a magnificent triple corona, approximately 16° in radius to the outermost red. The phenomenon did not last more than two or three minutes at most, and as the cloud thickened the corona rapidly deteriorated into an ordinary one with radius smaller than that of the innermost of the original three rings. During its short duration the triple corona was carefully examined, and the estimation of its radius was made possible by the fact that the cloud sheet in which it was formed was not extensive enough completely to cover the halo.

On a rough approximation the angular radii of the three red rings were about 6°, 10°, and 16° respectively. There was a strong bluish-white aureole edged with brown between the sun and the first violet. The first ring colours were in the normal sequence from the violet to the red, but in the second ring the colours seemed impure, a pinkish-red and a bluish-green, while those of the third and outermost ring were simply the emerald-green and rose-pink so often seen in the phenomena of iridescence. In fact, the lower edge of the outer ring almost reached the margin of the cloud-sheet and the rose colour of the corona merged with and spread into a very fine iridescent area along the edge and contours of the cloud. The iridescent colours were confined to rose-pink and emerald-green in the neighbourhood of the ring, but further along the edge of the sheet some violet and



Simultaneous Halo and Triple Corona.

Observed by Mr. G. A. Clarke, at Aberdeen, June 13th, 1921.



A MERCURY BAROMETER FOR AIRSHIPS.

yellowish-green was seen. This irisation lasted for some time after the triple corona had disappeared. The irisation seemed also to show up the tiny ripples and waves in the cloud sheet, at the extreme edge of which there might be seen groups of very small crossed ripples, the groups being alternately emerald and rose-colour.

During the afternoon these cloud sheets kept forming and evaporating in rapid succession, and were succeeded by heavier sheets of alto-cumulus at 18 h. By 16 h. 30 m. the halo of 22° had faded to a much paler tint, showing little colour, but its upper portion now showed a bright colourless arc of contact. At 18 h. the halo of 22° was still faintly visible, and a brilliantly coloured arc of contact to the halo of 46° was also seen, no trace of the halo itself being visible.

G. A. CLARKE.

[Mr. Clarke follows Pernter in calling the last-mentioned arc the arc of contact of the halo of 46°. The arc is frequently seen without the halo of 46°, and the generally accepted theory as given, for example, by Humphreys (Physics of the Air, p. 511) requires that the distance from the sun for the various colours should be greater than in the halo. Moreover, a photograph showing the arc and the 46° halo with a distinct gap between them is reproduced by Benson. (*Ann. Obs. Montsouris.* Paris, 1910. P. 478.) The arc being part of a circle round the zenith, the name "circumzenithal arc" is appropriate. Examinations of this arc with the aid of a theodolite are desirable.—ED. M.M.]

A Mercury Barometer for Airships.

To meet the needs of the large rigid airships a mercury aerial barometer has recently been designed by the Instrument Department, Air Ministry, and constructed by Messrs. Negretti and Zambra. A general view of the lower part of this instrument is shown in the accompanying figure.

The barometer is of the Kew type and is supported on gimbal bearings from a bracket attached to the framework of the airship in such a way that the column may remain vertical with the supporting bracket inclined at 20° to the vertical in any direction. Two dashpots are provided to damp out any swinging of the instrument. These consist of cylinders which are attached to the back of the mercury cistern and carry loosely fitting pistons suspended by ball joints from the supporting bracket; the cylinders are filled with a mixture of glycerine and water.

The mercury column is of large diameter, 0·5 inch, to eliminate the necessity for any correction for capillarity, while to avoid any inaccuracies due to the fact that the pressure in the control car is very rarely static,* the mercury cistern is not directly open to the atmosphere, but is connected to the static tube of a hanging head slung some 30 feet below the ship, and therefore clear of any disturbance due to the passage of the ship through the air. The nipple to which the static head is connected is fixed to the supporting bracket, and a rubber tube leads therefrom to a stopcock on the cistern, thus avoiding any restraint on the swinging of the barometer.

The end of the barometer tube which dips into the mercury in the cistern is nearly closed by a conical plug, the exact position of which may be adjusted by a screw. By use of this device any oscillations of the mercury column may be damped out, or again the column may be restrained in any one position at will for a reading to be made at leisure. Moreover, to facilitate transport of the instrument the column may be pumped down and the plug closed.

The right-hand side of the barometer carries a pressure scale graduated in millibars; the vernier has a coarse adjustment by sliding and a fine adjustment by rack and pinion operated from the knurled knob seen just beneath the gimbal ring.

The left-hand side of the column carries a movable scale showing heights in feet. This scale is graduated according to the usual convention to be correct for all heights when the air pressure is 1013·2 mb. at the zero height and the air temperature is uniformly 50° F. For convenience of use in landing and in other operations the height scale may be adjusted by means of the knurled knob on the left of the column to place its zero opposite any desired pressure. This height scale is intended as a rough guide when quick readings are called for; for accurate estimates of height it is necessary to use the pressure readings in conjunction with temperature observations.

