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TABLE OF CONTENTS.

LIST OF PLATES.

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ROYAL METEOROLOGICAL SOCIETY.

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REPORT ON THE INTERNATIONAL METEOROLOGICAL CONFERENCE AT MUNICH,

AUGUST 26th to SEPTEMBER 2nd, 1891.

By ROBERT H. SCOTT, M.A., F.R.S., Foreign Secretary.

[Read November 18th, 1891.]

THE Meeting which took place at Munich was a Conference, not a Congress. In other words, it was an assemblage of meteorologists, and meteorological systems as such, and not of representatives of governments.

It had been decided by the International Meteorological Committee, at Zürich, in 1888, to give the meeting this, more or less, private character, mainly on the ground that more than one government had expressed itself strongly against the idea of any more official assemblage. The result of this has been that in some cases the gentlemen invited were unable to obtain permission from their respective authorities to attend, on the plea that no invitation, through diplomatic channels, had been received.

The Conference was, however, attended by 32 persons. The whole proceedings were marked by the most thorough good fellowship, and, in fact, it is in the fostering of this feeling, much more than in the discussion of abstruse scientific questions, that the real value of these international gatherings is to be found.

The countries represented were as follows, taking them in alphabetical order.

EUROPEAN.

Austria	1	France	2	Roumania	1
Bulgaria	1	Germany	9	Russia	3
Denmark	1	Holland	1	Spain	1
England	1	Hungary	1	Sweden	1
Finland	1	Norway	1	Switzerland	1

EXTRA EUROPEAN.

Brazil	1	Queensland	1	United States	4

Of these countries Bulgaria, Roumania, Brazil, and Queensland were for the first time represented at such a Meeting.

The sittings were held in the large Board Room of the Polytechnic School at Munich. The language of the Conference was German, the locality being in Germany, but all resolutions were submitted, and many speeches made, in the three languages, English, French and German, while the minutes of proceedings were prepared, printed, and, for the first three days at least, issued, in the three languages.

In accordance with the usual practice, the chief of the local meteorological service, Dr. Carl Lang, was elected president. He nominated as vice-presidents Prof. Mascart and Prof. Harrington, to represent the French and Anglo-Saxon elements respectively. The secretaries were also selected for the three languages, and were Dr. Erk, M. Teisserenc de Bort, and your humble servant. I can assure you that their post was by no means a sinecure—to stay, after a three-hour meeting, for four hours more, writing protocols, in three languages, is not an agreeable task. The meetings lasted for three hours on each of the first four days, and for about six hours on the last two.

Coming now to the actual decisions of the Conference, I must, in the first instance, deal with the special questions sent forward by our own Council: they were Nos. 19, 20, and 32 of the programme.

The first two referred to anemometry.

"19. The general adoption of a standard anemometer for the determination of the velocity of the wind."

"20. The general adoption of a uniform height above the ground for anemometers."

These questions are of somewhat old date, as they were originally put forward in the year 1885, and suggested for the Paris Meeting of the International Committee in that year; and I think I am justified in assuming that had the results already attained by Mr. Dines on the subject of wind measurements been before the Council the suggestions above given would have been differently worded.

The whole subject of anemometry was treated *en bloc* by Dr. Wild, in a report printed in the appendix. No form of instrument but Robinson's was discussed, so that no selection of a type instrument took place. It was expressly declared to be impossible to lay down general rules for the height above ground or exposure of the instruments. This decision will not be unacceptable to some of our Fellows, who go so far as to condemn all existing anemometrical records on the ground that all the instruments are placed on some building which produces eddies, instead of being placed on a scaffolding.

The third suggestion from the Society, No. 32 of the programme, as to the preparation of tables for the reduction of temperature to sea-level, has been disposed of satisfactorily by the publication of the International Tables.

As regards the other subjects discussed, the following is a brief summary of the utterances.

Thermometry.—It is recommended that the standard thermometers in each country be compared with the standard instrument at the Bureau International des Poids et Mesures at Sevres, and that the practice of referring temperatures to the air thermometer should be introduced as soon as possible, but at latest with the year 1901.

A considerable discussion took place as to the hour of reading the maximum and minimum thermometers, the resolution of the Vienna Congress, that these two readings should be made at the latest observing hour of the day, being not universally adopted at present. The Conference on this occasion stated that it was of paramount importance to give in every case the hour at which the maximum and minimum thermometers were read and set.

Radiation.—It was held that no form of actinometer had as yet been proposed which could be recommended for general adoption.

Hygrometry.—The Conference reiterated the recommendation of the Roman Congress as to the general application of mechanical ventilation to the wet bulb. I may venture to point out that this will present difficulties at second order—not to speak of telegraphic reporting—stations.

Rain.—The definition of a rainy day was lowered, and now a fall of 0·1 mm. or of 0·004 inch, is to constitute a day of precipitation, while the number of days per month on which 0·04 inch fell is to be recorded. A suggestion of Pére Colin's, of Antanarivo, to give dew in a separate column, was declined, but M. Colin was requested, if possible, to give measurements of the fall of dew in Madagascar.

No change was made in the Roman proposals as to the placing of gauges occasionally on roofs, except to say that these should not be pointed, M. Arcimis explaining that roof exposure was the only possible one in Cadiz.

Snow.— Special attention was directed to the subject of snow lying on the ground, and it was decided to employ a symbol ⊠ to indicate that more than half of the country surrounding a station was covered with snow.

It is resolved to collect and print information as to the practices of snow collection and measurement at present in force.

Some discussion took place as to some of the other symbols recommended by previous conferences, notably as to silver thaw and glazed frost, and also as to halos and coronæ, about which there is a confusion in English books, the German equivalent of the *halo* with a radius of 22° being "Ring," and of the *corona*, "Hof."

Sunshine.—The Conference recommended the extension of sunshine observations, but did not deal with the question of the relative merits of the two modes of measuring the duration of this element.

Clouds.—Some discussion took place as to the estimation of the total amount of cloud in the sky, and it was proposed to limit the region taken into consideration to a certain zenithal zone. The Conference recommended that at certain stations in each country comparative observations should be made of the amount of cloud for the whole sky, with a clear horizon, and for zenithal zones of 45° and 60° respectively.

As to the classification of clouds the longest discussion took place, and, in my opinion, has resulted in confusion worse confounded. It goes without speaking that I was outvoted on this matter, but I was accompanied in misfortune by Prof. Harrington for the United States, and by Dr. Schultheiss of Carlsruhe. The resolution of the Conference, carried by a large majority, was to adopt the classification of clouds, with ten grades, proposed by Prof. Hildebrandsson and Mr. Ralph Abercromby, but immediately thereupon a committee was appointed by the following resolution :—

"The cloud atlas, in its present form, is to be recognised as the first satisfactory attempt to introduce uniformity in the classification and nomenclature of cloud observations. It is desirable to form a committee in order to obtain smaller and cheaper representations of cloud pictures, without abandoning the use of colour. The committee should consider the cloud atlas, as well as the other pictures submitted to them."

I venture to remark that the resolution just read absolutely upsets the previous decision, adopting the classification represented by the cloud atlas. This cloud atlas is to be considered, but by the resolution previously passed the classification therein embodied is adopted, and thereby excluded from further consideration.

The committee entrusted with the arrangement of future cloud pictures is composed of MM. Hann, Hildebrandsson, Rotch, and Teisserenc de Bort, with the right of co-option. Herr Singer, of Munich, has already been co-opted.

A report on the mode of observing cirrus clouds was prepared, and will be printed in the Report of the Meeting.

Wind.—I have already mentioned the action as regards wind, in so far as it concerns this Society. The further points dealt with by the resolution were the publication of such records only as were obtained from duly verified instruments, and a demand for a fresh determination of the velocities corresponding to degrees of the Beaufort scale.

Time.—A suggestion from the recent Geographical Congress at Rome in favour of the introduction of universal or zone time was emphatically rejected, as local time is alone suitable for climatological inquiries.

It was further decided to number the hours, in publications, from 0 h. to 23 h, beginning with midnight.

Correction of barometrical readings for gravity.—This matter was again brought forward, and it was resolved to recommend its introduction with 1901, and that it should always be stated whether this correction has been applied or not.

Frequency of occurrence instead of mean value.—A proposal to substitute for the usual publication of the mean value of a phenomenon, a statement of the frequency of occurrence of a particular reading, was not adopted.

The resolutions as regards weather telegraphy were of a general nature, and hardly call for notice here.

The last matter which may interest the Society as connected with the proceedings of the Conference is the discussion as to the preparations for the next meeting, which is proposed to be in the form of a Congress, that is, summoned through diplomatic channels, and is to be held, it is hoped, in Paris in 1896.

A proposal to create an International Bureau with a salaried staff and an office in some metropolis or other did not meet with favour, and finally a committee was appointed, to consist of 17 members, of whom 14 were elected on the spot.

The names are :—

von Bezold	Lang
Billwiller	Mascart
de Brito Capello	Mohn
Hann	Scott
Harrington	Snellen
Hepites	Tacchini
Hildebrandsson	Wild

It will be seen that all the members of the old International Committee were reappointed with the exception of Dr. Neumayer, who begged to be allowed to resign his seat on the Committee.

The three vacant seats will probably be filled by representatives of three important British extra-European organisations.

Prof. Wild was selected President, and your humble servant could not escape his fate of having to act as Secretary, an office he has now held for 17 years.

I cannot conclude this notice without adverting to one matter which forces itself upon my notice. I exhibit the photograph of the Conference, and beside it that of the Congress of Rome, 12 years before. There are only seven faces which appear on both these pictures, and I am the only person who has attended every one of the International Meetings, Congresses, Conferences, and Committees, from Leipzig in 1872 to Munich in 1891.

DISCUSSION.

Mr. A. L. Rotch said that as a member of the Committee on Cloud Pictures appointed by the Conference, he must take exception to Mr. Scott's statement that the adoption by the Conference of the cloud classification of Hildebrandsson and Abercromby precluded any work by the Committee. His own task was to choose the best illustrations of the adopted types of cloud, with a view to reproducing them in colour as cheaply as possible in an atlas. About twenty pictures were chosen from the photographs of Dr. Hildebrandsson of Upsala, Dr. Riggenbach, of Bâle, and M. Garnier of Paris. Some very fine photographs have since been submitted by Dr. Neuhauss of Berlin, some of which were exhibited by Mr. Rotch. It is the intention of Dr. Singer, of Munich, to publish a cheaper atlas of the typical clouds, the pictures being photo-lithographed in one colour, as in the specimen sheets shown. Mr. Rotch read a letter from Dr. Hildebrandsson, in which he described the difficulties of reproducing the coloured cloud pictures. For the measurement of cloud heights and velocities which it is proposed to undertake in various parts of the world, Dr. Hildebrandsson recommends the use of photographic cameras attached to theodolites as already employed at Upsala and Blue Hill.

Mr. Symons said that the Society's thanks were due to Mr. Scott for his very lucid account of the six days' hard work done by the Conference. He did not feel at all happy about the suggestion the Conference had made concerning placing rain-gauges on roofs, as he had a strong objection to rain-gauges being so placed. The distinction drawn between flat roofs and those which were pointed was a very important one, as the late Mr. G. Dines had shown from a careful series of experiments conducted at Hersham that, provided a flat roof was of sufficient area, the rainfall collected by a gauge placed thereon might not be seriously affected by its elevation.

ACCOUNT OF AN ELECTRIC SELF-RECORDING RAIN GAUGE.

By W. J. E. BINNIE, B.A.

(Communicated by G. J. Symons, F.R.S.)

Plates I. and II.

[Received November 2nd.—Read November 18th, 1891.]

This gauge was constructed on the assumption that all drops falling from an orifice or tube are identical in weight, as long as the dimensions of the orifice are not varied.

Before entering upon a discussion as to how far this assumption is correct, I shall briefly describe the action of the gauge itself. This can best be described under two heads :—

1. The Transmitter.
2. The Receiver.

The Transmitter. (See Fig. 1, Plate I.)

The drawings show (Fig. 1) a longitudinal section ; (Fig. 2) a plan of the splash cup ; (Fig. 8) a plan of the contact lever, &c.

