SYMONS'S

MONTHLY

# METEOROLOGICAL MAGAZINE.

CCCCXIV.] JULY, 1900. [PRICE FOURPENCE, or 5s. per ann. post free.

## INDIAN FAMINE-CAUSING DROUGHTS AND THEIR PREVISION.

*Continued from page* 69.

With regard to yearly anomalies in the monsoons and their rainfall, it appears to be a common delusion amongst those who are unacquainted with India, to imagine them to be extremely regular both as to date of arrival and character, thus rendering their prediction a comparatively simple matter. This however, is far from being the case. Even taking India as a whole, the marked date of the burst of the S.W. monsoon varies occasionally as much as from three weeks to 30 days, while the total annual rainfall of the entire Indian area has varied from 6½ inches deficiency in 1868, to 9 inches excess in 1893. Concentrated in one spot this latter surplus would amount to 211 cubic miles of water. Let me give an illustration by which it may be brought home to the imagination. Suppose a gigantic hose-pipe half an acre in section to stretch from the earth to the moon and to be filled with water. This water would barely represent the excess of 9 inches rainfall spread over the Indian area, while if it were required to irrigate India by the hose-pipe so as to allow the water poured out to amount to the given excess at the end of the six months of the S.W. monsoon, it would have to be continuously projected from the hose with the enormous velocity of 55 miles per hour. Such variations of water supply can hardly be regarded as an insignificant variation from the annual average. It has moreover been established by the late Mr. Blanford, that while the average rainfall variation over the whole area is not more than from 15 to 20 per cent., the rainfall is most variable when it is smallest in amount and most regular and steady when it is greatest; so that, in certain regions, variations frequently occur of several hundred per cent., leading to disastrous floods or droughts, especially in the dry zone.

Prevision of such anomalies in time to warn the local governments and agriculturists of impending unfavourable seasons and possible scarcity and famine, through either drought or flood, is the principal aim of the Indian seasonal forecsats.

The method began under Mr. Blanford by the recognition of certain contrasts and sequences between the rainfall of the summer and winter seasons, and in particular the snowfall on the Himalaya and the character of the subsequent summer monsoon over the neighbouring plains. This was found to be inverse, so that a heavy snowfall, especially if it lasted well into the spring months, argued a deficient or retarded monsoon.

Though this factor is now found to be subordinate to the absolute strength of the monsoon current, it still forms one of the four main conditions from which the extension and character of the S.W. monsoon is inferred. The others are—

(2). The local peculiarities of the weather during the months immediately preceding the arrival of the monsoon, and which are best indicated by local variations of monthly barometric pressure from the normal.

(3). The absolute force of the south-east trade wind in the south Indian Ocean before it breaks through the belt of equatorial calms and appears in the Indian seas as a S.W. monsoon wind, and which at present can only be determined from the logs of ships traversing the Indian Ocean or by cable from the Seychelles and Mauritius.

(4). The occurrence of long-period waves of barometric pressure (variations from the normal for the whole area), and in particular whether the wave is rising or falling. If rising, the probability is that the monsoon will be deficient; if falling, that it will be strong and rainy.

The second of these conditions used to be considered the only one which determined the monsoons, but is now found to be chiefly useful in determining the local character and irregularities of the monsoonal rains; in other words, the pressure differences act much as the inequalities in a mould into which molten metal is poured, in determining its flow and aggregation.

While the general troughs and ridges of pressure alter considerably from year to year, they always tend to preserve their initial type all through the monsoon period. Besides these, certain local sinks or barometric hollows which are associated with locally heavy downpours, appear to persist or recur several years in succession in the same locality.

A knowledge of the two last conditions, (3) and (4), is now recognised as displacing that of every other condition in point of primary importance in determining the strength and character of the S W. monsoon current.

The first two conditions are now chiefly used in determining the local behaviour and limits of the current when it has once developed over the Indian area; and since such behaviour is considerably modified by the strength of the current itself, their rôle is obviously subordinate to that of any means by which the strength of the current may be forecasted shortly before it invades the Indian land area.

As yet, (3) cannot be directly determined by any rational method of scientific deduction. Recent investigations, however, by the aid of the ample data which is now collected at the Indian ports from ships traversing the Indian Ocean, and embodied in a series of monsoon charts, show that during the prevalence of the S.W. monsoon, the equatorial calm belt—(where according to the old text-book theory the N.E. and S.E. trade winds were supposed to meet, rise, and after discharging their surplus burden of humidity in torrential rains, fall back as upper currents towards the poles)—ceases to exist, and the south-east trade wind, finding its upward escape closed, like a torrent of lava breaks down the wall of opposing weaker N.E. winds, and after a preliminary burst in the first week of June, settles down into quiet possession of the Indian land area. Impelled thither quite as much by a *vis a tergo* as a *vis a fronte,* and forming part of the general summer circulation of the North-Eastern quarto-sphere, it is impossible at present to trace how far variations in this current are due to southern oceanic or northern land conditions. Early information, however, of its strength and reliance on the principle of persistence, are found to give very fairly reliable results. At the same time, an extension of the means of determining the causes and character of the particular type of circulation present in different years, by closer connection with Mauritius and West Australian stations on the one hand, and with central Siberian on the other, is a desideratum of the highest importance.

The last principle is regarded by several leading scientists as supplying the hitherto much desired "open sesame" to long-period prediction, not merely within the Tropics but elsewhere. As a matter of fact, it has been found that the pressure over the entire Indian area is subject to a series of oscillations (or waves) above and below the average, varying in length from 6 to 24 months, and usually some multiple of the half-year. Twelve of these occurred over India during the past 20 years, and by comparison it has been found that when the wave of pressure is rising during the monsoon period, the rainfall is in defect and *vice versâ.*

By a glance, therefore, at the slope of the pressure anomaly curve, which can be plotted out month by month, it is possible to read the symptoms of the coming monsoon with far greater accuracy than the day's weather in these islands can be prevised by tapping the hall-barometer.

As Mr. Eliot says, these waves are due to variations (checks or accelerations) in the seasonal mass transfer of air across the Equator between Southern Asia and the Indian Ocean, and a proof of this is to be found in the remarkable fact that as a general rule they are found equally marked but *reversed in phase* at Mauritius.