A MEETING of the International Commission for the Exploration of the Upper Air was held at Bergen, on the invitation of Prof. V. Bjerknes, president of the commission, in the week ending July 30th An account of the proceedings will be given in this Magazine next month.

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* The static pressure is the pressure in the free atmosphere at the same level. If a tube with holes in its sides is set in such a way that the air can stream past it without being obstructed, the pressure inside the tube is equal to the static pressure.

Royal Meteorological Society.

It has been arranged to hold a meeting of the Royal Meteorological Society in Edinburgh on Wednesday afternoon, September 7th. Upon the incorporation of the Scottish Meteorological Society with the Royal Meteorological Society early in the present year, it was decided to hold periodical meetings north of the Border in addition to those held regularly in London. The meeting in September is the first of those to be held in Scotland, and the date has been chosen to coincide with that of the British Association Meeting in Edinburgh during the week September 7th–14th. The Meteorological Luncheon which has been held during the British Association Meeting for a number of years past, will this year be open to Fellows of the Royal Meteorological Society as well as to members of the British Association. It has been fixed for Thursday, September 8th. An excursion to Eskdalemuir open to Fellows of the Society has been arranged for Tuesday, September 6th.

British Association Meeting, September 7th–14th 1921.

It is hoped that, during the meeting of the British Association, a Daily Weather Report will be produced in Edinburgh, by the Meteorological Office, on the lines of that at present issued from "Local Centres," and that copies will not only be exhibited to members of the Association, but also distributed to other addresses in Edinburgh.

In this connection, too, it is hoped that it may be possible to arrange for practical demonstrations to be given, showing how anyone equipped with a small wireless receiving set may pick up the synoptic data issued daily at fixed hours by the Meteorological Offices of this and other countries, and so be in a position to construct synoptic charts of the weather over a wide area, shortly after the observations are taken. A number of papers of meteorological interest will be read before section A of the British Association. The collection of meteorological diagrams and photographs arranged for the meeting of the Royal Meteorological Society will be on view throughout the week.

Ball Lighting seen at St. John's Wood.

The following details concerning a "fireball" which she observed during the thunderstorm of June 26th have kindly been given by Mrs. D——, of Circus Road, St. John's Wood.

It will be remembered that the thunderstorm was remarkable for its long duration and for the large area which it covered as well as for light rainfall and slow movement. Mrs. D—— had been watching the storm from her window, which faces south-east, for a long while when, about 2 a.m. (Summer time) she suddenly noticed the fireball. It appeared as an incandescent mass floating in the atmosphere below the clouds. It was pear-shaped, the greatest width being equivalent to three moons, the height to four or five. No estimate of the distance was made; the elevation seems to have been about 35°, the bearing about south-east. The phenomenon lasted for at least two minutes, for Mrs. D—— had time to go to a friend's room and rouse her to see it set before it vanished. The fireball had a slight "to and fro" movement, but did not travel far, whilst it was under observation. There was continuous rumbling of distant thunder at the time, but no special noise which was associated by the observer with the vanishing of the fireball.

Several newspapers have been so good as to insert a notice to the effect that persons who had observed such a phenomenon were requested to communicate with the Meteorological Office. A summary of the reports which have been received will be published in the next issue of this Magazine.