Referring to Fig. 1, *A* is a rain-gauge funnel, 2 ins. in diameter, which is surrounded by a 5-in. cylinder *B*, whose rim is flush with that of *A*. All the rain which falls on *A* is conveyed into the apparatus by the tube *C*, that which falls upon the annular space between *A* and *B* escapes over the top of the box through suitable holes D, D'. The rain passes through C, the lower end of which is ground flat in a plane at right angles to the longitudinal axis of the tube, and covered with cambric or other suitable material at E. The water, on reaching the cambric at the end E, moistens it, spreading out until it has reached the external circumference of the tube. It then collects and falls from the cambric as a drop, whose size can be easily measured. The cambric is used for two reasons, (1) we can obtain a larger drop by this means than if a tube alone were used, as water only chokes the bore of small tubes unless passing in large quantities, and (2) the area of formation of the drop remains constant, as the water can spread no further in a horizonal plane than the external circumference of the tube. Creep which occurs from the internal to the external circumference of the tube is thus avoided. The drop falls from the cambric on to the plate situated at one extremity of the bent lever M (Figs. 1 and 3). This lever is balanced about an axis N, working in two uprights O and O' (Fig. 3). To the one end of the axis is attached a thin wire of some well-conducting metal, which dips into a drop of mercury lying in a depression in the surface of the foot of the upright. To this upright is attached one terminal of the circuit. At the further extremity of the lever M is a small adjustable counterpoise P (Fig. 3), which keeps the lever, when at rest, in contact with the backing-screw Q, the position of which can also be adjusted. Underneath the lever between the axis and the plate is a small pointer made of platinum, placed immediately above, but not in contact with, the mercury in the tube S. Into the mercury in this tube dips the other terminal of the circuit, which terminal should be of iron, platinum, or other non-amalgable but well-conducting metal. The whole of the lever and uprights are made of metal. The momentum of the drop striking the plate L causes the lever to dip, thus closing the circuit, until the counterpoise brings the lever back again to rest upon Q. Round the plate is a cup T (Figs. 1, 2 and 3), which consists of two tubes; the upper tube splash-protector is open at both ends and can slide over the other, which is slotted from the top downwards so as to allow sufficient motion for the lever, and is provided with a discharging tube U (see Fig. 1) passing into a collecting vessel. In Fig. 3 the lower slotted tube is shown in position, the upper tube being removed. The rain-gauge box is provided with four large iron spikes by means of which it is fixed in the ground, or better, let into concrete. These have been omitted in the figure.

If the drops were of constant size, under varying conditions, we should obtain a measure of the amount of water fallen by experimentally determining the size of the drop, and then recording the number of drops which fell during any period.

The conditions which exercise an effect upon the size of the drop are two; (1) the interval elapsing between the fall of the drops; and (2) the variations in temperature.

To show how temperature affects the size of a drop, let us take the case of a drop which is about to fall from a vertical tube of such a diameter that the water, before falling in the shape of a drop, chokes the bore of the tube, which would happen with all tubes up to a diameter of about $\frac{3}{4}$ centimetre. Then the size of the drop falling from the tube is such that the weight of the drop, just before falling, is equal to the upward force exerted by surface tension.

Let a be the radius of the tube and w the weight of the drop. Then if r is the radius of the drop after falling from the tube (the drop being supposed spherical),

$$\tfrac{4}{3}\pi\, r^3 g = 2\pi\, a\, T$$

where T is the surface tension,

$$i.e.\ r^3 = \tfrac{1}{8}\, a$$

(approximately), taking 80 as the value of the surface tension.

On Plate II. are shown the theoretical values from tubes of various dimensions. Eighty was taken as the value of the surface tension at the temperature at which the experiments were carried out. This value would not, however, hold for all temperatures, there being a variation of about $\frac{1}{1200}$ per degree Fahrenheit. Hence the difference in weight of a drop, under similar conditions, falling from the same tube at 72°F. and at 82°, would amount to about 3 °/₀ of the whole weight of the drop.

If we took the weight of the drop at a temperature midway between these temperatures, we should find a variation of $1\frac{1}{2}$°/₀ on each side of the mean value. If the theory, as it stands above, explained all, this would be the total amount of error, but as Professor Guthrie first pointed out (*Proceedings Royal Society*, Vol. XIII., pp. 444-88) a variation occurs when the interval between the fall of the drops varies. I have, myself, (*Report of British Association*, 1890, p. 731) carried out a series of experiments showing the variation in the size of drops falling from tubes, plates, cones, &c., due to this cause.

On Plate II. I have plotted the variations of the drops with different intervals from tubes ·244 = A, ·3 = B, ·33 = C, ·38 = D, and ·56 = E centimetres in diameter. The temperature during these experiments varied very little. The horizontal distances represent the mean interval of time in seconds between the fall of each drop, the vertical the variations in the size of the drop in hundredths of a cubic centimetre.

The first thing that strikes one is the similarity of the curves. The drop remains constant in size, or very nearly so, until the interval is decreased to five seconds; then, as this interval decreases, the drop rapidly gets larger, as shown by the upward sweep of the curve, until, when the interval is nothing, the drops coalesce to form a stream.

The generally accepted explanation of this fact is, that supposing the supply of water to the tube to be cut off at the moment when the drop had become of such a weight as to fall, the drop would not fall immediately, but would remain for some time in a state of unstable equilibrium. But, supposing that the water was still being supplied to the drop while it was in this state, the fall would be hastened, but the drop would be of a greater weight than it theoretically ought to be, this effect being due to the fact of the surface layer of liquid acting as an elastic film. Hence the increased weight of the drop would depend upon the weight of supply. It is pretty evident from the diagram that this variation has nothing to do with the dimensions of the orifice.

Let us take the size of the drop, which is about $\frac{1}{6}$th of a cubic centimetre, as it falls from the rain-gauge tube, so large a drop being adopted for two reasons, (1) the impact being greater the little lever need not be made so light, and the counterpoise can be made heavier so as to ensure a prompt return to rest; and (2) as the variations depend upon the interval, to a similar extent in drops of different size, we can collect more water, before variation sets in, with large drops than with small.

If we could design a funnel of such a diameter, that, with the heaviest known rate of rainfall, the drops would never have an interval between them of less than five seconds, then error from this cause could be almost entirely eliminated. Here we are met with two difficulties, (1) the diameter of the funnel can hardly be made less than 2 ins. without liability to error: (Prof. Eastman's observations at Washington with gauges from 1 to 6 ins. in diameter, show that even down to 2½ ins. the error is not likely to exceed 1°/₀, and the Strathfield Turgiss experiments show that even with funnels down to 1-in. diameter, when carefully measured, the error is inappreciable); and (2) the rate of rainfall is occasionally exceptionally heavy.

Let us take the heaviest rate of rainfall at 7 ins. per hour, and suppose that we use a 2-in. funnel, the size of the drop being $\frac{1}{6}$th of a cubic centimetre: then the amount of rain collected in a minute would be ·366 cubic inches. Each drop = ·0102 cubic inches: therefore in one minute we should have 36 drops; *i.e.* the interval between the fall of the drops would be 1·7 s. Suppose we were to assume for the weight of the drop its value when the interval was 5 s.; then, during a shower at the rate of 7 ins. per hour, we see by the curves that we should get an error of about 8·5°/₀. On the other hand, during an exceedingly light shower, the error from this cause would probably never exceed 2°/₀.

It might, perhaps, be thought that the errors to which this instrument is liable would more than counteract any advantages it possesses. As to the temperature error, it is one which seems impossible to be overcome without using artificial means for keeping the temperature constant. After continued observation, however, a temperature mean could be obtained for each month which would render the possible error from this cause very small. The error for different intervals between the fall of each drop, is practically only of importance in a few exceptional cases, for the drop remains nearly constant for intervals longer than five seconds.

One of the above drops in five seconds, using a 2-inch funnel, would mean a rainfall at the rate of nearly 3 ins. per hour, and one has only to look through *British Rainfall* to see that this rate of fall, even, is not often reached in the same place. During the last 21 years, a rate of rainfall more than 3 ins. per hour has been recorded 72 times. During these 21 years, this rate of rainfall has been exceeded seven times at one observatory, that of Mr. Symons in Camden Square. The frequency of the observation of this heavy rate of fall at this locality is, no doubt, due to the great care which has been bestowed upon the registration of rainfall at this observatory and the exceptional instruments provided there, and not to peculiar meteorological causes.

Only twice during the 21 years has the rate at 7 ins. an hour been exceeded, so that if one of the above described gauges had been beside the gauges in Camden Square during these 21 years, only on seven occasions would there have been an appreciable error due to this cause. It must also be borne in mind that every recording gauge which automatically discharges itself takes no account of the rainfall during the discharge.

I shall now proceed, as briefly as possible, to describe the recording instrument.

The Recording Instrument.—The instrument next to be described entirely gets rid, if necessary, of the error due to a very heavy rate of rainfall, though it is such that it could not be very well placed in the hands of a perfectly unskilful person. In describing it I shall assume that it is placed in such proximity to a house as to allow of the battery and recording instrument being kept inside, the wires being conducted thither from the gauge. (See Plate I.)

Fig. 4 shows a view of the weight-cord drum.
,, 5 ,, side elevation of the apparatus.
,, 6 ,, plan of the style holder.
,, 7 ,, plan of the escapement.
,, 8 ,, an elevation of the escapement lever.

Against the drum *A* (Fig. 5), which is driven by clockwork in the ordinary manner, presses a style *B* (Figs. 5 and 6), which consists of a writing style carried at the end of an arm attached to the carrier *C*, the style being kept pressed against the drum by the spring-arm. The carrier is provided with a little catch *D* (Figs. 5 and 6) which can revolve in a plane parallel to the face of the carrier. When the style is pressed back and the catch revolved in the same direction as the hands of a watch till it presses against the arm, the style is kept by means of the catch from pressing against the paper. By this means the style is removed from the drum, when it is required to replace the diagram, &c. The carrier *C* is tapped and is carried upon the screw *L*, the back part being prolonged into a tail-piece *M* (Fig. 6), which slides in a vertical slot in the upright *N* (Fig. 5). *N* is bent horizontally at its upper end, and to it is hinged the distance piece *O* provided with a screw *P*, which screw when it rests upon a depression in the vertical bar round which the drum revolves, shows that the bar is parallel in all planes to the screw *L*. The screw *L* passes through the horizontal plate of *N* at its upper end, and is there provided with a pinion into which is geared the wheel F. To the wheel F is rigidly attached the drum *Q*, round which is wrapped a string, which passes over the pulley *R* and round that of the weight *W*, the drum being made threefold and wound in alternately opposite directions, so that the pen is first raised to the top, then lowered again to be raised once more. This gives us 6 ins., four of which may be advantageously kept as a reserve. The tendency of this weight is to cause the screw to revolve so as to raise the carrier. The lower end of the screw is provided with a toothed wheel *S* (Fig. 7) geared into a pinion, which is rigidly attached to the fly-wheel *T* (Figs. 5 and 7); in the figure the cock of *T* is shown removed. This fly is provided with a pin *U*, which is placed vertically at some point in the circumference (Figs. 5 and 8). The electric escapement (Fig. 7) is as follows. *V* is an electro-magnet, provided with an armature *Z* bent at right angles at its extremity and slotted so as to admit loosely the bent lever *X* (Figs. 7 and 8). This lever is bent as shown in Fig. 7, it can revolve about an axis at the further extremity from the electro-magnet, and is provided with two stops *U* and *Y'* (Fig. 8). These stops are so placed that any body moving parallel to and in contact with one face of *Y* would come into contact with, and be stopped by, one face of *Y'*. At the same time they are at such a distance apart that a small body such as the stop pin of *T* (Fig. 7) would pass between them. The lever *X* works between two vertical pins (1) and (2) (Figs. 7 and 8). When it is required to throw the apparatus out of action in order to bring *C* back again to zero, the lever *X* (Fig. 7) is raised until it can be pressed back over the top of 2; on lowering it behind 2 it remains in this position when both stops are clear of the stop pin on *T*, and *L* is then free to revolve.

The action of the instrument is as follows. Each current sent by the transmitter causes the electro-magnet to attract its armature *Z*. The stop *Y* is withdrawn and the wheel *T* revolves under the influence of the weight, until the pin comes in contact with *Y'*. Here it remains until the current from the transmitter ceases, when *Z* returns to its original position and the wheel *T* completes its revolution, being brought again to rest by *Y*.

Thus every current which is transmitted allows the fraction of a revolution of *L*, raising *C* a certain definite distance on the drum. As these currents are each due to the fall of a certain quantity of rain, the curve traced by the style upon the drum shows the variations in the intensity of the rainfall, the paper on the drum being divided into inches and tenths from the known size of the drop and the gearing.