Moreover, these waves are not merely useful in deciding the character of the summer monsoon, but are equally closely connected with the presence or absence of those valuable, if scanty, rains which drop from the upper S.W. current more or less every year in

Northern India, in the winter months between November and March, when the N.E. monsoon—so-called—prevails near the surface.

The relation between the pressure anomaly curve and the winter rains is, curiously enough, precisely the reverse of that which obtains during the summer monsoon, a rising curve being associated with heavy, and a falling curve with light rains.

It would be unnecessary to enter into the reason for this, which is fairly obvious to the student of Indian meteorology. Empirical though it is at present in form, the fact is exceedingly valuable in relation to the prevision of the highly important winter rains and rabi crop of Northern India, upon the success or failure of which the question of famine in that area so often hinges.

Apart from these six monthly barometric waves, there is little doubt that certain influences are at work in the atmospheric circulation over the Indian area which co-operate with other periodic factors in tending to cause excess or defect of rains at intervals of from 9 to 12 years. What these influences exactly are it is difficult to say. To some extent they appear to be associated, as we have above noticed, with the eleven year period of sunspots; and certain irregularities in the parallelism of the two phenomena are, in my opinion, no argument against their covariancy and even casual connection, since the North and South Indian areas are at some seasons meteorologically distinct. So far as the facts go, they may be summarised as follows :—

(1). Extensive droughts occur in the dry area of Southern India, embracing in particular Northern Mysore, South Deccan, South-West Hyderabad, but occasionally reaching Guzerat and parts of the Bombay and Madras Presidencies, at intervals of 9 to 12 years and usually, but not regularly, about a year before the sunspot minimum. When the conditions are sufficiently acute, famine occurs in the ensuing year.

(2). A severe drought in the Peninsular of Southern India is followed by a severe drought and ensuing famine in Northern India in about 5 cases out of 7.

This sequence is attributed by Mr. Eliot to the empirical law of opposition in the seasonal rainfalls of Northern India and in the general monsoon conditions of Northern and Southern India.

Thus a drought and high barometric pressure in Southern India usually coincides with low pressure and heavy summer monsoon in Northern India. This latter tends to be followed by a heavy winter rainfall and this again by the compensatory law, first discovered by Prof. Hill and the writer in 1877, by subsequent deficient summer rainfall in Northern India.

(3). Besides these, summer droughts tend to occur in Northern India alone, in years of maximum sunspot, connected in some way with the abnormal high pressure over Western Asia which prevails at such epochs.

There is thus a double periodicity of drought and famine in North

India and a single periodicity in South India in the sunspot cycle, though the relation between the phenomena is too spasmodic and irregular to be utilised as a reliable factor for prevision.

Bruckner's empirical cycle of 35 years, whatever its cause, undoubtedly exists in the Indian area. Under the title of the "Grand cycle" it has long been known in Ceylon, and it is quite possible that the present famine which, from its area and the immense number (six million) of people who are still on relief works appears to be the greatest famine of which we have any record, may be the aggregate effect of the simultaneous occurrence of a Bruckner with a sunspot cycle drought.

The problem is similar to that of the combinations of harmonic undulations which cause unusual tides and its solution and application to prevision can only be effected by systematic study of the billows and ripples which appear in the long and short records of barometric pressure over wide areas and for many years.

DOUGLAS ARCHIBALD.

[The official forecast of the Meteorological Reporter to the Government of India has reached us, as we go to press, and we are glad to report that the probabilities are favourable to a normal rainfall in the coming monsoon.—ED. *M.M.*]

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## METEOROLOGICAL EXTREMES.—III. WIND FORCE.

*To the Editor of the Meteorological Magazine.*

SIR,—I do not think at the present time that we have reliable data on which to found an estimate of the extreme force of the wind, since there are very few instruments in use that are capable of showing either the extreme pressure or the extreme velocity. In many ways with regard to self-recording meteorological instruments we are in the condition with which the Chinese are credited with respect to roast pork. It is said that a Chinaman's house, in which a pig chanced to be shut up, caught fire and was burnt down. After the accident the neighbours ate and enjoyed what was left of the pig, and roast pig came into favour as an article of diet, but it remained a very expensive luxury, since the method of roasting one pig involved the loss of a house, and even then it was only parts that were cooked to the right extent. We are not in a position to laugh at the Chinese, for our photographic curves of temperature and barometric pressure are about as expensive and unnecessary as their fabled method of roasting pork. Still we do at least get a correct record of the temperature and barometric pressure; a statement, unfortunately, which cannot be made with regard to the wind.

The Robinson anemometer is a most convenient instrument, and when it is properly exposed, kept properly oiled, and the right factor is used, gives a very reliable record; but how very rare it is to find these conditions fulfilled.

The trace of the recording instrument, as you point out, is coarse and blurred, but that is simply because we prefer to have it so. An instrument giving a fine trace on common instead of on metallic paper could easily be obtained. It would cost less to make and to keep up, and would enable us to get velocities for short periods, but doubtless that same inscrutable reason which leads to the publication of records known to be incorrect by at least 25 per cent. is also efficacious in preventing the use of an improved method of registration. It is simply a case of the Chinese method of roasting pork.

However, with the best possible practical system of registration the Robinson anemometer is incapable of giving the extreme velocities that last for less than a minute or so, and although the tube anemometer can show better results, its values for the maximum velocity are certainly unreliable. In my opinion, no instrument that is free to oscillate can possibly give a reliable maximum. Observational results have shown (*Quarterly Journal Royal Met. Soc.*, July, 1894, page 180) that altering the weight only of a pressure plate will alter by some 50, or even 100, per cent. its record of maximum pressure, and that generally the heavier, but sometimes the lighter, plate will record the greater value. It is plain, under these circumstances, that we cannot depend upon any oscillating plate, for if we constructed one of such a weight that it recorded some gusts correctly, it would be incorrect for others.