F. J. W. W.

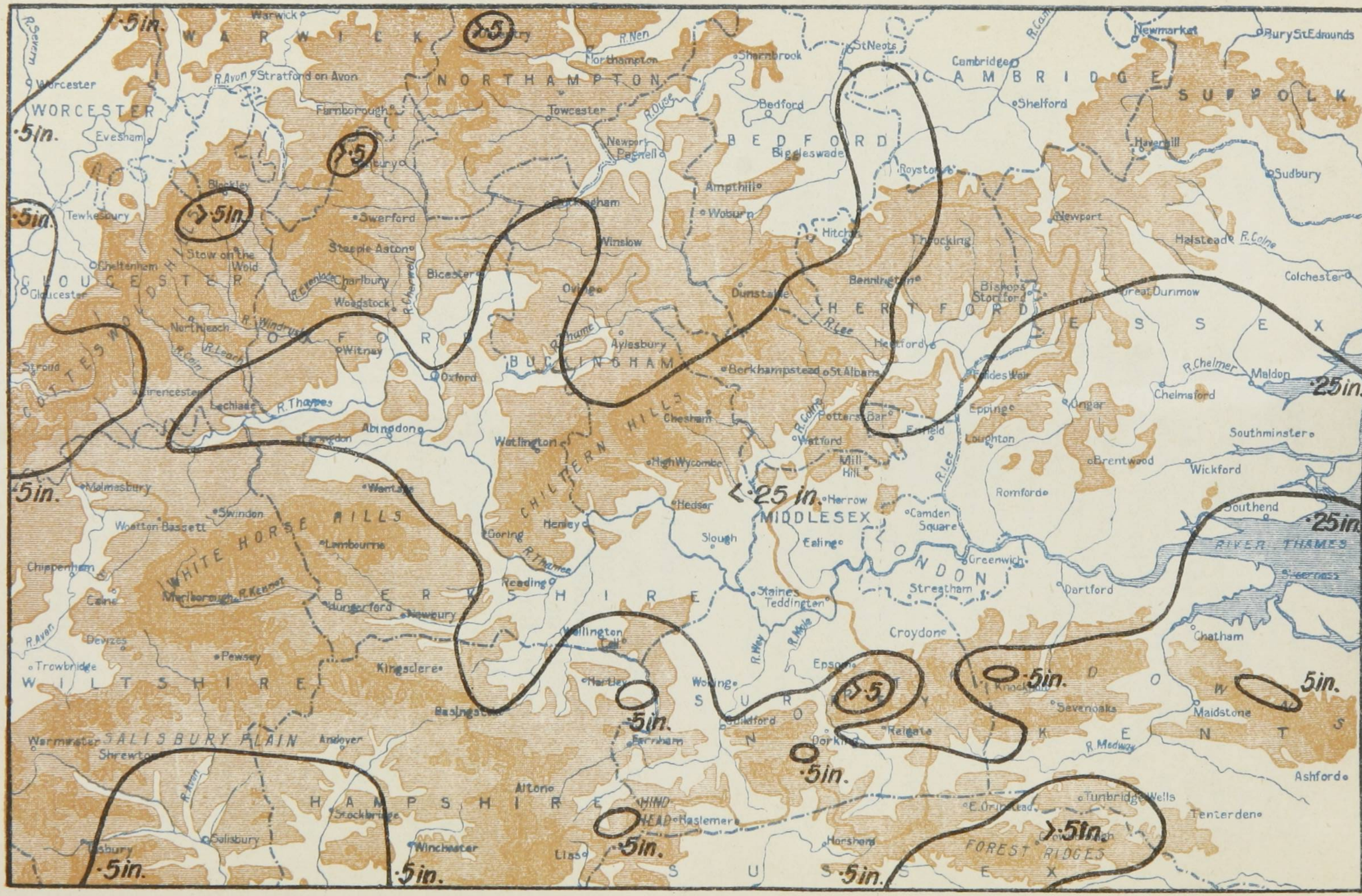
Artificial Rain-making.

DURING the prolonged drought of the past weeks the question as to the possibility of the production of rain by artificial methods has received considerable attention. On July 13th a question was asked in the House of Commons as to whether the Government would be prepared to initiate experiments for the purpose of inducing rainfall. The reply given was to the effect that from past experiments meteorologists were of opinion that explosions would not induce a fall of rain. Unless an explosion could produce a cold current or cause sufficient disturbance in the atmosphere to bring about the thorough mixing of cold and warm layers of air no rainfall could be induced.

On July 12th and shortly after the *Daily Express* conducted various experiments; on two occasions rockets were fired into the air, and on another occasion the clouds were sprayed with liquid air from an aeroplane. No meteorological results could be traced.

Accounts have also been published in the press of rain-making as practised by a Mr. Hatfield in Canada. Mr. Hatfield attempts to "overturn the atmosphere" by chemical fumes, the nature of which are, at present, a secret. It is said that his efforts have been followed by rain, and that he has been paid about £600 for one month's rain-making.

THAMES VALLEY RAINFALL —— JULY, 1921.



Watershed of River Thames above Teddington, and River Lee above Fields Weir.

Isohyetals

ALTITUDE SCALE

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

SCALE OF MILES

0 5 10 15 20

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

Ps.3334/945. Wt. 26. D.P.15. 1250. 8/21.

News in Brief.

At the end of June 1921 Professor F. H. Bigelow retired from the Argentine Meteorological Office after 15 years service. Professor Bigelow made his reputation as a meteorologist in the United States, and during his residence in Argentina he has elaborated a theory designed to unify the sciences of Meteorology, Magnetism and Solar Physics.

It was reported in the press that on July 17th Thetford experienced a fall of 1·50 in. of rain in 20 minutes. Rainfall of this intensity is very unusual. It is now stated, however, that an error had insinuated itself into the report circulated by a news agency.

The actual record was ·80 in. in 30 minutes, the heaviest fall in so short a period recorded at Thetford during 22 years.

The Rede Lecture on "The Air and its Ways," given by Sir Napier Shaw at Cambridge on June 9th, is published in a slightly abridged form in *Nature* of July 21st, 1921.

The Weather of July 1921.

The distribution of pressure over western Europe was anticyclonic for the first three weeks, with dry weather generally. Towards the end of the month Atlantic depressions brought rain to the west and north of the British Isles, and to Scandinavia, but over south-east England, France and Central Europe there was no real break in the drought, in spite of the passage of a deep depression across England on the 29th. Great heat prevailed for the most of the month in England and in west and south-west Europe generally, but in Scotland and in the Scandinavian and Baltic areas conditions were much cooler, though there were a few hot days.