As to working, I have had the instrument outside during the blizzard in March, and during part of July and August 1891, and it has worked satisfactorily, since the water collected checked well against the fall recorded on the drum. On July 19th, a rainfall at the rate of 6 ins. per hour was recorded.

When once adjusted, it remains in adjustment unless it receives a violent blow. The cambric in such an atmosphere as that of London requires to be renewed about once a week.

DISCUSSION.

Mr. HARRIES said that when at Toronto in July last, Mr. Carpmael, the Director of the Canadian Meteorological Service, showed him an electrical registering rain gauge, constructed very much on the same lines as Mr. Binnie's instrument. Electrical contact is formed as each drop falls on a lever placed between the funnel and the receiver, and the time of contact is automatically recorded in the interior of one of the computing rooms of the Observatory. The duration of rain is thus registered, but he (Mr. Harries) was not certain whether the amount could be obtained from the same record. The instrument is fixed in the ground in close proximity to the ordinary rain gauge.

Mr. WHIPPLE inquired what amount of paper was required to record one day's rainfall.

Mr. SYMONS said that when the idea of this form of rain gauge was suggested to him he thought it would not be practicable to construct a trustworthy instrument, as he believed it would be found that the drops would not be sufficiently uniform in size. However, the instrument had been constructed and had been proved to give interesting results, although a lengthy comparison with some other form of continuously recording rain gauge was desirable. This new form of rain gauge had two advantages over other patterns; (1) he knew from experience that it was often difficult to get a good pencil trace from ordinary forms, the recording portion of which had to be placed out of doors, where, the paper becoming damp, the pencil trace was either faint or it tore the paper. (2) All gauges which after receiving a certain quantity of rain discharged, either by tipping or by a siphon, lost the fall during the time of those actions, there was no such loss with this gauge. He, however, did not like to use electricity in recording apparatus, because it so often failed at an important moment. The instrument seemed to work exceedingly well, its error, even under exceptional circumstances, only amounting to two or three per cent. He considered great ingenuity had been displayed by Mr. Binnie in the construction of this rain gauge.

Mr. HOPKINSON said that it appeared to him that the instrument collected the actual amount of rain which fell, so that its daily trace could be checked by measuring the amount of water accumulated during the 24 hours.

Mr. BAYARD inquired whether the rain recorded was only that which fell within the inner rim of the receiver? If so, he did not see the object of the outer rim.

Mr. A. R. BINNIE said that for the past two years he had watched the development of this rain-gauge, and when the idea of such a thing was mooted he, like Mr. Symons, was extremely sceptical concerning its practicability. He did not believe that a gauge would be constructed on this principle which would give sufficiently accurate results; but after having taken part in a good number of experiments in connection with the construction and working of this form of rain-gauge, he had been led to believe that it really was a good instrument, and one which would give valuable results. The gauge did actually check its own indications, but he agreed with Mr. Symons that it would be advisable at first, to give confidence, to have an ordinary gauge in its vicinity, so that the records obtained from the new form of instrument could be thoroughly tested, but he felt certain that this ordinary gauge would soon become unnecessary, as he believed that the author's gauge would establish confidence in its own record. It was hardly suitable for mountain work, except in cases where the expense of a long line of wire communication could be incurred, but it was well adapted for ordinary observatory work, and was likely to afford valuable records respecting heavy rainfall in short periods.

Mr. GASTER inquired whether Mr. W. J. E. Binnie could give any idea as to the probable cost of this instrument.

Mr. W. J. E. BINNIE, in reply, said that he had not before heard of any similar form of rain gauge being in existence. It was not generally believed that drops were so uniform in size as the diagram indicated. The paper on which the registrations were traced allowed three quarters of an inch for a time interval of an hour, and about four inches for one inch of rain recorded. If it was thought desirable, a table of coefficients might be compiled from the diagram, giving the results of experiments made with drops at various rates, and by this means such corrections could be applied to the registrations of the instrument as would make it perfectly accurate. The second rim was placed round the inner receiving vessel in order that the gauge should be uniform in exposure with an ordinary 5-inch rain gauge. The price of the instrument was about £7 10s.

ON WET AND DRY BULB FORMULÆ.

By Prof. J. D. EVERETT, M.A., F.R.S.

(Communicated by G. J. Symons, F.R.S., Secretary.)

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[The following Paper was written by Professor Everett many years since, while he was engaged upon the translation of Deschanel's *Traité Elémentaire de Physique*. It has never been published, and believing that it was very desirable that that should be done, I have asked and obtained the author's permission to offer it to the Royal Meteorological Society.—G. J. S.]

August on the Continent of Europe, and Dr. Apjohn in this country, investigated, independently of each other, a method of determining, by calculation, the maximum vapour tension for the dew-point from the temperatures of the dry and wet bulb. August's investigations are contained in *Poggendorff's Annalen* for 1825 and 1828, and Apjohn's in the *Phil. Mag.* for 1835 and the *Trans. R.I.A.* for 1837.

The physical principle assumed by both investigators is precisely the same. Dr. Apjohn (*Trans. R.I.A.* Vol. XVII. p. 277) states it in the following very distinct terms :—

"When in the moist-bulb hygrometer the stationary temperature is attained, the caloric which vaporises the water is necessarily exactly equal to that which the air imparts in descending from the temperature of the atmosphere to that of the moistened bulb ; and the air which has undergone this reduction becomes saturated with moisture."

August's statement of it (*Pogg. Ann.* V. 1825, p. 76), literally translated from the original German, is as follows :—

"The air around the moist thermometer will, in the nearest layer, which we may take as thin as we please, assume the temperature of the thermometer, and will be in a state of saturation at this temperature, inasmuch as the vapour already contained in it is, by that newly evolved, increased to the maximum. The immediate surrounding of the thermometer (a space bounded perhaps by two concentric very near spherical surfaces), in which we can assume equal temperature with the thermometer and maximum vapour density, we shall in our examination lay as foundation.

"There are in this space three constituents : (1) dry air ; (2) atmospheric vapour (denoting by this name the quantity of vapour which the surrounding air already contains) ; (3) newly formed vapour.

"The first two constituents have evidently yielded up their heat to assist in the formation of the third. Thus what the dry air and atmospheric vapour have lost in heat, the newly-formed vapour has rendered latent in its formation."

With these assumptions, if we know the specific heat at constant pressure of the external air, which it is to be noted is not dry air, the latent heat of vaporisation at the temperature of the wet bulb, the relative density of vapour at this temperature, and the height of the barometer, and if we have also a table of maximum vapour-tensions for different temperatures, we can easily form an equation which gives the tension of the vapour in the external air, and this is the same thing as the maximum tension for the dew-point; hence, by reference to the table, the dew-point is known.

In fact the mass of the external air, or what August calls the *first two constituents* of the saturated film, is to the mass of the third constituent, the newly-formed vapour, as the barometric pressure is to the product of the pressure of this newly-formed vapour by its relative density. But the pressure of the newly-formed vapour is the excess of maximum tension for the wet bulb temperature above maximum tension at the dew-point. The masses are therefore as $h : D\,(f' - F)$,

and we have the equation

$$s\,(t - t')\,h = LD\,(f' - F) \qquad (1)$$

where

t = temperature of dry bulb $\qquad f$ = maximum tension for t
t' = temperature of wet bulb $\qquad f'$ = " t'
T = dew-point $\qquad F$ = " T
s = specific heat of the external air
h = barometric pressure
L = latent heat of vaporisation
D = relative density of vapour as compared with the external air at the same pressure and temperature.

Equation (1) may be written

$$f' - F = (t - t')\,h\,.\,\frac{s}{LD}$$

Dr. Apjohn treats $\frac{s}{LD}$ as a constant quantity, and gives it the value $\frac{1}{2610}$ or $\frac{1}{87} \times \frac{1}{30}$. This is for the Fahrenheit scale. Reduced to suit the Centigrade scale, Dr. Apjohn's value becomes $\frac{1}{1450}$.

The value finally adopted for $\frac{s}{LD}$ was $\frac{\cdot 568}{640 - t'}$.

Regnault, in a very elaborate paper in *Ann. de Chim.* Vol XV. published in 1845, computes on August's principles the theoretical value $\frac{\cdot 429}{610 - t'}$, but states that, when the relative humidity exceeds 0·40, a much better agreement with observation is obtained by adopting the value $\frac{\cdot 480}{610 - t'}$. In all these cases, the temperatures of observation are supposed to be above freezing, as the computation is modified when the wet bulb is frozen, We shall now proceed to compare these formulæ at the wet bulb temperature 50°F. or 10° C.

Apjohn's value of $\frac{s}{LD}$ is $\frac{1}{1450}$

August's ... ... $\frac{1}{1109}$

Regnault's theoretical value is $\frac{1}{1399}$

" empirical ... ... $\frac{1}{1250}$

I have now to call attention to an important circumstance which has been generally overlooked, namely, that in none of the theoretical investigations yet published have the latest and best determinations of specific and latent heat been employed. All three of the authors whom I have named employ the value of s (the specific heat of air) obtained by Delaroche and Berard, namely ·267, whereas Regnault's experiments, which were conducted subsequently to the publication of his paper on Hygrometry, give the value ·237.

For L, the latent heat of vapour, Apjohn adopts as sufficiently near for practical purposes the constant value 1129 F. or 627 C. August adopts the value $640-t'$, and Regnault the value $610-t'$, the correct value as afterwards determined by Regnault being $606{\cdot}5-695\,t'$, which, however, does not differ much at ordinary temperatures, from the value actually employed by Regnault.

As regards the relative density of steam D, the assumptions made by the three authors do not differ sensibly from one another, nor from the generally received value according to the latest determinations; this value may be taken as ·622,

Putting in the best values at present available, the value of $\frac{s}{LD}$ is $\frac{\cdot 381}{606{\cdot}5-\cdot 695\,t'}$ or say $\frac{\cdot 381}{607-\cdot 7t'}$, which at the temperature $t'=10°$ becomes $\frac{1}{1575}$.[1]

This value, it will be observed, differs considerably from any of the four values, which have been tabulated above, and it differs most of all from that

[1] At average temperatures and pressures, this gives very nearly

$$f-F=\tfrac{1}{2}\,(t-t')$$

tensions being expressed in millimetres of mercury, and temperatures in degrees Centigrade. For inches of mercury and degrees Fahr. it gives

$$f-F=\frac{t-t'}{95}$$

and Regnault's empirical formula gives

$$f-F=\frac{t-t'}{84}$$

value which Regnault empirically adopted as agreeing best with actual analysis of the air, as well as with direct observation of the dew-point, the discrepancy amounting to some 25 per cent.

It appears, then, that there must be some flaw in the theory as laid down by August and Apjohn.

As regards this theory, I would remark in the first place that the fundamental principle which has been assumed by both authors, and which I have given above in their own words, is obviously untrue. It involves two false assumptions:—

(1) That all the air which loses heat to the wet bulb falls to the temperature of the wet bulb.

(2) That all the air which loses heat to the wet bulb becomes saturated with vapour.

I think there can be no reasonable doubt that, when the wet bulb is in a current of air (and this condition is essential to its proper working), portions of air pass the wet bulb at such distances as to be cooled by all intermediate amounts between nothing and the maximum difference. Also that portions of air pass at such distances from the wet bulb as to acquire increments of vapour-tension of all intermediate amounts between nothing and the maximum increase. But August and Apjohn ignore both the heat lost and the vapour taken up by all air except such as undergoes both changes to the full amount.

But false premises sometimes lead to a true conclusion, and in the present case the two false assumptions which I have pointed out tend to correct one another. It is by no means easy to pronounce whether their combined result would be to make the calculated dew-point too high or too low. If we suppose that the depression of temperature and the exaltation of vapour-tension are always proportional to one another, not only in comparing one particle with itself at different times, but also in comparing one particle with another, it will follow that the two false assumptions exactly correct one another, at least if it be true that some of the air is saturated at the temperature of the wet bulb.

Probably, however, vapour diffuses less readily than heat; so that, practically, a larger mass of air is concerned in giving heat to the wet bulb than in taking up the vapour which is generated. This is why a better result is obtained by assigning an unduly large value to the specific heat of air than by assigning the true value.

This difference in diffusive powers has more room to operate as the air is calmer, and is altogether overpowered by the forced convection which occurs in high wind.

Moreover, it appears from Regnault's comparisons above referred to, that when the air was at more than four-tenths of saturation, it was necessary to modify the original formula in a way equivalent to assuming, instead of the already too large value of the specific heat of air, a value still larger in the ratio $\frac{480}{429}$, but for air drier than this the original formula gave better results than the formula thus modified. This seems to prove that the superiority of heat to vapour in diffusive power is more marked in moist than in dry air.