There are now a few pressure plates constructed to give a record of the maximum pressure only, but as yet no gale of exceptional severity has passed over them. From the records of these instruments, and also from that of the Bridled Anemometer at Holyhead, I am of opinion that a pressure exceeding 30 lbs. per square foot, or a velocity exceeding 100 miles per hour, is extremely rare in the British Isles. The recorded mean velocity of 75 miles per hour (true) at Fleetwood would lead to the conclusion that 100 miles per hour must have been considerably exceeded in the gusts, but I am inclined to think the very high velocities that occur at this station are due to some peculiarity of the exposure.

There can be no doubt that far greater pressures occur in the American tornadoes. In them, however, much of the destructive effect is due to the sudden diminution of barometric pressure, and the well-known instance of the straw driven into the bark of a tree was probably due to the bark opening to allow an exit for air, or vapour from the sap, underneath, and then closing again on the straw.—Yours truly.

W. H. DINES.

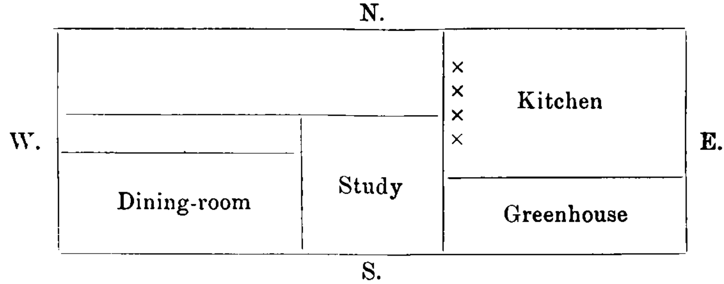
*June 29th, 1900.*

## THUNDERSTORMS OF JUNE 11TH & 13TH, 1900.

*To the Editor of the Meteorological Magazine.*

SIR,—My house was struck by lightning on the 11th June, at 10.30 p.m. The marvellous way in which it passed through and all round the house, and yet spared us all, I cannot understand.

The sides of the house face the cardinal points of the compass, and the main building consists of three floors, but the kitchen is built out on the E. side, and has no rooms over it.




At the E. side of the main house there is a stack of four chimneys. The three northern flues were struck, the northernmost pot being smashed and scattered in every direction, but mostly to N.W. The house roof was stripped, a hole being made in it N.W. of the stack large enough to put a cart body through. Many of the slates were blown to pieces and bore marks of fire; they were scattered all over the garden. Part of the charge at this level apparently made its way to the rain-water pipe, and descended to the tank in the yard, the flag of which was broken, and a piece cut out of the underside; it then passed on from the tank up to the pump and split the trough.

On the floor beneath, the lightning burst from the chimney stack northward and westward through the E. and S. walls of the N. bedroom, leaving holes—some the size of a finger—into the centre of the wall and sending pieces of plaster to the far end of the room. It also burst from the chimney eastwards through the roof of the kitchen, making again a hole big enough to put a cart body through. It also passed across to the S.E. corner of the kitchen roof, where it made a hole under the slates, and apparently passed to earth down the N.E. corner of the greenhouse; it also passed along an iron bar in the E. end of the greenhouse, burning a place the size of a penny at each end of it, and knocking off plaster outside at the same spots.

I was sitting not far from the fireplace in the study, which is at the S E. corner of the house, its chimney being the third flue of the stack already referred to. The report was as loud as a cannon, and the effect was like a violent blow at the back of the head and neck and between the shoulders. The current passed across the room in a westerly direction—leaving a track of soot—to the bell wires in the passage, and was seen to pass the dining-room door as a flame; at the entrance it made a hole through the wall to the verandah, throwing plaster 10 yards into the garden; it also blew out the bell handle in the dining-room, and tore off bits of paper. It seems to have passed down the irons of the verandah roof and to earth by the pillars, killing plants trained up them. Two servants in the second floor bedroom over the study were knocked down, and one of them was stiff all down one side; fortunately, there is no chimney to their room.—Yours truly, R. ELMHIRST.

*Farnham Lodge, Knaresborough, June 28th, 1900.*

On the same day (June 11th) thunderstorms were general over the midlands, and the north of England, and in the press it was reported that buildings were struck by lightning at Swindon, Birmingham, Leicester, Melton Mowbray, Sheffield and Seaham Harbour, several chimneys being thrown down. At Kirkby Stephen the church tower was struck; while at the Yorkshire Yeomanry Camp, at Harrogate, the officer in command, Colonel Heywood Jones, was killed. He was not many yards from the officers' ante-room, and was carrying an open umbrella.

Heavy hail was reported from many places. The observer at Hoar Cross states that the hailstones weighed 6 to the lb. In the Northampton district much damage was done to glass; and at Ashby-de-la-Zouch windows were broken; at Market Harborough the hail is said to have been as large as walnuts, in East Durham the size of marbles, and at Leicester as large as filberts.

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*To the Editor of the Meteorological Magazine.*

SIR,—A thunderstorm passed over this village on Wednesday, June 13th. The lightning was exceptionally vivid and blue, the thunder of a sharp, crackling character. At the height of the storm, at 9.12 p.m, a house within about 250 yards of the Rectory was struck, more or less damaging slightly every room, with displacement of roofing slates and the chimney stack, the upper part having to be rebuilt. The inmates (three persons) fortunately escaped injury.

Rainfall measured at 9 a.m. on June 14th, 0·53.—Yours truly,

W. L. W. EYRE.

*Swarraton Rectory, Alresford.*

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## ON A RECENT RECURRENCE IN WEATHER.—A LUNAR OR 30 DAY PERIOD.

*To the Editor of the Meteorological Magazine.*

SIR,—In a letter on the above subject contributed to the *Meteorological Magazine* of June last year (Vol. 34, p. 68), I said in referring to the length of a temperature period, "The interval is too short to determine whether the period had the exact length of the lunar period or had any relation of cause and effect, although the presumption favors it" Since then I have accumulated sufficient data to convince me that the mean length of the large oscillations of temperature with which I was there dealing is somewhat longer than the lunar month, and hence presumably not connected with it. The splendid work of Ekholm and Arrhenius have shown a connection between the moon's motion and changes in the electric potential of the air, and there may be other meteorological changes connected with the moon's motion, but probably very slight. Leaving out of account any consideration of cause, I have now much data to show that these large atmospheric oscillations, or waves, of different lengths move eastward with a velocity proportional to the wave length.