At the beginning of the month the anticyclone was situated between Scotland and Iceland, with north-east winds and dry weather over the British Isles. There was some warm days inland, but the nights were cool, with ground frost locally. Pressure was relatively low over the Baltic and Central Europe, with some local rain. The anticyclone moved south on the 4th, and on the next day lay directly over England, where it persisted without much change of position till the 12th. The weather was fine and became very hot, temperatures reaching 90° F. in parts of England on the 10th and 11th, and reaching 84° F. as far west as Cahirciveen on the 12th. Temperature also reached 84° F. at Aberdeen on the 10th, but

(*Continued on* p. 202.)

Rainfall Table for July 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*	2·38	·13	3	5	·06	29	3
Tenterden (View Town)	*Kent*	2·09	·29	7	14	·23	28	4
Arundel (Patching Farm)	*Sussex*	2·40	·33	8	14	·19	28	4
Fordingbridge (Oaklands)	*Hampshire*	2·00	·58	15	29	·13	17	8
Oxford (Magdalen College)	*Oxfordshire*	2·27	·26	5	8	·08	23	4
Wellingborough (Swanspool)	*Northampton*	2·29	·20	5	9	·10	28	4
Hawkedon Rectory	*Suffolk*	2·44	·40	10	16	·22	6	6
Norwich (Eaton)	*Norfolk*	2·59	·50	13	19	·16	6, 28	5
Launceston (Polapit Tamar)	*Devon*	2·69	1·41	36	52	·97	28	11
Sidmouth (Sidmount)	"	2·51	·48	12	19	·17	28	7
Ross (Chasedale Observatory)	*Herefordshire*	2·25	·49	13	22	·28	25	4
Church Stretton (Wolstaston)	*Shropshire*	2·45	1·15	29	47	·57	25	7
Boston (Black Sluice)	*Lincoln*	2·20	·42	11	19	·14	6	7
Worksop (Hodsock Priory)	*Nottingham*	2·27	·49	12	22	·22	25	7
Mickleover Manor	*Derbyshire*	2·45	·68	17	28	·33	25	6
Southport (Hesketh Park)	*Lancashire*	2·86	1·72	44	60	·52	23	13
Harrogate (Harlow Moor Ob.)	*York, W. R.*	2·69	1·42	36	53	·39	23	11
Hull (Pearson Park)	" *E. R.*	2·34	·59	15	25	·18	25	9
Newcastle (Town Moor)	*North'land*	2·65	1·65	42	62	·44	23	13
Borrowdale (Seathwaite)	*Cumberland*	8·46	6·85	174	81	..	..	..
Cardiff (Ely Pumping Stn.)	*Glamorgan*	3·11	1·00	25	32	·35	25	10
Haverfordwest (Gram. Sch.)	*Pembroke*	3·20	2·29	58	72	1·03	28	9
Aberystwyth (Gogerddan)	*Cardigan*	3·86	1·83	47	47	·67	25	7
Llandudno	*Carnarvon*	2·39	1·51	38	63	·48	28	12
Dumfries (Cargen)	*Kirkcudbt.*	3·24	6·27	159	193	2·27	28	17
Marchmont House	*Berwick*	3·05	2·84	72	93	·65	25	14
Girvan (Pinmore)	*Ayr*	3·65	4·70	119	129	1·09	28	19
Glasgow (Queen's Park)	*Renfrew*	2·92	3·34	85	114	·56	30	15
Islay (Eallabus)	*Argyll*	3·41	3·84	97	113	·72	24	21
Mull (Quinish)	"	4·05	3·99	101	99	·60	24	21
Loch Dhu	*Perth*	4·83	6·00	152	124	2·05	30	14
Dundee (Eastern Necropolis)	*Forfar*	2·74	2·14	54	78	·62	28	12
Braemar (Bank)	*Aberdeen*	2·56	2·29	58	89	·88	28	8
Aberdeen (Cranford)	"	2·96	1·69	43	57	·43	28	11
Gordon Castle	*Moray*	3·20	2·27	58	71	1·22	28	10
Fort William (Atholl Bank)	*Inverness*	4·85	5·71	145	118	·95	21	20
Alness (Ardross Castle)	*Ross*	3·03	2·94	75	97	·95	28	14
Loch Torridon (Bendamph)	"	5·42	4·92	125	91	1·05	21	19
Stornoway	"	3·03	3·21	81	106	·68	27	20
Wick	*Caithness*	2·63	2·42	61	92	·44	21	19
Glanmire (Lota Lodge)	*Cork*	2·90	3·83	67	132	·87	28	10
Killarney (District Asylum)	*Kerry*	3·32	3·80	97	114	1·10	27	15
Waterford (Brook Lodge)	*Waterford*	3·24	4·62	117	143	2·36	28	9
Nenagh (Castle Lough)	*Tipperary*	3·14	3·78	96	120	1·27	28	14
Ennistymon House	*Clare*	3·75	3·72	95	99	·57	22	15
Gorey (Courtown House)	*Wexford*	2·94	3·97	101	135	1·67	27	13
Abbey Leix (Blandsfort)	*Queen's Co.*	3·13	5·41	137	173	2·25	28	13
Dublin (FitzWilliam Square)	*Dublin*	2·56	4·24	108	166	1·50	27	13
Mullingar (Belvedere)	*Westmeath*	3·18	3·78	96	119	·96	28	13
Woodlawn	*Galway*	3·48	4·00	102	115	·90	28	16
Crossmolina (Enniscoe)	*Mayo*	3·64	3·48	88	96	·68	24	16
Collooney (Markree Obsy.)	*Sligo*	3·44	5·13	130	149	1·10	30	19
Seaforde	*Down*	3·19	4·78	121	150	1·97	28	16
Ballymena (Harryville)	*Antrim*	3·43	4·63	118	135	·79	30	17
Omagh (Edenfel)	*Tyrone*	3·40	4·28	109	126	·80	24	15

Supplementary Rainfall, July 1921.