Other sources of error are, radiation to the wet bulb from surrounding objects, and, to some trifling extent, conduction down the stem of the wet bulb thermometer, both of which tend to increase the discrepancy which we are considering. The absolute amount of radiation is proportional to the difference of temperature between the wet bulb and surrounding objects, and therefore increases with the dryness of the air, but the largest *percentage* of error from radiation must occur in the calmest weather, because calmness does not affect the activity of radiation, while it does greatly diminish the rapidity of convection and evaporation.

All sources of error are exaggerated by calm. If it be the case, as Regnault's experiments seem to show, that, even in a strong draught, a better result is obtained by employing the erroneous value ·267 for the specific heat of air than by using the true value ·237, it seems to follow that the air in actual contact with the wet bulb is, so to speak, nearer to the temperature of the wet bulb than to saturation, that is to say, denoting its temperature by τ and its vapour-tension by φ—

$$\frac{\tau - t'}{t - t'} \text{ is less than } \frac{f' - \phi}{f' - F}$$

whence

$$\frac{t - \tau}{t - t'} \text{ is greater than } \frac{\phi - F}{f' - F}$$

or the change which the air has undergone from its original condition is greater as regards temperature than as regards vapour-tension, if the greatest possible change be in each case the unit of comparison.

In fact, the correct equation which should take the place of (1) is

$$\int s\,(t - \tau)\,h\,dv = \int LD\,(\phi - F)\,dv,$$

dv denoting the volume of an element of air near the wet bulb. What I have indicated as probably the main source of the discrepancy observed by Regnault, may be expressed by saying that the limits for v are not the same in the two integrals, but are wider for the first member of the equation than for the second. In high wind this inequality cannot subsist, and the only way of compensating the assumption of an unduly large value for s lies in assuming too large a value for $\frac{\phi - F}{t - \tau}$. The value which has been assumed for the latter is $\frac{f' - F}{t - t'}$, and I think we must conclude, from the evidence now before us, that, in a strong draught, $\frac{\phi - F}{t - \tau}$ is really less than this.

As I have only met with one critique on the principles of Apjohn and August, namely that of Regnault, and as it partly agrees with and partly differs from the views which I have just expressed, I shall give a literal translation of it. In p. 212 of his Article on "Hygrometry," by way of explaining the discordance between theory and experiment, he says :—

"I do not think we can admit as the basis of calculation for the psychrometer the fundamental hypothesis adopted by M. August, namely, that all the air which furnishes heat to the wet thermometer descends to the temperature t' indicated by this thermometer, and becomes completely saturated with humidity.

"*The ratio of the quantity of heat which the air carries off from the bulb by evaporation of water to the quantity of heat which it loses by cooling* is probably greatest when the air is driest, because in this state it is much more greedy of moisture than when it approaches its state of saturation.

"Lastly, the temperature of the wet bulb is not only influenced by the air immediately around it; it is subjected to the radiation of the enclosure, the influence of which will be variable according to the state of agitation of the air."

The reasoning in the former of these paragraphs is not very clear. It seems to lose sight of the axiomatic principle that, when the wet bulb is remaining steady at one temperature, it must be giving and receiving equal quantities of heat. The heat which it gives is that which becomes latent in evaporation; and if the heat which it receives *from the air* is less than this, it must receive from other sources (by radiation and conduction) an amount precisely equal to the difference.

The practical conclusion which Regnault draws is, that theory can only indicate the form of the formula of reduction to be employed, and that the values of the constants must be determined empirically.

In the presence of this uncertainty as to a rational formula, I think Mr. Glaisher did wisely in constructing his table of factors, which give the dew-point approximately by the most direct calculation which is admissible. The inherent difficulties of hygrometric observation and deduction are great, and have not yet been fully overcome.

DISCUSSION.

Mr. Gaster, after saying that meteorology was suffering from the want of a good and handy hygrometer, remarked that something ought to be done to give observers more confidence in the hygrometrical indications, and then the instrument would be better attended to. He had known several cases in which, through gross inattention to the covering and cleansing of the wet-bulb thermometers, the instrument was rendered worse than useless for hygrometrical purposes. Then there is the painful fact that even when the greatest care is exercised, and the muslin changed, say, as often as once in three weeks, the indications of the wet-bulb are by no means satisfactory, as it is found that at the expiration of that short period the condition of the muslin covering, though clean, has altered from what it was when first put round the bulb, so that the thermometer readings at the end of the three weeks are not to be compared with those at the beginning. When these facts are considered in connection with the doubt which hangs about the formulæ employed, it is evident that the hygrometrical results at present used are of a most misleading character.

Results of Meteorological Observations made at Akassa, Niger Territories, May 1889 to December 1890.

By FRANK RUSSELL, F.R.G.S., F.R.Met.Soc.

[Received September 3rd.—Read November 18th, 1891.]

THESE observations were resumed on May 22nd, 1889, and have been conducted upon the methods and with the same instruments as during 1887 and 1888, described in the *Quarterly Journal*, Vol. XV. p. 199, with the addition of earth temperature. The interval includes 589 days; the actual number upon which the observations were made is reduced to 508, the omissions being 14 days in October 1889, the months of October, November, and 6 days in December 1890.

Barometer.—The mean pressure for this period is 29·982 ins. The highest recorded 30·187 ins. on July 29th, 1890; the lowest 29·785 ins. on December 19th, 1889; the difference being 0·402 in. The monthly inequalities are for August 1889 and July 1890 in excess, whilst for December 1889 and February 1890 occur the greatest defects. These divergences are represented by 0·183 in. in 1889, and 0·179 in. in 1890. The oscillation was greatest in December 1889, 0·295 in., and June 1890, 0·222 in., and least in August 1889, 0·122 in., and July 1890, 0·134 in., the mean for the period being 0·184 in.

Temperature.—The highest means are for the months December to April, and the maximum for the year occurred during the early days of April. The lowest means are registered for August and September, and the minimum for the year about August 8th. The difference between the maximum and minimum temperatures for each month is greatest from November to January.

The mean temperature for September was 1°·5 below the mean for the whole period, that for April 2°·4 above, and the mean temperature of these months differs but 0°·3 from the general mean 77°·9.

The highest temperature recorded in the shade was 91°·5 in December 1889, being 1°·8 over the average for that year, and 13°·2 above the general mean. The lowest, 60°·5, occurred in August 1890, the difference from the average being 8°·6, and from the mean 17°·1. The range of temperature is thus 31°·0 for the period, that for any single day was as high as 22°·5.

Temperature of Soil.—At a depth of three feet the range of temperature recorded was 3°·5, highest 81°·9 in August, and lowest 78°·4 in July. The mean temperature derived from the depths one, two and three feet was 80°·1, which differs about 2°·0 from the mean shade temperature of the air at the same hour, 9 a.m.

Radiation.—The highest recorded temperature in the sun's rays was 155°·2 in October 1889. The lowest on grass was 56°·3 in August 1890. The annual range was thus 98°·9. The mean monthly range was 64°·3, that for June 1890 being below, and October 1889 above,

RESULTS OF METEOROLOGICAL OBSERVATIONS MADE AT AKASSA, NIGER TERRITORY, MAY 1889 TO DECEMBER 1890.

Months.	Barometer. Means. 9 a.m.	Barometer. Means. 9 p.m.	Barometer. Extremes. Highest Observed.	Barometer. Extremes. Lowest Observed.	Temperature. Extremes. Highest.	Temperature. Extremes. Lowest.	Temperature. Means. Max.	Temperature. Means. Min.	Temperature. Means. Mean.	Temperature. Means. 9 a.m.	Temperature. Means. 9 p.m.	Radiation. Black Bulb in Sun. Highest.	Radiation. Black Bulb in Sun. Mean.	Radiation. Min. on Grass. Lowest.	Radiation. Min. on Grass. Mean.	Sunshine. Total hours Recorded.	Sunshine. Percentage of possible duration.	Hygrometry. Dew-Point. 9 a.m.	Hygrometry. Dew-Point. 9 p.m.	Hygrometry. Relative Humid. 9 a.m.	Hygrometry. Relative Humid. 9 p.m.	Hygrometry. Vap. Tension. 9 a.m.	Hygrometry. Vap. Tension. 9 p.m.	Wind Velocity. Amount in 12 hours. Greatest.	Wind Velocity. Amount in 12 hours. Least.	Wind Velocity. Monthly Mean. Day.	Wind Velocity. Monthly Mean. Night.	Wind Velocity. Daily Average per hour.
	Ins.	Ins.	Ins.	Ins.	°	°	°	°	°	°	°	°	°	°	°			°	°	%	%	In.	In.	Miles.	Miles.	Miles.	Miles.	Miles.
1889.																												
May ⅓ ..	30·013	29·976	30·046	29·847	87·7	72·8	84·6	74·3	79·5	81·8	76·6	152·9	139·8	70·3	73·0	..	15·3	76·8	74·4	85·0	92·0	·921	·851	92·2	10·5	68·2	27·4	4·0
June	·039	30·013	·121	·910	88·4	72·0	82·6	73·7	78·1	79·5	75·7	153·6	131·9	69·2	71·7	67·9	18·3	75·5	74·3	87·6	95·5	·882	·850	117·8	15·3	59·5	33·6	3·9
July	·043	·011	·112	·911	85·1	69·8	80·9	73·2	77·1	77·9	75·2	149·3	127·5	66·6	70·7	70·0	17·4	73·7	72·5	86·2	90·9	·830	·799	137·0	10·8	79·1	59·5	5·8
August ..	·065	30·030	·103	·981	83·4	70·9	81·5	73·4	77·4	78·4	74·7	149·6	134·2	66·1	69·2	89·8	23·8	73·2	71·8	84·3	90·1	·817	·779	117·0	14·0	78·4	48·5	5·3
September	30·034	29·990	·071	·922	83·9	69·7	80·5	72·6	76·5	77·2	74·1	152·1	131·2	64·0	68·3	34·9	9·6	74·0	73·0	89·9	95·9	·840	·811	94·7	3·8	63·8	38·2	4·3
October ..	29·974	·953	·037	·886	86·5	70·8	83·2	73·3	78·2	79·4	76·1	155·2	144·6	65·9	69·7	92·0	24·8	75·0	74·4	87·4	96·0	·869	·851	80·0	3·5	57·2	19·4	3·2
November	·958	·935	·045	·821	87·5	66·0	85·9	72·0	78·9	85·8	74·1	151·8	137·0	61·0	67·2	119·0	33·5	74·1	72·5	81·9	94·6	·847	·801	114·2	1·0	48·9	13·9	2·6
December	29·900	29·829	30·030	29·735	91·5	70·0	86·1	73·1	79·6	81·4	76·6	142·6	130·1	65·1	69·7	..	..	76·7	74·9	85·5	94·1	·919	·867	..	..	..	..	..
Means for 8 Months	30·003	29·967	..	..	86·8	70·2	83·2	73·2	78·2	..	..	150·9	138·3	66·0	70·0	..	..	74·9	73·9	86·0	93·6	·866	·826	..	..	65·0	34·3	4·2
1890.																												
January	29·937	29·915	30·015	29·804	89·8	65·5	86·7	71·6	79·1	80·6	74·1	140·3	131·4	58·3	66·0	..	..	75·2	72·5	83·7	94·4	·876	·810	..	..	..	..	..
February	·908	·876	29·983	·825	89·5	69·4	86·3	73·5	79·9	81·4	76·8	147·8	134·0	63·3	67·7	134·4	40·2	75·7	74·8	83·0	93·0	·876	·865	91·3	3·1	69·7	29·4	4·1
March ..	·937	·907	30·000	·799	88·6	70·1	85·7	72·9	79·3	81·0	76·5	154·0	139·0	66·9	69·5	121·0	30·5	75·4	74·3	83·0	93·0	·881	·848	113·3	6·0	70·1	30·1	4·3
April	·981	·921	29·994	·859	88·7	70·4	85·8	74·2	80·0	83·1	76·9	149·1	137·4	66·6	71·0	129·2	35·6	76·5	75·0	80·8	93·9	·913	·869	94·8	4·5	70·4	25·3	4·0
May	29·992	29·959	30·052	·881	86·7	69·0	83·9	72·8	78·3	81·4	76·2	151·2	134·9	65·0	69·3	126·2	33·3	75·4	73·7	82·1	92·1	·880	·833	105·0	5·7	72·8	32·2	4·4
June	30·051	30·021	·119	29·897	85·1	70·8	81·4	73·5	77·4	78·5	75·6	148·8	128·7	68·0	78·7	51·3	13·9	73·9	72·4	85·7	89·8	·838	·796	109·0	9·8	53·8	74·5	5·3
July	·088	·054	·137	30·003	83·4	67·2	80·4	71·8	76·1	76·9	74·0	146·2	131·0	61·2	67·4	107·0	31·2	71·5	70·3	80·7	88·2	·773	·741	112·3	6·4	78·0	44·4	5·1
August ..	·058	·014	·116	29·938	83·9	60·5	82·1	70·9	76·5	78·5	73·3	151·1	139·4	56·3	66·8	141·8	41·5	71·2	69·9	70·9	88·0	·766	·729	120·0	2·4	79·6	36·5	4·8
September	30·040	30·014	·089	·915	83·8	68·7	81·4	71·5	76·4	77·2	73·4	154·5	133·9	65·1	68·1	41·3	15·6	73·7	72·1	89·0	95·6	·831	·788	87·5	3·9	50·1	21·4	3·0
October ..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..
November	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..
December	29·969	29·954	30·054	29·888	86·0	68·7	83·7	72·8	78·2	80·4	75·2	146·4	134·4	65·1	69·2	91·5	29·7	75·4	73·3	85·4	93·0	·881	·820	77·3	3·3	49·9	15·1	2·7
Means for 10 Months	29·996	29·964	..	..	86·6	68·0	83·7	72·6	78·1	..	..	148·9	134·4	63·6	69·4	..	..	74·4	72·9	82·4	92·1	·852	·810	..	..	66·0	34·3	4·2