H. HELM CLAYTON.

*Blue Hill Observatory, Readville, U.S.A., June 6th, 1900.*

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## THE VISITATION OF THE ROYAL OBSERVATORY.

THE visitation of the Royal Observatory has for many years past been held on the first Saturday in June, but many astronomers (including the Astronomer Royal) having had this year to go abroad for the purpose of observing the total solar eclipse of May 28th, the visitation did not take place until June 26th. The opportunity of going over the Observatory, which the occasion affords, enables us to give some information on various changes of importance that have of late been made in the Meteorological Department.

On entering the Observatory, and proceeding through the grounds, the visitor will be charmed with the modern structure, the New Observatory, built by the present Astronomer Royal, at the extreme end of the ground beyond the Magnetical and Meteorological Department. This building, which has been in course of erection for some years past, is now complete; it consists of a central tower which was first built, to which four wings have at different periods since been added. Above the central tower is placed the Thompson Equatoreal, used to a great extent for general celestial photographic work, many excellent specimens of which were on view on visitation day. For the astrographic chart which has been for some years in progress, a special instrument in the older part of the Observatory is employed; this work is one so vast that the whole heavens was divided into portions or zones, of which certain of the national or public observatories each takes one. The new observatory building provides, what has been long required, a much needed accommodation for the greatly increased staff, as compared with that existing within the memory of many. More room was also wanted for the ever increasing books of calculations and photographic records, as well as for the proper disposition of the growing library, which, from being in the earlier part of Airy's time all contained in one not very large room, became dispersed in various rooms, until now brought together in the New Observatory.

Our present concern is, however, with the Magnetical and Meteorological Department, more especially the latter. In the course of building the New Observatory, its influence had to be considered in two ways: as regards magnetism, because the amount of iron used in its construction affected to an appreciable extent the determination of the absolute values of declination, dip, and horizontal force; and as regards meteorology, because the position occupied by the standard thermometers for air temperature became too much overshadowed. For both reasons it was necessary to seek for a new position; and this gave some trouble, since on account of the magnets it should be one free from any suspicion of disturbance from iron, whilst for the thermometers there should be also free circulation of air. The position ultimately selected is in a secluded portion of the park, on the eastern side of the Observatory, at a distance of about 350 yards. It is a nearly square piece of ground, the sides being each about 60 yards in length; it is well clear of trees, forming an excellent meteorological station, and is enclosed by a wood fence. In this enclosure is placed the new pavilion for the magnetic instruments for absolute measure, and the revolving stand carrying the standard dry and wet bulb thermometers, and those for maximum and minimum of air temperature was removed thereto in January, 1899. A Stevenson screen has been also set up this spring in the new ground; observation of the thermometers in the older Stevenson screen in the Observatory ground, commenced in 1887, being still continued. The radiation thermometers are in the new ground, and a rain gauge has also been placed therein. The photographic registration of the dry and wet bulb thermometers, commenced in 1848, is continued, at present, within the Observatory precincts. It may be of interest to remark that the register of the wet bulb thermometer stands, on the photographic sheet, immediately below that of the dry bulb, also that the degrees of the scales of both thermometers are photographed, showing as parallel lines throughout each register, the ten-degree lines being bolder than the others. The thermometers planted on the roof of the magnet house in 1886, and since regularly observed, of which the exposure has been throughout satisfactory, provide material for establishing the continuity of the temperature record by the thermometers in the new ground, but some little time must elapse before the precise difference between the two stations can be determined.

Some general history of the revolving stand on which, as mentioned, the standard thermometers for air temperature are placed, may be desirable. It was originally designed by Sir George Airy, though commonly known as the Glaisher stand. Its general construction, which is pretty well-known, is briefly as follows: An upright board, on the front of which the thermometers are placed, has attached to its back, at the upper edge, two inclined boards having an air space between them, the whole forming a frame capable of being revolved in azimuth on its vertical axis. The frame is turned at stated times during the day, whatever the state of the sky, to keep the inclined side always directed towards the sun. When first set up in the year 1841, the stand was placed on the north side of the magnet house, between the northern and eastern arms of the building, remaining in this position until 1846, when it was moved to the free space on the south side, to a distance of something more than 20 feet from the building, being again moved in 1863 some 10 feet further south, and eventually transported in 1899, owing to the interference of the New Observatory, to the new ground, as already mentioned. The stand is of the same general form as when set up in 1841, having since received one or two slight modifications only.

When the Stevenson screen began to come into general use for observation of shade temperature, the suggestion was made that a Stevenson screen should take the place of the open screen at Greenwich. But considering that the open screen had then been many years in use at Greenwich, this was scarcely to be expected. Both patterns of screen may have their faults, but continuity of record at Greenwich would not have been better preserved by replacing one imperfect screen by another. But to afford the means of comparison with other places, a Stevenson screen, the Royal Meteorological Society's pattern, was set up at Greenwich in the year 1887, as already mentioned. The maximum readings on the open stand were found to be higher, and the minimum readings lower, than those in the adjacent Stevenson screen. This is not surprising, and is not to be taken as implying error of the former. The exposure in the closed Stevenson screen is in some degree artificial, tending to contract the diurnal range by dwarfing the maximum and raising the minimum. It was at one time suggested that the higher open screen maxima at Greenwich might be due to radiation from other objects. But from a number of experiments made on unusually hot and sunshiny days in 1886 and 1887, this was found to be a misconception (details of the experiments are given at the end of the Introduction to the Greenwich Magnetical and Meteorological Observations for 1887).

A screen of some kind probably gives a better value of air temperature for investigation of climatic variation. But whilst meteorologists so much trouble themselves about the small differences between different screens, the question may arise as to the real value of shade temperatures from an agricultural or horticultural point of view, or even as affecting ourselves. The late C. Leeson Prince recorded, for a great number of years, not only shade temperatures, but also air temperatures, as given by ordinary thermometers (4 feet from the ground) exposed to the full rays of the sun, in regard to which some interesting remarks are to be found in his *Topography and Climate of Crowborough Hill, Sussex*, pp. 23 to 26.