Div.	STATION.	RAIN. in.	RAIN. mm.
II.	Ramsgate	·12	3
„	Sevenoaks, Speldhurst	·29	7
„	Hailsham Vicarage	·43	11
„	Totland Bay, Aston	·47	12
„	Ashley, Old Manor Ho.	·68	17
„	Grayshott	·51	13
„	Ufton Nervet	·18	5
III.	Harrow Weald, Hill Ho.	·15	4
„	Pitsford, Sedgebrook	·27	7
„	Chatteris, The Priory	·16	4
IV.	Elsenham, Gaunts End	·26	7
„	Lexden, Hill House	·26	7
„	Aylsham, Rippon Hall	·40	10
„	Swaffham	1·75	44
V.	Devizes, Highclere	·42	11
„	Weymouth	·28	7
„	Ashburton, Druid Ho.	·92	23
„	Cullompton	·74	19
„	Hartland Abbey	·89	23
„	St. Austell, Trevarna	1·45	37
„	North Cadbury Rec.	·71	18
„	Cutcombe, Wheddon Cr.	1·47	37
VI.	Clifton, Stoke Bishop	·87	22
„	Ledbury, Underdown	·40	10
„	Shifnal, Hatton Grange	·78	20
„	Ashbourne, Mayfield	·94	24
„	Barnt Green, Upwood	·55	14
„	Blockley, Upton Wold	·56	14
VII.	Grantham, Saltersford	·29	7
„	Louth, Westgate	·30	8
„	Mansfield, West Bank	·60	15
VIII.	Nantwich, Dorfold Hall	·64	16
„	Bolton, Queen's Park	1·59	41
„	Lancaster, Strathspey	1·52	39
IX.	Rotherham		
„	Bradford, Lister Park	1·49	38
„	West Witton	3·06	78
„	Scarborough, Scalby	1·63	41
„	Middlesbro', Albert Pk.	1·66	42
„	Mickleton	1·40	36
X.	Bellingham	2·61	66
„	Ilderton, Lilburn	2·65	67
„	Orton	3·71	94
XI.	Llanfrechfa Grange	·97	25
„	Treherbert, Tyn-y-waun	5·14	131
„	Carmarthen Friary	2·94	75
„	Llanwrda, Dolaucothy	3·52	89
„	Lampeter, Falcondale	2·43	62
„	Cray Station	5·80	147
„	B'ham W.W., Tyrmyndd	2·33	59
„	Lake Vyrnwy	3·25	83
„	Llangynhafal, P. Drâw	2·10	53
„	Oakley Quarries	7·71	196
„	Dolgelly, Bryntirion	2·59	66
„	Lligwy	2·08	53
XII.	Stoneykirk, Ardwell Ho.	4·20	107
„	Carsphairn, Shiel	6·38	162
XII.	Langholm, Drove Rd.	4·97	126
XIII.	Ettrick Manse	4·62	117
„	North Berwick Res.	2·19	56
„	Edinburgh, Royal Ob.	2·21	56
XIV.	Biggar	3·17	81
„	Leadhills	6·42	163
„	Maybole, Knockdon	4·74	120
XV.	Dougarie Lodge	3·93	100
„	Inveraray Castle	4·19	106
„	Holy Loch, Ardnadam	7·31	186
XVI.	Loch Venachar	4·60	117
„	Glenquey Reservoir	4·20	107
„	Loch Rannoch, Dall	2·46	63
„	Trinafour	3·05	77
„	Blair Atholl	2·68	68
„	Coupar Angus	2·18	55
„	Montrose Asylum	1·83	47
XVII.	Logie Coldstone, Loanh'd	1·91	49
„	Fyvie Castle	1·69	43
„	Grantown-on-Spey	2·25	57
XVIII.	Cluny Castle	2·67	68
„	Loch Quoich, Loan	..	..
„	Fortrose	2·37	60
„	Faire-na Squir	4·30	109
„	Skye, Dunvegan	3·39	86
„	Glencarron Lodge	..	..
„	Dunrobin Castle	2·38	61
XIX.	Tongue Manse	2·55	65
„	Melvich Schoolhouse	2·15	55
„	Loch More, Achfary	6·43	163
XX.	Dunmanway Rectory	5·36	136
„	Mitchelstown Castle	3·86	98
„	Gearahameen	6·90	175
„	Darrynane Abbey	3·96	101
„	Clonmel, Bruce Villa	4·85	123
„	Cashel, Ballinamona	5·26	134
„	Roscrea, Timoney Pk.	4·91	125
„	Foynes	4·31	109
„	Broadford, Hurdlesto'n	4·32	110
XXI.	Kilkenny Castle	3·60	91
„	Rathnew, Clonmannon	4·79	122
„	Hacketstown Rectory	2·93	74
„	Balbriggan, Ardgillan	4·05	103
„	Drogheda	4·03	102
„	Athlone, Twyford	3·71	94
XXII.	Castle Forbes Gdns.	3·87	98
„	Ballynahinch Castle	4·00	102
„	Galway Grammar Sch.	3·93	100
XXIII.	Westport House	2·51	64
„	Enniskillen, Portora	4·83	123
„	Armagh Observatory	3·64	93
„	Warrenpoint	3·79	96
„	Belfast, Cave Hill Rd.	3·64	93
„	Glenarm Castle	3·26	83
„	Londonderry, Creggan	3·55	90
„	Sion Mills	3·78	96
„	Milford, The Manse	2·59	66
„	Narin, Kiltoorish	3·41	87
„	Killybegs, Rockmount	4·34	110