RESULTS OF METEOROLOGICAL OBSERVATIONS MADE AT AKASSA, NIGER TERRITORY, MAY 1889 TO DECEMBER 1890.

Months.	Rain.				Wind Direction with Amount of Rain and No. of Days.																				Cloud.		Weather.				
	Total.	No. of Rainy Days.	Greatest Fall.	Date.	N.		NE.		E.		SE.		S.		SW.		W.		NW.		Calm.		Totals.		Amount at 9 a.m.	Amount at 9 p.m.	No. of Days K.	No. of Days T.	No. of Days <.	No. of Days d	No. of Days ≡
					Days.	Rain.	Days.	Rain.	Days.	Rain.	Days.	Rain.	Days.	Rain.	Days.	Rain.	Days.	Rain.	Days.	Rain.	Days.	Rain.	Days.	Rain.							
1889.	Ins.		Ins.			Ins.		Ins.		Ins.		Ins.		Ins.		Ins.		Ins.		Ins.		Ins.		Ins.							
May ⅓......	9·755	9	3·580	30	..	..	2	2·15	..	..	..	..	..	..	4	2·75	1	3·58	..	..	2	1·28	9	9·76	9·0	3·6	4	3	2	5	..
June	17·548	26	2·630	26	1	0·60	4	2·17	..	..	..	..	..	..	9	6·27	2	1·67	..	..	10	6·84	26	17·55	8·5	6·1	12	7	1	11	16
July	17·970	20	4·160	11	1	4·16	..	..	..	..	..	..	1	3·53	9	4·27	2	1·04	2	3·09	5	1·89	20	17·97	8·4	7·8	4	1	..	8	31
August	26·885	16	8·350	28	..	..	..	..	..	..	..	..	2	0·24	10	16·02	1	0·11	1	5·81	2	4·71	16	26·89	8·3	7·6	2	..	..	7	14
September	28·875	28	3·400	8	..	..	2	0·47	..	..	..	..	3	0·82	9	12·18	4	4·34	..	..	10	11·07	28	28·87	9·0	8·0	1	4	..	..	..
October	19·125	17	5·050	7	..	..	2	1·97	..	..	1	0·02	..	..	6	10·29	1	2·20	..	..	7	4·65	17	19·12	9·0	7·0	6	4	1	7	2
November ..	3·055	12	0·930	15	..	..	..	..	..	..	2	0·94	..	..	4	0·43	..	..	..	..	6	1·69	12	3·05	8·7	7·7	8	4	2	15	14
December ..	7·055	7	4·100	19	..	..	..	..	..	..	1	0·50	..	..	5	5·90	..	..	..	..	5	0·65	7	7·05	7·3	5·7	9	7	..	10	6
Totals for 7⅓ Months	130·268	135	..	..	2	4·76	10	6·76	..	..	4	1·46	6	4·59	56	58·11	11	12·94	3	8·90	47	32·78	135	130·26	..	..	46	30	6	63	83
1890.																															
January ..	3·630	4	1·535	13	..	..	..	..	..	..	..	..	..	..	1	1·54	..	..	1	1·45	2	0·64	4	3·63	5·3	1·8	1	1	1	16	14
February ..	5·020	9	2·810	19	..	..	4	3·80	..	..	2	0·25	..	..	1	0·18	1	0·70	1	0·09	..	..	9	5·02	6·7	5·0	7	3	0	20	10
March	11·039	16	3·740	27	..	..	6	1·68	1	1·11	3	1·41	..	..	2	2·85	1	0·11	2	3·75	1	0·13	16	11·03	8·2	5·0	9	7	1	23	7
April	7·680	12	3·360	19	..	..	2	4·25	..	..	..	..	..	..	5	1·53	..	..	1	1·01	4	0·89	12	7·68	7·0	4·1	9	9	5	20	..
May	13·380	22	2·610	7	..	..	6	2·53	..	..	3	0·33	..	..	8	5·52	..	..	1	0·83	4	4·16	22	13·38	8·0	4·0	14	5	3	17	..
June	22·767	20	3·520	14	1	1·22	..	..	..	..	..	..	..	..	12	9·72	..	..	1	2·23	6	9·59	20	22·76	8·9	8·0	5	4	..	3	7
July	8·505	11	4·900	1	..	..	..	..	..	..	..	..	2	4·92	8	2·82	1	0·77	..	..	..	..	11	8·50	8·0	5·1	..	1	..	11	4
August	0·285	5	0·150	21	..	..	..	..	..	..	..	..	1	0·06	3	0·07	1	0·15	..	..	..	..	5	0·28	7·6	5·4	..	..	..	7	..
September..	24·715	26	6·700	15	..	..	..	..	..	..	..	..	..	..	5	2·82	9	7·49	3	3·24	9	11·16	26	24·71	9·1	6·8	..	5	2	2	3
October	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..
November ..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..
December ..	6·330	19	2·230	5	..	..	..	..	..	..	1	2·32	..	..	7	2·47	1	0·08	..	..	10	1·46	19	6·33	7·3	2·8	6	11	..	11	1
Totals for 10 Months	103·351	144	..	..	1	1·22	18	12·27	1	1·11	9	4·31	3	4·98	52	29·52	14	9·30	10	12·61	36	28·04	144	103·35	..	..	51	46	12	130	46

TEMPERATURE OF THE SOIL AT 9 A.M.

1890.	July.			August.			September.			December.		
	Mean.	Max.	Min.	Mean.	Max.	Min.	Mean.	Max.	Min.	Mean.	Max.	Min.
Below the Surface.	°	°	°	°	°	°	°	°	°	°	°	°
1 foot	80·1	81·2	78·3	81·6	82·8	80·7	79·4	83·1	70·9	80·2	81·6	77 9
2 feet	80·3	81·3	78·8	81·7	82·3	80·9	80·8	82·6	79·2	80·7	81·6	79·7
3 ,, ...	79·4	80·1	78·4	80·8	81·9	80·1	80·5	81·8	79·2	80·0	80·6	79·7

Sunshine.—The average duration of bright sunshine recorded was 25¼ °/₀ of the possible amount, and was greatest in the month of August 1890. This was an unusually hot and dry period for that year, showing an excess over both 1888 and 1889. September 1889 gives the smallest result, being but 9½ °/₀. Although in no instance is a very high average reached; the interval comprised between November and May gives a fairly good continuous result.

Vapour-tension.—The actual amount of vapour present in the atmosphere is greatest in the months of April and December, and least during July-August. The mean difference is about one-seventh of the average quantity.

The mean percentage of relative humidity was highest in September and lowest in July.

Rainfall.—Most rain falls in September, and least in January. The period of wet days is embraced by the months July to October, and the dry season by those of November to February. The number of days upon which rain fell was 279, or 56½ °/₀ of those on which observations were made. The total measured 283·62 ins., and of this 57¼ °/₀ was due to winds from South-west by West to North, 15 °/₀ to those from North-east by East to South. The largest amounts of rain occurred on August 28th, 1889, when 8·85 ins. fell in 24 hours, wind South-west, and on September 15th, 1890, when 6·70 ins. fell, wind West veering to South to calm.

Wind.—The mean hourly velocity per day was 5·5 miles, per night 2·8 miles, and was highest during the rainy season and lowest in the dry.

Cloud.—On the average $\frac{7}{10}$ths of the sky was obscured by clouds, which were most prevalent from June to November and least during January.

Fogs and Mists, &c.—These are common throughout the year; their intensity is greatest in June and July, and least in May and September. Dew is deposited from November to May, most copiously during February to April. Unusual visibility of distant objects occurs between the heavy rain, which it appears to precede closely. Halos not seen, lunar coronæ and rainbows seldom. Harmattan dust during November and December is sufficiently dense to cut off the sun's rays of light, but not his heat, which at midday is often intense. At these months sand-flies and fire-flies are abundant during the nights, whilst during the daylight of November 19th, 1889, we were visited by swarms of gadflies. In the wet season, when the nights are calm and pressure high, the air is stifling, and so depressing as to make it almost impossible to sleep.

Electrical Phenomena were frequent. Heavy thunderstorms occurred during April, May and June, in March and December thunder alone, and in April and May lightning alone. On August 27th, 1889, a thunderstorm commenced at 11 a.m., wind North-west, with heavy rain at 2 p.m., and the downpour continued for several days. At 9 a.m. 28th, gauged 5·81 ins.; 6 p.m. same day 3½ ins.; 29th, 9 a.m., this had swollen to 8·35 ins.; 6 p.m., 3·75 ins.; 9 a.m. 30th, 4·83 ins.; and 9 a.m. 31st, 2·35 ins., making a total for four days of 21·34 ins. Wind veering to South-west followed by settled calm.

The period has been a very unhealthy one, and the year 1890 especially so. The weather was exceptionally dry, with small-pox and phthisis amongst the native population. The West Coast reports generally were also unfavourable in reference to the condition of resident Europeans, and at the principal ports quarantine regulations were put in force, consequent upon an outbreak of yellow fever in places situated to the south-west. At Bonny 10 deaths occurred from November to February, out of a population of some 16 Europeans.

REPORT ON THE THUNDERSTORMS OF 1888 AND 1889.

By WILLIAM MARRIOTT, F.R.Met.Soc., Assistant Secretary.

(Plates III. and IV.)

[Read December 16th, 1891.]

At the end of the year 1887 the Council, at the request of the Hon. Ralph Abercromby, decided to take up the systematic investigation of Thunderstorms over the South-east of England, a grant of £25 having been obtained from the Royal Society for the purpose of defraying the cost of printing forms, observation books, &c.

In order to organise the observations, the Council appointed the Thunderstorm Committee, who prepared instructions and forms, and issued circulars to all rainfall observers in the South-east of England, as well as to the Fellows of the Society, asking them to make certain definite observations on all thunderstorms that might occur in their neighbourhood. In response to this appeal 92 persons promised to send in observations of thunderstorms from the South-east of England and 131 from other parts of the country. Some of these persons failed to send in any reports for 1889, as in that year observations were only received from 51 places in the South-east of England, and from 119 places in other parts of the country.

INSTRUCTIONS.

The instructions to the observers were the following :—

ROYAL METEOROLOGICAL SOCIETY.

INSTRUCTIONS FOR THUNDERSTORM OBSERVERS (1888).

Observers are divided into three classes:—A, B, and C.

Class A are expected to fill up so much of the form as is headed A; but may add anything they may have observed that comes under B or C.

Class B are expected to fill up so much of the form as is headed both A and B; but may add under C.

Class C are expected to fill up A, B, and C, besides adding anything else they may think noteworthy, especially sketches or height determinations of clouds.

No one is to be deterred from filling up part of a form because he cannot fill all.