The record of Temperature being one of the most important has been referred to at some length. Other matters are not especially affected by the presence of the New Observatory. The sunshine recorder was moved from the roof of the magnet house to above the old Flamsteed building four years ago. It may be remarked, that the better to compare together the magnetical and meteorological photographic and automatic records, as is at times desirable, the time scales are all (with one exception, the sunshine record) of equal length, 0·55 in. to one hour. This scale is, however, much too contracted for the record of wind pressure at Osler's anemometer in gales of wind, because in successive momentary gusts the pencil moves too much over one part of the paper. A special gearing is, therefore, attached to the driving clock by which the paper can be made, at pleasure, to travel twenty-four times faster than the usual rate, which gives a really independent record of the ever-changing pressures that occur in high winds.

## ROYAL METEOROLOGICAL SOCIETY.

THE second afternoon Meeting of the present Session was held at the Society's rooms, 70, Victoria Street, Westminster, on Wednesday, June 20th; the President, Dr. C. Theodore Williams, being in the Chair.

The following gentlemen were elected Fellows:—Mr. Murray L. Allen, Dr. Nicholas Cullinan, Mr. A. J. L. Evans, Dr. J. St. Clair Gunn, Capt. W. P. Lapage, Mr. John Little.

The President announced that the late Mr. G. J. Symons, F.R.S., had bequeathed to the Society the photograph Album presented to him by the Fellows of the Society in 1879, a portion of his library, and the sum of £200.

Mr. W. Marriott read a paper on "Rainfall in the West and East of England in relation to Altitude above Sea Level." This was a discussion of the mean monthly and annual rainfall at 309 English and Welsh stations for the 10 years 1881–90, which the author had grouped together for each 50 feet up to 500 feet, and above that altitude for each 100 feet. All stations which drained to the west were considered as "western," and all which drained to the east as "eastern." The results were exhibited in the form of a number of interesting diagrams. These showed clearly that there is a general increase in the amount of annual rainfall as the altitude increases, and also that the rainfall is considerably greater in the west than in the east. The monthly diagrams brought out some striking features, among which may be mentioned (1) that the monthly rainfall in the west is subject to a much greater range than in the east; (2) that in the west the maximum at all altitudes occurs in November, but in the east it is generally in October; (3) that in the west the three spring months, April, May and June, are very dry; and (4) that both in the west and in the east there is a great rise in the rainfall from June to July. The author considered that exposure, position and surroundings, as well as altitude above sea level, greatly affect the rainfall.

The President, Mr. Baldwin Latham, Mr. Sowerby Wallis, Mr. E. Mawley, Rev. Dr. J. D. Parker, Dr. H. R. Mill, Mr. R. H. Curtis, Mr. F. J. Brodie, and Mr. J. Hopkinson took part in the discussion on the paper.

A paper by Mr. J. Baxendell, giving a "Description of Halliwell's Self-Recording Rain Gauge," was read by the Secretary. This gauge, which has been designed and constructed by Mr. F. L. Halliwell, the chief assistant at the Fernley Observatory, Southport, yields very satisfactory records. It combines the tipping bucket and the siphon, and the bucket when full is rapidly discharged. The gauge is also moderate in price.