Climatological Table for the

STATIONS	PRESSURE		TEMPERATURE							
			Absolute				Mean Values			
	Mean of Day 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	1026·0	+10·3	59	23, 24	28	3	47·1	36·1	41·6	+1·5
Gibraltar	1017·9	−0·9	65	24	42	8	59·1	50·0	54·6	−1·3
Malta	1017·9	+2·9	64	7	44	2	58·7	51·4	55·1	+0·8
Sierra Leone	1011·1	+0·1	97	17	70	14	91·1	73·0	82·1	−0·2
Lagos, Nigeria	1010·9	+0·8	91	25	68	4	82·8	77·3	80·1	−2·0
Kaduna, Nigeria	1013·2	+4·0	98	24	56	4	93·7	60·0	76·9	−1·3
Zomba, Nyasaland	1007·4	−0·4	85	5, 20	62	13	81·9	65·5	73·7	+2·0
Salisbury, Rhodesia	1007·4	−2·5	88	4	57	1, 22	81·4	61·6	71·5	+2·6
Cape Town	1011·4	−2·0	100	24	52	5	82·5	63·1	72·8	+2·8
Johannesburg	1011·6	+0·4	83	6	47	24	74·9	55·4	65·1	−0·3
Mauritius	..	..	..	..	..	..	..	..	..	..
Bloemfontein	..	..	90	2	49	5	80·4	59·6	70·0	−1·9
Calcutta, Alipore Obsy.	1011·8	−1·5	92	28	52	11	83·3	61·3	72·3	+1·3
Bombay	1011·4	−1·2	96	16	64	6	84·4	68·8	76·6	+1·0
Madras	1011·9	−0·9	94	28	63	11	86·3	66·7	76·5	−1·2
Colombo, Ceylon	1010·8	+0·2	93	11	66	22	87·2	69·9	78·5	−2·1
Hong Kong	1018·2	−0·6	78	28	44	4	64·8	55·9	60·3	+1·2
Sydney	1017·9	+3·9	90	26	60	5	78·7	65·1	71·9	+0·8
Melbourne	1017·7	+3·4	102	1	53	8	81·2	61·3	71·3	+3·9
Adelaide	1016·2	+1·9	108	12	54	4, 18	89·0	65·4	77·2	+3·1
Perth, Western Australia	1010·7	−2·3	106	6, 8	56	1	92·7	70·1	81·4	+7·4
Coolgardie	1011·5	−1·0	108	10	58	2	95·7	65·8	80·7	+4·7
Brisbane	1016·6	+4·5	93	5	65	10	84·1	67·6	75·9	−0·6
Hobart, Tasmania	1019·3	+6·0	84	12	47	7	71·0	55·3	63·1	+0·8
Wellington, N.Z.	1018·1	+2·8	77	16	42	13	69·5	54·5	62·0	−0·4
Suva, Fiji	1009·3	+1·6	90	9, 11	70	23	87·0	74·4	80·7	+0·2
Kingston, Jamaica	1015·3	−0·4	90	26	67	sev.	86·4	68·5	77·5	+1·0
Grenada, W.I.	..	..	..	..	..	..	..	..	..	..
Toronto	1018·2	+0·2	53	16	7	24	35·4	21·6	28·5	+6·8
Winnipeg	1015·9	−5·9	40	27	26	19	19·8	2·2	11·0	+11·6
St. John, N.B.	1017·0	+2·9	46	17	−5	1	29·8	12·3	21·1	+1·2
Victoria, B.C.	1018·1	+2·2	55	10	27	16	45·6	37·3	41·5	+1·2

LONDON, KEW OBSERVATORY.—Mean speed of wind 6·5 mi/hr ; 10 days of fog.
GIBRALTAR.—4 days with hail, 4 days with thunder heard, 6 days with gale.
MALTA.—Prevailing wind direction NWly ; mean speed 9·3 mi/hr.
SIERRA LEONE.—Prevailing wind direction SW.