Every observer will be furnished with:—

1. A strongly-bound pocket-book containing the form of observations in which the original records are to be made.

2. Twelve forms of observations, on paper suitable for transmission by post. The records from the pocket-book will be copied into this in ink, and forwarded within three days of the occurrence to the Assistant Secretary of the Royal Meteorological Society.

A separate form will be used for each thunderstorm, however many there may be on the same day. Thunderstorms will be considered distinct when they are separated by more than one hour without thunder or lightning.

DATE.—The date of a thunderstorm will be reckoned for the day on which it commenced, *e.g.*, if the storm began at 11 p.m., 30th July, it will be counted for the 30th, even though it may last till 4 or 5 a.m. on the 31st.

When only three blank forms remain, make a memorandum to that effect on the front page of the form you send, and a fresh supply will be forwarded.

GENERAL CHARACTER.—Thunderstorms are of many types—for instance, there is the well-defined thunderstorm; the squall with thunder; and periods of ill-defined rainy weather when lightning is seen flickering and thunder heard growling all night among mountains. Then there is sheet lightning, thunder without lightning, and so on. This line might be filled up by the following epithets:—Well-defined storm; squalls or showers with thunder and lightning; ill-defined thunderstorm, or thundery period; thunder without lightning; sheet lightning.

INTENSITY.—1. slight; 2. moderate; 3. severe.

NEAR OR DISTANT.—Near, if any thunder is heard less than ten seconds after the flash of lightning; distant, if the shortest interval is more than ten seconds. Scratch out the word "near" or "distant" as the case requires.

If no seconds watch is available, eleven or twelve beats of the pulse, according to the temperament, may be employed instead.

TIME.—This should be noted to the minute; the watch or clock used should be corrected once a week by the nearest railway or telegraph station or post-office clock.

DIRECTION OF THUNDER OR LIGHTNING.—This should be reckoned to eight points, N.; N.E.; E.; S.E; S.; S.W.; W.; and N.W. *N.B.* True North corresponds to about N.N.E. of the compass.

THUNDER, LIGHTNING, RAIN, HAIL.—When some of these do not occur, write—none. Do not leave the space merely blank.

WIND.—Direction to eight points:—N.; N.E.; E.; S.E.; S.; S.W.; W.; and N.W. Force on Beaufort's scale, 0-12; 0 being dead calm; 12, a hurricane. Note especially under the next heading of "General Remarks," the time when any hot or cold blasts occur.

GENERAL REMARKS.—State anything you notice, such as if the wind came in a well-defined squall, or any other peculiarity of the storm. If the space in this part of the form is too small, there is abundance of room for notes on the front page.

WAS STORM DESTRUCTIVE?—Yes or no. Give details of any destruction and names of sites of damage under "General Remarks."

LEAST NUMBER OF SECONDS BETWEEN LIGHTNING AND THUNDER.—Time this if possible.

OTHER ELECTRICAL PHENOMENA.—Note "St. Elmo's Fire," Aurora, &c., within twelve hours of storm or anything else of interest.

FORM, COLOUR, AND DESCRIPTION OF FLASHES.—Note whether sheet, forked, beaded, bomb-like, thunderbolt, &c. Also if the flashes rise from or fall to the ground. Note also the colour.

CLOUDS (Form).—This cannot be done too carefully or minutely. Note particularly the shape and time of formation of the first clouds in front of the rain. Sketch, or still better, photograph whenever possible.

PRESSURE, TEMPERATURE. HUMIDITY, WIND AND CLOUD DIRECTION.—Insert as much of this as you can; the form need not be completely filled up. Wind and cloud are the most important. Note most carefully the direction to which successive layers of cloud are going one above the other, and do not mix up the observations on different levels. There are often four or five to be distinguished. Barometer readings should be corrected both for temperature and altitude.

TIME FOR C. OBSERVERS.—Though the time at which any phenomenon occurs —time of first rain, time of wind shift, &c., is of primary importance, instrumental readings at every even quarter of an hour—*e.g.* 4, 4.15, 4.30, &c.—are specially requested, as this facilitates comparison.

NEWSPAPER CUTTINGS.—All observers are requested to send the Society any cuttings from newspapers that refer to any notable storms.

FORM FOR OBSERVATIONS.

The form for observations is given below. Very few of the observers, however, furnished particulars as to the forms and motion of the clouds. Such information would have been most valuable.

A

Station *Reference No.*

On *the* *of* 188

General Character

Intensity

Near or Distant?

THUNDER	First heard at	h.	m.	m. in the
	Loudest „	„	„	„ „
	Last „	„	„	„ „
LIGHTNING (including Sheet)	First seen at	h.	m.	m. in the
	Brightest „	„	„	„ „
	Last „	„	„	„ „

RAIN	Began at	h.	m.	Heaviest at	h.	m.	Ended at	h.	m.
HAIL	„			„			„		

B

	Before Storm.	During Storm.	After Storm.
WIND Direction ..			
WIND Force (0—12)			

GENERAL REMARKS FOR A, B, & C.

C

Was storm destructive?

Least No. of secs. between Lightning and Thunder secs. at h. m. m.

Other electrical phenomena.
Form, colour, and description of flashes.

CLOUDS (form).

PRESSURE, TEMPERATURE, HUMIDITY & CLOUD (Direction).

Time.	Barom.	Thermom.		Wind.		CLOUD (Direction) and REMARKS.
		Dry.	Wet.	Direction.	Force.	
....	....	....	....	....	....	....
....	....	....	....	....	....	....
....	....	....	....	....	....	....
....	....	....	....	....	....	....

METHOD OF DISCUSSION.

As Mr. Abercromby was unable, owing to ill-health and absence from England, to supervise the discussion of the very large mass of printed and other materials that have been received, the Council requested me to undertake the discussion of the observations as a special investigation. I should very much have preferred that Mr. Abercromby should have superintended the discussion, as he was the originator of the scheme and had definite ideas as to the objects to be accomplished, and also as to how they might be attained. The investigation being an entirely new one, I have had to proceed on new lines, and have, consequently, not been able to consult with, or to avail myself of the advice of, anyone who had already worked at the subject.

The discussion has been confined to the observations made during the years 1888 and 1889.

In this investigation the time of the hearing of the *first* peal of thunder has been taken as the commencement of the storm.

By a further grant from the Royal Society an additional computer was engaged to assist in tabulating the large mass of materials which the Society had collected respecting thunderstorms.

The first step was to read out from the reports the times of the first thunder in each storm, and to enter them into forms of hourly frequency for each station, and also to plot the same on large maps specially prepared for the purpose. The second step was to enter and plot the times of sheet lightning. The third step was to note and plot the occurrences of hail. The fourth step was to ascertain and mark on the maps the positions of the places at which it was reported that any damage by lightning had occurred. Different symbols were employed for indicating (1) loss of human life; (2) loss of animal life (*e.g.* sheep, cattle, horses, &c.); and (3) structural damage (*e.g.* houses, buildings, trees, &c.). This last was a tedious and difficult proceeding, as all the newspaper reports had to be carefully examined and the sites of the various places (very often practically almost unknown and therefore most difficult to find) ascertained.

The Thunderstorm Committee decided that the stations should be arranged according to the Divisions adopted by the Registrar-General of Births and Deaths, and also employed in Symons's *British Rainfall.* The maps were accordingly printed with these Divisions marked on them. There are eleven Divisions, which contain the following counties:—

Division.	Counties.
I.	Middlesex.
II.	Surrey, Kent, Sussex, Hampshire, Berks.
III.	Herts, Buckingham, Oxford, Northampton, Huntington, Bedford, Cambridge.
IV.	Essex, Suffolk, Norfolk.
V.	Wilts, Dorset, Devon, Cornwall, Somerset.
VI.	Gloucester, Hereford, Shropshire, Stafford, Worcester, Warwick.
VII.	Leicester, Rutland, Lincoln, Notts, Derby.
VIII.	Cheshire, Lancashire.
IX.	Yorkshire.
X.	Durham, Northumberland, Cumberland, Westmoreland.
XI.	Monmouth and Wales.

These Divisions are not by any means of the same size, No. I. consisting only of the small county of Middlesex, while Nos. II. and V. together comprise the whole of the south of England. I have not, however, except in Table I., confined myself to these Divisions, as the observers were not sufficiently numerous to be representative of the whole of the Divisions. In fact, for a complete investigation into thunderstorm phenomena, the country should be studded with observers not more than five miles apart.

I fear that all the observers have not reported *every* thunderstorm that has occurred in their neighbourhood, as at some stations the totals are very small compared with others close by where the observers have been on the watch for thunderstorms. Bearing this in mind, and as it is also not possible to weight the observations, I have not considered it desirable to give here the details for each station.

Days of Thunderstorms, Lightning and Hail.

The stations reporting the greatest number of days with thunderstorms were as follows:—

Days of Thunderstorms.

1888.		1889.	
Bennington, Herts	36	Tean, Stafford	33
Tean, Stafford	25	Bennington, Herts	32
Rowington, Warwick	20	Rounton, Yorks	26

RESULTS OF METEOROLOGICAL OBSERVATIONS MADE AT AKASSA, NIGER TERRITORY, MAY 1889 TO DECEMBER 1890.

Months.	Barometer.				Temperature.							Radiation.				Sunshine.		Hygrometry.						Wind Velocity.				
	Means.		Extremes.		Extremes.		Means.					Black Bulb in Sun.		Min. on Grass.				Dew-Point.		Relative Humid.		Vap. Tension.		Amount in 12 hours.		Monthly Mean.		
	9 a.m.	9 p.m.	Highest Observed.	Lowest Observed.	Highest.	Lowest.	Max.	Min.	Mean.	9 a.m.	9 p.m.	Highest.	Mean.	Lowest.	Mean.	Total hours Recorded.	Percentage of possible duration.	9 a.m.	9 p.m.	9 a.m.	9 p.m.	9 a.m.	9 p.m.	Greatest.	Least.	Day.	Night.	Daily Average per hour.
1889.	Ins.	Ins.	Ins.	Ins.	°	°	°	°	°	°	°	°	°	°	°			°	°	%	%	In.	In.	Miles.	Miles.	Miles.	Miles.	Miles.
May 1/3 ..	30·013	29·976	30·046	29·847	87·7	72·8	84·6	74·3	79·5	81·8	76·6	152·9	139·8	70·3	73·0	..	15·3	76·8	74·4	85·0	92·0	·921	·851	92·2	10·5	68·2	27·4	4·0
June	·039	30·013	·121	·910	88·4	72·0	82·6	73·7	78·1	79·5	75·7	153·6	131·9	69·2	71·7	67·9	18·3	75·5	74·3	87·6	95·5	·882	·850	117·8	15·3	59·5	33·6	3·9
July	·043	·011	·112	·911	85·1	69·8	80·9	73·2	77·1	77·9	75·2	149·3	127·5	66·6	70·7	70·0	17·4	73·7	72·5	86·2	90·9	·830	·799	137·0	10·8	79·1	59·5	5·8
August ..	·065	30·030	·103	·981	83·4	70·9	81·5	73·4	77·4	78·4	74·7	149·6	134·2	66·1	69·2	89·8	23·8	73·2	71·8	84·3	90·1	·817	·779	117·0	14·0	78·4	48·5	5·3
September	30·034	29·990	·071	·922	83·9	69·7	80·5	72·6	76·5	77·2	74·1	152·1	131·2	64·0	68·3	34·9	9·6	74·0	73·0	89·9	95·9	·840	·811	94·7	3·8	63·8	38·2	4·3
October ..	29·974	·953	·037	·886	86·5	70·8	83·2	73·3	78·2	79·4	76·1	155·2	144·6	65·9	69·7	92·0	24·8	75·0	74·4	87·4	96·0	·869	·851	80·0	3·5	57·2	19·4	3·2
November	·958	·935	·045	·821	87·5	66·0	85·9	72·0	78·9	85·8	74·1	151·8	137·0	61·0	67·2	119·0	33·5	74·1	72·5	81·9	94·6	·847	·801	114·2	1·0	48·9	13·9	2·6
December	29·900	29·829	30·030	29·735	91·5	70·0	86·1	73·1	79·6	81·4	76·6	142·6	130·1	65·1	69·7	..	..	76·7	74·9	85·5	94·1	·919	·867	..	..	..	..	..
Means for 8 Months	30·003	29·967	..	..	86·8	70·2	83·2	73·2	78·2	..	..	150·9	138·3	66·0	70·0	..	..	74·9	73·9	86·0	93·6	·866	·826	..	..	65·0	34·3	4·2
1890.																												
January	29·937	29·915	30·015	29·804	89·8	65·5	86·7	71·6	79·1	80·6	74·1	140·3	131·4	58·3	66·0	..	..	75·2	72·5	83·7	94·4	·876	·810	..	..	..	..	..
February	·908	·876	29·983	·825	89·5	69·4	86·3	73·5	79·9	81·4	76·8	147·8	134·0	63·3	67·7	134·4	40·2	75·7	74·8	83·0	93·0	·876	·865	91·3	3·1	69·7	29·4	4·1
March ..	·937	·907	30·000	·799	88·6	70·1	85·7	72·9	79·3	81·0	76·5	154·0	139·0	66·9	69·5	121·0	30·5	75·4	74·3	83·0	93·0	·881	·848	113·3	6·0	70·1	30·1	4·3
April	·981	·921	29·994	·859	88·7	70·4	85·8	74·2	80·0	83·1	76·9	149·1	137·4	66·6	71·0	129·2	35·6	76·5	75·0	80·8	93·9	·913	·869	94·8	4·5	70·4	25·3	4·0
May	29·992	29·959	30·052	·881	86·7	69·0	83·9	72·8	78·3	81·4	76·2	151·2	134·9	65·0	69·3	126·2	33·3	75·4	73·7	82·1	92·1	·880	·833	105·0	5·7	72·8	32·2	4·4
June	30·051	30·021	·119	29·897	85·1	70·8	81·4	73·5	77·4	78·5	75·6	148·8	128·7	68·0	78·7	51·3	13·9	73·9	72·4	85·7	89·8	·838	·796	109·0	9·8	53·8	74·5	5·3
July	·088	·054	·137	30·003	83·4	67·2	80·4	71·8	76·1	76·9	74·0	146·2	131·0	61·2	67·4	107·0	31·2	71·5	70·3	80·7	88·2	·773	·741	112·3	6·4	78·0	44·4	5·1
August ..	·058	·014	·116	29·938	83·9	60·5	82·1	70·9	76·5	78·5	73·3	151·1	139·4	56·3	66·8	141·8	41·5	71·2	69·9	70·9	88·0	·766	·729	120·0	2·4	79·6	36·5	4·8
September	30·040	30·014	·089	·915	83·8	68·7	81·4	71·5	76·4	77·2	73·4	154·5	133·9	65·1	68·1	41·3	15·6	73·7	72·1	89·0	95·6	·831	·788	87·5	3·9	50·1	21·4	3·0
October ..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..
November	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..
December	29·969	29·954	30·054	29·888	86·0	68·7	83·7	72·8	78·2	80·4	75·2	146·4	134·4	65·1	69·2	91·5	29·7	75·4	73·3	85·4	93·0	·881	·820	77·3	3·3	49·9	15·1	2·7
Means for 10 Months	29·996	29·964	..	..	86·6	68·0	83·7	72·6	78·1	..	..	148·9	134·4	63·6	69·4	..	..	74·4	72·9	82·4	92·1	·852	·810	..	..	66·0	34·3	4·2