# SUPPLEMENTARY TABLE OF RAINFALL, JUNE, 1900.

| Div | STATION. | Total Rain. | Div. | STATION. | Total Rain. |
|---|---|---|---|---|---|
| | | in. | | | in. |
| I. | Uxbridge, Harefield Pk.. | 2·67 | XI. | Builth, Abergwesyn Vic. | 5·82 |
| II. | Dorking, Abinger Hall. | 3·43 | ,, | Rhayader, Nantgwillt... | 3·78 |
| ,, | Birchington, Thor ...... | 2·36 | ,, | Lake Vyrnwy ........... | ... |
| ,, | Hailsham ................ | 1·99 | ,, | Corwen, Rhug ........... | 2·25 |
| ,, | Ryde, Thornbrough ...... | 2·93 | ,, | Criccieth, Talarvor ...... | 2·61 |
| ,, | Emsworth, Redlands ... | 3·24 | ,, | I. of Anglesey, Lligwy.. | 1·91 |
| ,, | Alton, Ashdell ........... | 3·02 | ,, | I. of Man, Douglas ...... | 2·50 |
| III. | Oxford, Magdalen Coll.. | 2·37 | XII. | Stoneykirk, Ardwell Ho. | 1·79 |
| ,, | Banbury, Bloxham ...... | 1·84 | ,, | New Galloway, Glenlee | 5·03 |
| ,, | Northampton, Sedgebrook | 3·41 | ,, | Moniaive, Maxwelton Ho. | 3·98 |
| ,, | Alconbury ................ | 1·76 | ,, | Lilliesleaf, Riddell ...... | 4·65 |
| ,, | Wisbech, Bank House... | 2·27 | XIII. | N. Esk Res. [Penicuick] | 2·85 |
| IV. | Southend ................ | 2·68 | XIV. | Glasgow, Queen's Park.. | 4·04 |
| ,, | Colchester, Lexden ...... | 1·91 | XV. | Inverary, Newtown ...... | 4·57 |
| ,, | Saffron Waldon, Newport | 2·55 | ,, | Ballachulish, Ardsheal... | 4·20 |
| ,, | Rendlesham Hall ......... | 3·81 | ,, | Islay ..................... | 3·06 |
| ,, | Scole Rectory ........... | ... | XVI. | Dollar..................... | 3·19 |
| ,, | Swaffham ................ | 2·50 | ,, | Balquhidder, Stronvar... | 5·49 |
| V. | Salisbury, Alderbury ... | 2·39 | ,, | Coupar Angus Station... | 2·56 |
| ,, | Bishop's Cannings ...... | 2·27 | ,, | Blair Atholl ............. | 3·03 |
| ,, | Blandford, Whatcombe. | 2·25 | XVII. | Keith H.R.S.............. | 2·47 |
| ,, | Ashburton, Holne Vic... | 4·73 | ,, | Forres H.R.S. ........... | 1·28 |
| ,, | Okehampton, Oaklands. | 3·72 | XVIII. | Fearn, Lower Pitkerrie.. | 2·36 |
| ,, | Hartland Abbey ......... | 4·29 | ,, | S. Uist, Askernish ...... | 1·26 |
| ,, | Lynton, Glenthorne ... | 2·29 | ,, | Invergarry................ | 1·77 |
| ,, | Probus, Lamellyn ...... | 3·72 | ,, | Aviemore, Alvie Manse. | 2·52 |
| ,, | Wellington, The Avenue | 2·67 | ,, | Loch Ness, Drumnadrochit | 2·42 |
| ,, | North Cadbury Rectory | 3·13 | XIX. | Invershin ................ | 2·34 |
| VI. | Clifton, Pembroke Road | 2·48 | ,, | Durness .................. | 1·64 |
| ,, | Ross, The Graig ......... | 1·20 | ,, | Watten H.R.S............ | 2·41 |
| ,, | Wem, Clive Vicarage ... | 2·09 | XX. | Dunmanway, Coolkelure | 8·88 |
| ,, | Wolverhampton, Tettenhall | 2·39 | ,, | Cork, Wellesley Terrace | 4·04 |
| ,, | Cheadle, The Heath Ho. | 4·53 | ,, | Killarney, Woodlawn .. | 5·92 |
| ,, | Coventry, Priory Row .. | 3·47 | ,, | Caher, Duneske ......... | 3·53 |
| VII. | Market Overton ......... | 1·82 | ,, | Ballingarry, Hazelfort... | 3·89 |
| ,, | Grantham, Stainby ...... | 1·79 | ,, | Limerick, Kilcornan ... | 2·56 |
| ,, | Horncastle, Bucknall ... | 1·84 | ,, | Miltown Malbay ......... | 6·73 |
| ,, | Worksop, Hodsck Priory | 1·57 | XXI. | Gorey, Courtown House | 3·09 |
| VIII. | Neston, Hinderton ...... | 1·97 | ,, | Moynalty, Westland ... | 2·92 |
| ,, | Southport, Hesketh Park | 1·69 | ,, | Athlone, Twyford ...... | 4·84 |
| ,, | Chatburn, Middlewood. | 2·68 | ,, | Mullingar, Belvedere ... | 4·94 |
| ,, | Duddon Val., Seathwaite Vic. | 6·32 | XXII. | Woodlawn ............... | 4·48 |
| IX. | Melmerby, Baldersby ... | 3·29 | ,, | Crossmolina, Enniscoe .. | 6·55 |
| ,, | Scalby, Silverdale ...... | 2·21 | ,, | Collooney, Markree Obs. | ... |
| ,, | Ingleby Greenhow Vic.. | 3·22 | XXIII. | Enniskillen, Model Sch. | 3·57 |
| ,, | Middleton, Mickleton ... | 4·02 | ,, | Warrenpoint.............. | 6·08 |
| X. | Haltwhistle, Unthank H. | 4·37 | ,, | Seaforde................... | 3·20 |
| ,, | Bamburgh ................ | 3·64 | ,, | Belfast, Springfield ...... | 3·89 |
| ,, | Keswick, The Bank ...... | 4·43 | ,, | Bushmills, Dundarave.. | 3·37 |
| XI. | Llanfrechfa Grange ...... | 2·19 | ,, | Stewartstown ........... | 5·25 |
| ,, | Llandovery ............. | 4·89 | ,, | Killybegs ................ | 5·72 |
| ,, | Castle Malgwyn ......... | 3·69 | ,, | Horn Head .............. | 4·12 |
| ,, | Brecknock, The Barracks | ... | | | |