British Empire, February 1921.

TEMPERATURE Absolute Max. in Sun °F.	TEMPERATURE Absolute Min. on Grass °F.	Relative Humidity %	Mean Cloud Am'nt 0–10	PRECIPITATION Amount in.	PRECIPITATION Amount mm.	PRECIPITATION Diff. from Normal mm.	PRECIPITATION Days	BRIGHT SUNSHINE Hours per day	BRIGHT SUNSHINE Percentage of possible	STATIONS
102	19	80	7·3	0·19	5	− 34	2	1·9	20	London, Kew Observatory.
117	33	81	6·8	15·08	383	+276	19	..	..	Gibraltar.
124	..	84	6·0	1·13	29	− 22	11	4·5	42	Malta.
..	..	67	3·3	0·00	0	− 7	0	..	..	Sierra Leone.
158	64	86	7·3	0·02	1	− 50	1	..	..	Lagos, Nigeria.
..	..	30	..	0·00	0	− 5	0	..	..	Kaduna, Nigeria.
..	..	92	8·2	12·26	311	+ 35	21	..	..	Zomba, Nyasaland.
154	56	73	7·5	10·60	269	+ 87	15	..	..	Salisbury, Rhodesia.
..	..	64	4·8	1·36	35	+ 20	8	..	..	Cape Town.
..	46	77	6·3	2·63	67	− 63	12	7·7	59	Johannesburg.
..	..	..	..	..	..	..	..	..	..	Mauritius.
..	..	64	4·6	6·62	168	+ 80	10	..	..	Bloemfontein.
..	43	47	0·9	0·49	12	− 17	2	..	..	Calcutta, Alipore Obsy.
138	57	62	0·5	0·00	0	− 1	0	..	..	Bombay.
..	..	82	1·6	0·00	0	− 8	0	..	..	Madras.
165	56	63	4·4	0·19	5	− 48	1	..	..	Colombo, Ceylon.
..	..	68	4·6	1·04	26	− 17	1	7·7	68	Hong Kong.
145	53	68	5·2	0·93	24	− 91	9	8·0	60	Sydney.
153	45	85	4·7	1·50	38	− 5	9	..	..	Melbourne.
169	41	42	3·4	0·55	14	− 2	5	9·0	68	Adelaide.
166	51	47	3·4	1·55	39	+ 28	2	..	..	Perth, Western Australia.
175	..	31	3·6	0·00	0	− 19	0	..	..	Coolgardie.
155	61	63	5·5	1·07	27	−141	10	..	..	Brisbane.
153	40	66	5·9	1·08	27	− 10	11	8·0	58	Hobart, Tasmania.
144	27	69	5·4	0·72	18	− 65	4	8·2	60	Wellington, N.Z.
..	..	83	5·1	11·38	289	+ 32	23	..	..	Suva, Fiji.
..	..	74	6·0	0·56	14	− 1	6	..	..	Kingston, Jamaica.
..	..	..	..	..	..	..	..	..	..	Grenada, W.I.
102	5	66	1·2	1·35	34	− 32	10	..	..	Toronto.
..	..	93	6·0	2·52	64	+ 44	9	..	..	Winnipeg.
123	5	56	5·7	3·08	78	− 21	13	..	..	St. John, N.B.
105	23	87	7·6	4·28	109	+ 19	19	..	..	Victoria, B.C.

COLOMBO, CEYLON.—Prevailing wind direction N.; mean speed 5·0 mi/hr.
HONG KONG.—Prevailing wind direction ENE.; mean speed 13·0 mi/hr.
MELBOURNE.- Highest pressure for February for 64 years.
SUVA, FIJI.—10 days with thunder heard.

a cooler current then spread over Scotland from the north-west. Temperature exceeded 90° F. at many Continental stations, reaching 99° F. at Dijon and Strasbourg on the 12th. Scandinavia was affected by depressions, and there were 35 mm. of rain at Stockholm on the 12th.

After the 12th the anticyclone moved away slowly north-eastward, and a large depression on the Atlantic moved slowly east, so that a south-easterly type of weather set in over the British Isles. Temperature remained high in the south, but with an increase of cloud the heat was less intense. Scotland and the east coast of England were under the influence of a cool current which came round the anticyclone.

Between the 14th and 17th rain fell at a number of stations in the west and north of the British Isles, mostly in small amounts, and thunder occurred locally. During a thunderstorm at Holyhead on the 15th there were 16 mm. of rain in 18 minutes. There were also local thunderstorms at a very few stations in the east and south-east of England. Thunderstorms were rather numerous and severe in France at about this time, Biarritz having 31 mm. of rain on the 15th, and Belfort 15 mm. on this date and 65 mm. on the 17th.