Results of Meteorological Observations made at Akassa, Niger Territory, May 1889 to December 1890.

Months.	Rain. Total.	Rain. No. of Rainy Days.	Rain. Greatest Fall.	Rain. Date.	N. Days.	N. Rain.	NE. Days.	NE. Rain.	E. Days.	E. Rain.	SE. Days.	SE. Rain.	S. Days.	S. Rain.	SW. Days.	SW. Rain.	W. Days.	W. Rain.	NW. Days.	NW. Rain.	Calm. Days.	Calm. Rain.	Totals. Days.	Totals. Rain.	Cloud. Amount at 9 a.m.	Cloud. Amount at 9 p.m.	Weather. No. of Days K.	Weather. No. of Days T.	Weather. No. of Days ϟ	Weather. No. of Days ⏊	Weather. No. of Days ≡
1889.	Ins.		Ins.			Ins.		Ins.		Ins.		Ins.		Ins.		Ins.		Ins.		Ins.		Ins.		Ins.							
May ⅓ ……	9·755	9	3·580	30	..	..	2	2·15	..	..	..	..	..	..	4	2·75	1	3·58	..	..	2	1·28	9	9·76	9·0	3·6	4	3	2	5	..
June ……	17·548	26	2·630	26	1	0·60	4	2·17	..	..	..	..	..	..	9	6·27	2	1·67	..	..	10	6·84	26	17·55	8·5	6·1	12	7	1	11	16
July ……	17·970	20	4·160	11	1	4·16	..	..	..	..	..	..	1	3·53	9	4·27	2	1·04	2	3·09	5	1·89	20	17·97	8·4	7·8	4	1	..	8	31
August ….	26·885	16	8·350	28	..	..	..	..	..	..	..	..	2	0·24	10	16·02	1	0·11	1	5·81	2	4·71	16	26·89	8·3	7·6	2	..	..	7	14
September	28·875	28	3·400	8	..	..	2	0·47	..	..	..	..	3	0·82	9	12·18	4	4·34	..	..	10	11·07	28	28·87	9·0	8·0	1	4	..	..	..
October ….	19·125	17	5·050	7	..	..	2	1·97	..	..	1	0·02	..	..	6	10·29	1	2·20	..	..	7	4·65	17	19·12	9·0	7·0	6	4	1	7	2
November ..	3·055	12	0·930	15	..	..	..	..	..	..	2	0·94	..	..	4	0·43	..	..	..	..	6	1·69	12	3·05	8·7	7·7	8	4	2	15	14
December ..	7·055	7	4·100	19	..	..	..	..	..	..	1	0·50	..	..	5	5·90	..	..	..	..	5	0·65	7	7·05	7·3	5·7	9	7	..	10	6
Totals for 7⅓ Months	130·268	135	..	..	2	4·76	10	6·76	..	..	4	1·46	6	4·59	56	58·11	11	12·94	3	8·90	47	32·78	135	130·26	..	..	46	30	6	63	83
1890.																															
January ..	3·630	4	1·535	13	..	..	..	..	..	..	..	..	..	..	1	1·54	..	..	1	1·45	2	0·64	4	3·63	5·3	1·8	1	1	1	16	14
February ..	5·020	9	2·810	19	..	..	4	3·80	..	..	2	0·25	..	..	1	0·18	1	0·70	1	0·09	..	..	9	5·02	6·7	5·0	7	3	0	20	10
March ….	11·039	16	3·740	27	..	..	6	1·68	1	1·11	3	1·41	..	..	2	2·85	1	0·11	2	3·75	1	0·13	16	11·03	8·2	5·0	9	7	1	23	7
April ……	7·680	12	3·360	19	..	..	2	4·25	..	..	..	..	..	..	5	1·53	..	..	1	1·01	4	0·89	12	7·68	7·0	4·1	9	9	5	20	..
May ……	13·380	22	2·610	7	..	..	6	2·53	..	..	3	0·33	..	..	8	5·52	..	..	1	0·83	4	4·16	22	13·38	8·0	4·0	14	5	3	17	..
June ……	22·767	20	3·520	14	1	1·22	..	..	..	..	..	..	..	..	12	9·72	..	..	1	2·23	6	9·59	20	22·76	8·9	8·0	5	4	..	3	7
July ……	8·505	11	4·900	1	..	..	..	..	..	..	..	..	2	4·92	8	2·82	1	0·77	..	..	..	..	11	8·50	8·0	5·1	..	1	..	11	4
August ….	0·285	5	0·150	21	..	..	..	..	..	..	..	..	1	0·06	3	0·07	1	0·15	..	..	..	..	5	0·28	7·6	5·4	..	..	..	7	..
September..	24·715	26	6·700	15	..	..	..	..	..	..	..	..	..	..	5	2·82	9	7·49	3	3·24	9	11·16	26	24·71	9·1	6·8	..	5	2	2	3
October ….	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..
November ..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..
December ..	6·330	19	2·230	5	..	..	..	..	..	..	1	2·32	..	..	7	2·47	1	0·08	..	..	10	1·46	19	6·33	7·3	2·8	6	11	..	11	1
Totals for 10 Months	103·351	144	..	..	1	1·22	18	12·27	1	1·11	9	4·31	3	4·98	52	29·52	14	9·30	10	12·61	36	28·04	144	103·35	..	..	51	46	12	130	46

TABLE II.—HOURLY FREQUENCY OF THUNDERSTORMS IN EACH COUNTY DURING THE YEAR 1888.

County.	1 a.m.	2 a.m.	3 a.m.	4 a.m.	5 a.m.	6 a.m.	7 a.m.	8 a.m.	9 a.m.	10 a.m.	11 a.m.	Noon.	1 p.m.	2 p.m.	3 p.m.	4 p.m.	5 p.m.	6 p.m.	7 p.m.	8 p.m.	9 p.m.	10 p.m.	11 p.m.	Mid-night.
Bedford	..	..	..	..	..	..	..	..	..	..	..	..	1	1	..	..	..	..	..	..	..	..	..	..
Berks	..	..	..	..	..	..	1	..	..	..	1	2	1	1	1	2	1	1	..	..	..	..	..	..
Bucks	..	..	..	..	..	..	..	..	..	1	..	..	3	..	2	..	..	1	..	..	..	..	..	..
Cambridge	..	1	1	..	..	..	..	1	..	1	..	1	1	2	2	..	..	..	..	..	1	..	1	..
Cheshire	..	..	..	..	..	..	..	..	2	1	7	10	5	4	6	4	2	2	1	..	..	..	1	2
Cornwall	..	..	..	..	..	..	..	..	..	1	2	..	..	1	..	..	..	..	..	..	..	..	..	..
Cumberland	1	1	..	..	..	..	..	..	..	..	1	1	1	1	1	1	2	1	1	1	1	..	..	..
Derby	..	..	..	..	..	..	..	..	..	2	1	3	2	3	2	2	1	1	..	..	..	..	..	..
Devon	1	2	..	1	..	..	..	1	1	1	1	5	5	6	2	3	4	3	4	3	3	1	..	..
Dorset	..	..	..	..	..	..	..	..	..	..	..	4	..	..	2	2	1	..	..	..	..	1	..	..
Durham	..	..	..	..	..	..	..	..	..	..	2	1	2	4	1	1	1	1	..	..	..	..	..	..
Essex	..	1	1	..	..	..	1	1	..	1	4	2	2	3	4	3	6	2	2	..	1	2	1	1
Gloucester	..	..	..	..	..	..	..	..	..	1	2	1	1	4	5	4	1	1	..	..	1	..	..	..
Hants	..	..	..	..	..	..	1	2	3	4	6	7	7	3	5	5	6	4	..	2	..	1	1	1
Hereford	..	..	..	..	..	..	1	1	..	..	..	..	3	..	..	1	..	..	..	1	..	..	..	..
Hertford	1	..	1	..	1	..	..	1	..	1	1	3	3	2	2	3	2	1	2	..	3	2	1	..
Kent	1	..	1	..	..	1	1	2	3	3	10	11	10	11	7	12	5	3	4	5	6	2	2	2
Lancashire	..	1	1	..	..	..	..	..	1	4	6	10	6	1	6	5	6	4	3	1	1	1	1	1
Leicester	..	..	..	1	..	..	..	..	1	..	1	3	5	..	1	1	1	1	..	..	..	..	1	..
Lincoln	..	..	..	..	..	1	..	..	..	2	1	1	1	1	1	3	..	1	..	..	..	..	..	..
Middlesex	..	..	..	..	..	..	..	..	..	1	1	..	5	6	1	4	2	3	1	1	1	2	..	..
Norfolk	..	..	1	..	1	1	1	..	..	2	2	2	2	7	5	4	5	2	1	..	1	1	..	..
Northumberland	..	..	..	..	..	..	..	..	..	..	..	..	..	2	1	..	..	2	..	..	..	..	..	..
Nottingham	..	..	..	..	1	1	..	..	2	3	2	7	2	4	5	2	1	1	..	..	..	..	..	..
Oxford	..	..	1	..	..	..	..	..	..	2	..	2	1	1	3	1	1	..	..	..	..	..	..	..
Shropshire	..	..	..	..	..	..	..	..	..	..	..	..	1	..	2	..	..	..	..	..	..	..	..	..
Somerset	..	..	..	1	..	..	..	1	..	..	..	..	..	..	1	1	..	..	..	..	..	..	..	..
Stafford	..	..	..	..	1	1	..	..	2	2	4	4	7	2	4	5	1	3	..	..	..	1	1	..
Suffolk	2	1	..	..	..	1	1	..	..	1	..	1	..	5	3	6	1	..	3	2	..	1	..	1
Surrey	1	1	..	..	..	..	..	..	..	2	3	6	9	10	5	4	4	5	1	..	3	2	2	1
Sussex	..	..	..	..	1	..	1	1	3	5	5	2	3	5	5	3	3	2	3	1	3	3	3	1
Warwick	..	..	..	..	..	..	..	1	1	..	4	..	1	1	4	3	..	..	..	..	1	1	1	..
Westmoreland	1	..	..	..	..	..	..	..	..	..	..	..	..	..	1	..	..	..	..	1	..	..	..	..
Wilts	..	..	1	..	..	..	..	..	1	3	1	2	2	2	2	4	1	1	1	..	..	..	..	..
Worcester	..	..	..	..	..	..	..	..	..	..	2	..	..	..	4	2	..	1	..	..	1	..	..	..
Yorkshire	..	..	..	..	..	..	..	1	2	5	7	8	8	12	7	7	3	2	2	3	..	..	..	..
Wales	..	..	.	..	..	..	..	..	..	1	2	1	..	1	2	2	..	1	1	2	1	1	1	1
Percentage	0·8	0·8	0·8	0·3	0·5	0·6	0·8	1·4	2·3	5·2	8·2	10·4	10·4	11·0	10·9	10·4	6·3	5·2	3·1	2·4	2·9	2·3	1·8	1·2

TABLE III.—HOURLY FREQUENCY OF THUNDERSTORMS IN EACH COUNTY DURING THE YEAR 1889.