# JUNE, 1900.

| Div. | | STATIONS. [The Roman numerals denote the division of the Annual Tables to which each station belongs.] | RAINFALL. Total Fall. | Difference from average 1880-9. | Greatest Fall in 24 hours. Dpth | Date | Days on which ·01 or more fell. | TEMPERATURE. Max. Deg. | Max. Date | Min. Deg. | Min. Date. | No. of Nights below 32°. In shade. | On grass. |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | inches. | inches. | in. | | | | | | | | |
| I. | ENGLAND. | London (Camden Square) | 2·26 | + ·25 | ·39 | 25 | 14 | 90·1 | 11 | 45·8 | 5 | 0 | 0 |
| II. | | Tenterden | 2·14 | + ·29 | ·70 | 21 | 13 | 85·0 | 11 | 45·5 | 27 | 0 | 0 |
| ,, | | Hartley Wintney | 1·94 | ... | ·28 | 21 | 17 | 85·0 | 11 | 42·0 | 24 | 0 | 0 |
| III. | | Hitchin | 2·30 | + ·44 | ·58 | 1 | 15 | 86·0 | 11 | 44·0 | 4 | 0 | ... |
| ,, | | Winslow (Addington) | 3·90 | + 2·04 | ·79 | 7 | 16 | 84·0 | 11 | 43·0 | 27 | 0 | 0 |
| IV. | | Bury St. Edmunds (Westley) | 3·03 | + 1·24 | ·51 | 1 | 17 | 78·0 | 11 | 45·0 | 6 | 0 | ... |
| ,, | | Norwich (Brundall) | 2·70 | ... | ·67 | 1 | 20 | 82·2 | 12 | 45·8 | 27 | 0 | 0 |
| V. | | Winterbourne Steepleton | 3·20 | ... | ·56 | 14 | 16 | 73·4 | 10 | 41·5 | 27 | 0 | 0 |
| ,, | | Torquay (Cary Green) | 3·07 | ... | ·53 | 14 | 15 | 70·2 | 4 | 48·2 | 2*g* | 0 | 0 |
| ,, | | Polapit Tamar [Launceston] | 3·17 | + ·96 | ·85 | 12 | 18 | 72·2 | 4 | 39·0 | 1 | 0 | 0 |
| VI. | | Stroud (Upfield) | 1·98 | — ·41 | ·33 | 24 | 18 | 78·0 | 12*c* | 48·0 | 1 | 0 | ... |
| ,, | | Church Stretton | 2·87 | ... | ·60 | 24 | 17 | 74·0 | 10*d* | 39·0 | 1, 28 | 0 | 0 |
| ,, | | Worcester (Diglis Lock) | ... | ... | ... | ... | ... | ... | ... | ... | ... | ... | ... |
| VII. | | Boston | 2·84 | + ·95 | ·47 | 5 | 16 | 88·0 | 11*e* | 45·0 | 1*h* | 0 | ... |
| ,, | | Hesley Hall [Tickhill] | 1·36 | — ·56 | ·25 | 12 | 15 | 87·0 | 12 | 44·0 | 3, 5 | 0 | 0 |
| ,, | | Breadsall Priory | 3·89 | ... | 2·04 | 11 | 19 | ... | .. | ... | ... | ... | ... |
| VIII. | | Manchester (Plymouth Grove) | 3·29 | + ·64 | ·49 | 7 | 19 | 85·0 | 11 | 46·0 | 4 | 0 | 0 |
| IX. | | Wetherby (Ribston Hall) | 2·72 | + ·83 | ·92 | 11 | 13 | ... | ... | ... | ... | ... | ... |
| ,, | | Skipton (Arncliffe) | 4·74 | + 1·38 | 1·27 | 11 | 17 | ... | ... | ... | ... | ... | ... |
| ,, | | Hull (Pearson Park) | 1·93 | + ·18 | ·38 | 19 | 19 | 84·0 | 12 | 43·0 | 1*i* | 0 | 0 |
| X. | | Newcastle (Town Moor) | 4·92 | + 3·28 | 1·52 | 24 | 18 | ... | ... | ... | ... | ... | ... |
| ,, | | Borrowdale (Seathwaite) | 8·17 | + 1·59 | 1·55 | 30 | 18 | ... | ... | ... | ... | ... | ... |
| XI. | WALES. | Cardiff (Ely) | 2·16 | — ·27 | ·38 | 24 | 18 | ... | ... | ... | ... | ... | ... |
| ,, | | Haverfordwest | 4·13 | + 1·57 | ·69 | 4 | 19 | 75·0 | 4 | 45·0 | 1 | 0 | 0 |
| ,, | | Aberystwith (Gogerddan) | 3·75 | ... | ·89 | 21 | 14 | 78·0 | 10 | ... | ... | ... | ... |
| ,, | | Llandudno | 1·53 | — ·24 | ·29 | 21 | 15 | 77·5 | 10 | 44·0 | 1 | 0 | .. |
| XII. | SCOTLAND. | Cargen [Dumfries] | ... | ... | ... | ... | ... | ... | ... | ... | ... | ... | ... |
| XIII. | | Edinburgh (Blacket Place) | 2·83 | ... | 1·18 | 24 | 18 | 75·6 | 10 | 41·4 | 4 | 0 | 0 |
| XIV. | | Colmonell | ... | ... | ... | ... | ... | ... | ... | ... | ... | ... | ... |
| XV. | | Tighnabruaich | 4·35 | ... | 1·10 | 19 | 15 | 73·0 | 3, 4 | 44·0 | 24*j* | 0 | ... |
| ,, | | Mull (Quinish) | 3·56 | + ·27 | ·74 | 10 | 18 | ... | ... | ... | ... | ... | ... |
| XVI. | | Loch Leven Sluices | 2·50 | + ·75 | 1·10 | 24 | 9 | ... | ... | ... | ... | ... | ... |
| ,, | | Dundee (Eastern Necropolis) | 1·50 | ·00 | ·25 | 11 | 21 | 75·2 | 11 | 39·0 | 3 | 0 | ... |
| XVII. | | Braemar | 2·25 | + ·26 | ·56 | 22 | 16 | 70·3 | 3 | 37·1 | 4 | 0 | 3 |
| ,, | | Aberdeen (Cranford) | 1·94 | ... | ·50 | 11*a* | 17 | ... | ... | ... | ... | ... | ... |
| ,, | | Cawdor (Budgate) | 2·41 | + 1·01 | ·66 | 24 | 19 | ... | ... | ... | ... | ... | ... |
| XVIII. | | Strathconan [Beauly] | 3·27 | + ·78 | 1·00 | 21 | 12 | .. | ... | ... | ... | ... | ... |
| ,, | | Glencarron Lodge | 3·31 | ... | ·53 | 6 | 21 | 75·6 | 12 | 40·4 | 2 | 0 | ... |
| XIX. | | Dunrobin | 2·40 | + ·38 | ·78 | 22 | 13 | 68·0 | 14 | 40·0 | 2 | 0 | ... |
| ,, | | S. Ronaldshay (Roeberry) | 1·59 | — ·17 | ·48 | 21 | 18 | 66·0 | 18 | 39·0 | 2 | 0 | ... |
| XX. | IRELAND. | Darrynane Abbey | 3·77 | ... | ·82 | 8 | 23 | ... | ... | ... | ... | ... | ... |
| ,, | | Waterford (Brook Lodge) | 4·35 | + 2·28 | ·80 | 20 | 22 | 73·0 | 3 | 41·0 | 1 | 0 | ... |
| ,, | | Broadford (Hurdlestown) | 5·26 | ... | ·52 | 6 | 25 | ... | ... | ... | ... | ... | ... |
| XXI. | | Carlow (Browne's Hill) | 5·35 | + 3·51 | ·51 | 20 | 24 | ... | ... | ... | ... | ... | ... |
| ,, | | Dublin (FitzWilliam Square) | 3·17 | + 1·51 | ·52 | 20 | 22 | 71·6 | 15 | 47·2 | 23 | 0 | 0 |
| XXII. | | Ballinasloe | 4·78 | + 2·48 | ·49 | 12*b* | 26 | 71·0 | 3 | 44·0 | 23 | 0 | ... |
| ,, | | Clifden (Kylemore) | 9·01 | ... | 1·61 | 24 | 19 | ... | ... | ... | ... | ... | ... |
| XXIII. | | Waringstown | 2·96 | + ·89 | ·35 | 7, 23 | 13 | 79·0 | 5*f* | 36·0 | 24*j* | 0 | ... |
| ,, | | Londonderry (Creggan Res.) | 3·64 | + 1·22 | ·67 | 22 | 25 | ... | ... | ... | ... | ... | ... |
| ,, | | Omagh (Edenfel) | 5·22 | + 2·75 | ·72 | 30 | 23 | 76·0 | 3 | 44·0 | 1 | 0 | ... |

\+ Shows that the fall was above the average ; — that it was below it.