The depression over the Atlantic dispersed on the 17th, and the anticyclone spread back from Scandinavia over the British Isles. The weather became fine and very hot again over England, the thermometer touching 90° F. locally on the 19th and not falling below 69° F. on the following night at Kensington Palace, or below 67° at Portland Bill.

A new anticyclone spread up from the Azores to south-west Ireland on the 20th, and then moved south to the Bay of Biscay region, a westerly type of weather being established. Depressions moving east or north-east on the Atlantic brought rain and strong winds to the west and north of the British Isles and Scandinavia, but in the south of England the weather remained dry and warm, while in France intense heat continued, culminating on the 27th and 28th. On the first of these dates temperature reached 102° F. at Strasbourg and 101° F. at Toulouse, and on the following day it reached 104° F. at Strasbourg, 102° F. at Belfort, and 101° F. at Paris. Temperature also reached 101° F. at Breslau and Prague on the 29th. At some stations in the south of France the thermometer remained above 70° F. for several successive nights.

During the night of the 28th and morning of the 29th a deep depression moved north-eastward over England and caused a gale in the English Channel. There was little rain in south-east England, and practically none in France, but there was a considerable fall over a large area in the west and north of the British Isles. Holyhead had 47 mm. during the night of the 28th, and Baldonnel (Dublin) had 63 mm. during the 36 hours ending 7 a.m. on the 29th. Another depression followed, but moved north-east outside the Hebrides, the rain being again limited to the west and north.

After a cooler day on the 29th, temperature became high again over France at the end of the month, and over Central Europe the heat continued without interruption.

Fog was experienced rather frequently on our western coasts, but otherwise visibility was good over the British Isles. C. K. M. D.

At the beginning of the month thunderstorms, with violent rain, occurred in central and southern France, Toulouse being partially flooded. There was a temporary break in the drought in northern France and Belgium a fortnight later, but hot weather quickly reasserted itself. Forest fires were numerous in the Fontainebleau and other districts, and on the 28th a strong hot wind blew over Paris for several hours, with a cloudless sky.

Extensive forest and moorland fires have also occurred in Norway, Denmark, and Germany, where dry hot weather has been of long standing. The shade temperature at Geneva on the 28th was the highest recorded since 1870, and is said to have exceeded 100° F. The second half of the month was extremely hot in Rome. The whole of central and southern Russia can produce no appreciable harvest on account of the very severe drought, so that a famine of unparalleled severity threatens the entire country this winter.

A message to the *Times*, dated July 22nd, states that the heat in Irak has surpassed all previous experience since the British landing in 1914. A shade temperature of 128·9° F. is said to have been reached on the 16th, with an average maximum shade temperature for a fortnight of over 124° F. Authenticated records will be awaited with interest. Conditions have been almost unendurable in the Persian Gulf.

Periodical heat spells have been occurring in New York and in the whole middle section of the United States east of the Rocky Mountains. They are accompanied by high humidity of an almost unprecedented character. The cotton-growing districts, however, have had too much rain, and require hot dry weather to ensure even a small crop.

Excessive heat was being experienced in eastern Canada at the beginning of the month. There has been no such long period of intense hot weather in the history of Ontario. Enough rain fell later to reduce the forest fires considerably and to improve the crops, but more rain is needed.

Early in the month complete drought prevailed in northern Bombay, Rajputana, and north-west India, but fears of possible famine were subsequently dispelled by good rainfall lasting for a week.

Heavy gales and fierce rainstorms have swept New South Wales from Sydney northwards to the Queensland border, followed by disastrous floods in the coastal rivers. Much damage has been caused over a wide area. In southern Australia the winter has been dry and unusually mild.

The remarkable deficiency in the rainfall of the spring months continued throughout July over England and Wales. Extensive areas in the midland and southern counties had less than 20 per cent. of the average fall. Scotland had less than the average in the east and in some western districts, but there was an excess in the Highlands and in some southern counties. Rather more than the average fell over Ireland generally. The total amount was less than 1·00 in. to the east of a line from Plymouth to Hull and less than ·25 inch fell over a large part of the Thames Valley and Estuary. The fall increased to about 7·00 in. in the wettest parts of the Welsh mountains and the English Lake District. In Scotland it ranged from less than 2·00 in. along the east coast and rather more in the north and west to 8·00 in. at mountain stations in Perthshire and Inverness-shire. More than 2·00 in. fell everywhere in Ireland, and 5·00 was exceeded in parts of Leinster and Munster, where heavy thunderstorms occurred towards the close of the month. In a storm on the 28th more than 2·00 in. fell at several stations, and at Tramore (Co. Waterford) 3·97 in. was measured.

The general rainfall for July, expressed as a percentage of the average, was:—England and Wales, 40; Scotland, 105; Ireland, 130; British Isles, 86.

In London (Camden Square) the month was remarkable for brilliant sunshine, excessive warmth and deficient rainfall. The mean temperature, 69·4° F., was 6·0° above the average and the highest for any month in the 64 years' record. The rainfall was the least for any July in the same period, the nearest approach being ·45 inch in July 1868. Duration of rainfall, 3·3 hours. Evaporation, 4·17 in.