*a*—and 23. *b*—and 16. *c*—and 14. *d*—and 11, 12. *e*—and 12. *f*—and 14, 16. *g*—and 23, 27. *h*—and 2, 5, 21, 24. *i*—and 2, 3, 9. *j*—and 27.

# METEOROLOGICAL NOTES ON JUNE, 1900.

ABBREVIATIONS.—Bar. for Barometer; Ther. for Thermometer; Max. for Maximum; Min. for Minimum; T for Thunder; L for Lightning; TS for Thunderstorm; R for Rain; H for Hail; S for Snow.

## ENGLAND.

CAMDEN SQUARE.—On 11th the temp. in shade rose to 90°·1. In the 42 preceding Junes 90° has been reached only three times; in 1858, 92°·6 on 16th, in 1870, 91°·2 on 22nd, and in 1893, 90°·4 on 19th. On 20th, ·18 in. of R fell in 9 minutes.

TENTERDEN.—A welcome R fell on 21st, the previous showers having done little to benefit the grass, which was deficient owing to the dry May. Slight TSS on 12th, 22nd and 25th; a house being struck by L on 12th. The shade temp. rose above 80° on 10th, 11th and 12th. Duration of sunshine 206 hours 45 mins. Strong S.W. winds on 20th, 22nd, 25th and 30th; N.W. on 23rd and 26th.

HARTLEY WINTNEY.—The month commenced with cold N.E. winds, and dull and cloudy days, followed by S.W. winds, with R almost every day. R ·14 in. above the average. A wave of heat occurred from 9th to 13th, with a mean max. temp. of 81°·5. T on 10th, 11th, 12th and 24th. Ozone registered on 13 days, with a mean of 3.

WINSLOW, ADDINGTON.—The greatest June rainfall since 1879. There were few hot days, 80° being reached only twice. A heavy TS occurred in the evening on 11th, the T and L being incessant; ·59 in. of R fell in 15 mins. On the 12th there was another T and H storm, the hailstones being large and varying in shape; some irregular pieces an inch long; others flat and thin, as large as a shilling, and some globular, three-eighths of an inch in diameter.

BURY ST. EDMUNDS, WESTLEY.—A cool month, with sunshine below the average, and vegetation backward. TSS on 5th, 7th and 12th; distant T on 20th; T and H on 22nd.

NORWICH, BRUNDALL.—Mean temp. 59°·3. R ·85 in. in excess of the average. TSS on 5th, 6th, 8th, 12th and 22nd; L on 2nd; T and L on 20th. R of the first six months of the year 1·88 in. above the average.

WINTERBOURNE STEEPLETON.—The month was cold, the mean temp. and mean max. decreasing:—

| | Mean temp. | Mean max. |
|---|---|---|
| | ° | ° |
| First week | 57·4 | 67·0 |
| Second ,, | 57·4 | 65·4 |
| Third ,, | 56·0 | 63·0 |
| Fourth ,, | 54·9 | 62·3 |

Constant R after the 13th damaged the hay crops and hindered getting it in.

TORQUAY, CARY GREEN.—R ·88 in. above, and mean temp 1°·1 below, the average. Duration of sunshine 47 hours 45 mins. below the average: one sunless day.

POLAPIT TAMAR [LAUNCESTON].—A wet month, the R being 1·26 in. above the average. The total for the first six months of the year is 5·06 in. above the average. T and L on 4th and 13th, with H on 13th.

CHURCH STRETTON.—A showery, changeable month. Only three really hot days, the 10th, 11th and 12th, yet no cold nights owing to prevalence of cloud. T on 11th, 12th and 14th.

BREADSALL PRIORY.—The heaviest TS on record occurred on 11th, when 2·04 in. of R fell.

SEATHWAITE.—T and L on 11th and 14th.

## WALES.

HAVERFORDWEST.—A cold, unsettled month, with a great deal of R, and very little bright sunshine. From 2nd to 5th it was hot, and a TS occurred on 4th, with heavy R. The temp. rose to, or above, 70° on only two days, and some low night temperatures were recorded. Very little hay was cut at the close of the month.

ABERYSTWITH, GOGERDDAN.—A nice growing month. Wind S. or S.W. throughout.

## SCOTLAND.

EDINBURGH, BLACKET PLACE.—R 35 per cent., and rainy days 4, above the average. Mean temp. 0°·7 above, and duration of sunshine 34 hours below, normal. L on 10th; TSS, with H, on 11th and 12th; and TSS on 13th, 21st and 23rd. The TS on 12th was accompanied by great darkness, and was the most severe in this district since August 12th, 1884.

TIGHNABRUAICH, CRAIGANDARAICH.—The rainfall is an average one, chiefly made up by T showers. Average max. temp. 65°·2; average min. 49°·2.

ABERDEEN, CRANFORD.—Cold, with frequent foggy nights, and little sunshine. TS, with H, on 23rd, ·40 in. falling in 15 mins.

S. RONALDSHAY, ROEBERRY.—The first part of the month was dry and cold; the latter part mild and showery. Mean temp. 51°·3, being 0°·7 below the average.

## IRELAND.

DARRYNANE ABBEY.—A wet, cold and bad month. TS on 3rd, but not heavy.

BROADFORD, HURDLESTOWN.—A very wet June. T on 16th.

DUBLIN, FITZWILLIAM SQUARE.—Opening with fair, though cool weather, June belied its early promise, and proved extremely unsettled, showery and thundery. The mean temp. was 1°·1 above the average, but the amount of cloud was large (6·9). Bright sunshine prevailed for only 158 hours; and torrential showers fell on many consecutive days, being frequently accompanied by T and L. High winds were noted on four days, and a gale occurred on 24th. Solar halos were seen on 3rd and 4th. The temp. exceeded 70° on only two days. T on 7th; L on 5th, 11th and 25th. TSS on 6th, 12th, 13th, 14th and 19th. H on 14th.

BALLINASLOE.—TS on 13th; T on 5th and 7th. On the 16th ·48 in. of R fell in 31 minutes.

OMAGH, EDENFEL.—The brilliant summer in which the month commenced terminated on 4th, thenceforward the weather became progressively more and more rainy, totalling more than double the June average of 30 years. The temp. was, however, well maintained, so that growing crops were extremely luxuriant.