County.	1 a.m.	2 a.m.	3 a.m.	4 a.m.	5 a.m.	6 a.m.	7 a.m.	8 a.m.	9 a.m.	10 a.m.	11 a.m.	Noon.	1 p.m.	2 p.m.	3 p.m.	4 p.m.	5 p.m.	6 p.m.	7 p.m.	8 p.m.	9 p.m.	10 p.m.	11 p.m.	Mid-night.
Berks	..	..	..	..	..	1	..	..	..	..	1	1	1	1	3	1	2	3	4	..	1	..	..	..
Bucks	..	..	..	..	..	..	1	..	..	..	..	1	..	..	1	..	1	1	1	..	1	..	..	..
Cambridge	..	..	..	..	..	..	..	..	..	..	..	1	..	..	2	2	..	2	..	2	1	..	..	..
Cheshire	..	1	..	..	..	..	1	1	2	1	2	7	7	9	7	6	7	5	1	1	2	2	1	..
Cumberland	..	..	..	..	..	..	1	..	2	..	..	1	..	..	..	3	1	1	1	..	..	..	..	..
Derby	..	..	..	..	..	..	..	..	1	..	1	2	1	2	1	..	..	..	..	..	..	..	..	..
Devon	..	2	..	1	1	..	..	..	..	..	..	..	2	2	2	2	3	4	2	3	3	1	..	..
Dorset	..	..	..	..	1	..	..	..	..	..	..	..	..	..	..	..	2	..	1	..	..	..	..	..
Durham	..	..	..	..	2	1	..	..	..	2	..	1	1	2	3	3	2	1	1	..	1	..	1	..
Essex	..	..	..	1	..	..	..	..	..	..	2	2	3	2	1	3	3	2	1	2	2	..	1	..
Gloucester	..	..	..	..	..	1	..	..	..	..	1	4	1	9	6	4	5	..	..	..	..	..	1	..
Hants	..	..	..	..	..	..	..	..	..	..	1	5	3	4	6	4	4	2	..	2	1	1	..	..
Hereford	1	..	..	..	..	..	..	..	..	..	2	8	3	4	1	4	2	..	..	..	..	..	..	..
Hertford	1	..	..	..	..	..	1	..	..	1	1	2	..	2	..	7	3	6	1	2	3	..	..	..
Kent	2	1	..	..	..	..	..	1	1	..	3	1	9	2	4	6	4	5	3	2	2	1	..	1
Lancashire	..	..	1	..	..	..	1	1	2	2	4	6	5	6	6	4	3	..	1	..	1	..	..	..
Leicester	..	..	..	..	..	..	..	..	..	..	..	1	..	3	2	4	2	..	1	..	..	..	..	..
Lincoln	..	..	..	..	..	..	..	..	..	..	..	1	1	..	..	4	2	3	..	..	..	..	..	..
Middlesex	..	..	..	..	..	..	..	..	..	1	1	2	1	2	4	7	2	1	1	2	1	..	..	..
Norfolk	1	1	..	..	..	1	1	..	..	..	1	3	2	2	4	6	2	3	2	4	1	2	..	..
Northampton	..	1	..	..	..	..	..	..	..	..	..	..	1	..	..	..	..	..	..	..	..	..	..	..
Northumberland	..	..	..	..	..	..	..	..	..	1	..	2	..	3	1	1	1	1	..	..	..	..	..	..
Nottingham	..	..	..	..	..	..	..	..	..	..	4	5	4	5	10	3	6	3	..	..	..	..	..	..
Oxford	..	..	..	..	..	2	..	..	..	..	..	2	1	1	4	2	1	1	..	..	..	..	..	..
Shropshire	..	..	..	..	..	..	..	..	1	..	..	..	..	2	1	1	..	..	..	..	..	..	..	..
Somerset	..	..	..	..	..	..	..	1	..	..	..	..	2	1	..	..	..	1	..	1	..	..	..	..
Stafford	..	..	..	..	..	..	1	..	1	2	2	5	10	7	5	2	4	2	1	..	..	..	..	..
Suffolk	..	..	..	..	1	..	..	..	..	1	1	4	2	1	3	5	2	1	1	4	1	1	1	..
Surrey	..	..	..	..	..	..	..	..	1	2	4	7	5	2	12	10	9	5	1	2	..	1	1	..
Sussex	..	..	..	..	..	1	1	..	..	..	3	5	4	4	2	6	1	1	2	2	2	1	..	..
Warwick	..	..	..	..	..	..	1	..	..	..	..	..	..	2	2	2	1	..	..	..	..	..	..	..
Westmoreland	..	..	..	..	..	..	..	1	..	..	..	1	..	2	..	1	..	1	..	..	..	..	..	..
Wilts	..	..	1	..	..	..	..	..	..	..	1	1	3	3	3	..	3	..	..	1	1	..	..	..
Worcester	..	..	..	..	1	..	1	..	..	..	..	..	2	6	1	2	..	..	..	..	..	..	..	..
Yorkshire	..	..	2	..	..	1	..	1	1	3	5	6	8	11	10	9	13	3	2	..	2	1	..	..
Wales	..	..	1	..	1	..	..	..	..	..	2	1	1	2	4	1	1	..	..	..	..	..	..	..
Percentage	0·6	0·7	0·6	0·2	0·8	0·9	1·1	0·7	1·4	1·8	4·8	10·1	9·5	11·9	12·7	13·2	10·6	6·7	3·2	3·4	3·0	1·3	0·7	0·1

plotted thereon. These particulars included the times of the first and last thunder, the times of the commencement and ending of the rain, the occurrence of hail, the direction and force of the wind before, during, and after the storm, and also the changes in the temperature of the air. At first it seemed only possible to trace clearly the paths of a few storms, as the observers did not always distinguish between separate storms. But the times of the commencement of the rainfalls greatly assisted in tracking many other storms.

From these maps it is evident that several storms occurred often in the same neighbourhood, sometimes running nearly parallel with each other, sometimes following one another, and sometimes even crossing or merging into each other.

Specimens of these maps are given in Figs. 1 and 2, Plate III. The black circle indicates the position of the station at which thunder was heard. The figures give the times of the first and last thunder, and of the commencement and ceasing of the rain. Hail is indicated by the symbol ▲. The small arrows show the direction of the wind before, during and after the storm. The long arrows indicate the track of the storms.

A good example of three storms crossing or merging into one another occurred in the neighbourhood of London on June 6th, 1889; an evening long to be remembered for the brilliant display of lightning. One storm came up from the south-east and passed over the east of London; the second storm came up from the south-south-east and passed directly across London; while the third storm came up from the south-south-west, and passed over the western suburbs. The three storms apparently reached the north of London within a few minutes of each other. (Fig. 2, Plate III.)

Thunderstorms appear to travel at an average rate of about 18 miles per hour in ill-defined low barometric pressure systems, but at a higher rate in squally conditions. Numerous observations from stations very close together are required to determine satisfactorily the length and path of thunderstorms. I am inclined, however, to think that individual thunderstorms do not travel more than about 20 miles.

Thunderstorms evidently take the path of least resistance, and consequently are most frequent on flat and low ground.

Relation of Thunderstorms to the Distribution of Atmospheric Pressure.

As already mentioned, it was originally decided by the Council that the Thunderstorm investigation should be confined to thunderstorms over the south-east of England. This area answered fairly well for tracking the paths of such storms as occurred in that district, and for determining their rate of travel. But for the purposes of investigating the relation of thunderstorms to the distribution of atmospheric pressure, this region is much too circumscribed. I have, accordingly, not confined my attention to this district only, but have taken the whole of England and Wales.

I carefully examined the Daily Weather Charts, kindly placed at my disposal by the Meteorological Council, for each day on which a thunderstorm was reported. It soon became apparent that thunderstorms usually occurred when the isobars showed large areas of ill-defined low pressure, or when there was a "lane" or trough of low pressure between higher pressure on each side. There was also an occasional slight deflection of the wind at some of the stations. Mist or fog was very frequently prevalent. The height of the barometer does not appear to have any effect on the formation of the storms, for they have occurred with pressure as high as 30·4 ins. on May 21st, 1888, and with pressure below 29·0 ins. as on March 26th, 1888.

After examining a large number of these Daily Weather Charts with the Thunderstorm Maps, it appeared to me that further information might be obtained if charts were prepared showing the isobars for hundredths instead of tenths of an inch. As this was an extensive and laborious undertaking, I hesitated for a long time over the matter. Ultimately I decided to take the month of June 1888 (as thunderstorms were very frequent during that month), and to prepare charts for 9 a.m. and 9 p.m. for each day, showing 1. Isobars for two hundredths (·02) of an inch: 2. direction and force of the wind; 3. temperature; 4. relative humidity; and 5. vapour tension. For the preparation of these charts I used all the observations from the Society's Second Order and Climatological stations, and also from the Second Order stations of the Meteorological Office, as well as observations which I obtained by special request from a number of stations.

An examination of these detailed charts revealed the fact that instead of the pressure being so very ill-defined, as appeared on the Daily Weather Charts, there were frequently a number of small but distinct areas of low pressure, or cyclones, with regular wind circulation; and that these small cyclones passed over the districts from which the thunderstorms were reported. Sometimes it was not possible to make out well formed areas of low pressure for two hundredths of an inch, but there was a deflection of the wind which showed that there was some disturbing cause; and thunderstorms had usually occurred in that immediate neighbourhood. In addition to the direction of the wind, the direction of the motion of the clouds and upper currents were also plotted on the charts. When these showed different currents thunderstorms were almost invariably reported.

An interesting example is afforded by the charts of June 25th, 1888. At 9 a.m. the clouds and upper currents over the whole of the south-east of England were moving in a different direction to that of the surface wind, which was evidently affected by local disturbances. Over this district there were some thunderstorms in progress at that time, and others occurred a little later. (Figs. 3 and 4. The directions of the clouds and upper currents are shown by dotted arrows.)

The 9 p.m. chart shows a trough of low pressure reaching across the southern part of England from the south-east coast and covering the whole of Wales, and enclosing two low centres of 29·92 ins. Thunderstorms of a destructive nature occurred over nearly the whole of this district during the day. (Figs. 3 and 5.)

The thunderstorm depressions seem to circulate round the areas of lowest pressure in shallow depressions, and to travel in the direction of the prevailing wind. This is shown on almost all charts, when the region of lowest pressure comes well over England.

I was for a long time puzzled to know why it was that occasionally thunderstorms would pass over a station in the morning from one direction, and that in the evening they would come up from an exactly opposite direction. A good instance of this occurred on June 26th, 1888. In the morning a thunderstorm travelled from the east and passed over Greenwich a little before 8 o'clock; and in the evening another thunderstorm came up from the south-west or west and passed over the same place.

A copy of the records from the Greenwich barograph and anemograph are given in Fig. 9, Plate IV. From the isobaric charts it appears that in the morning a thunderstorm depression was passing over Greenwich in a westerly direction on the northern side of the area of low pressure; and that in the evening another depression passed in an easterly direction on the southern side of the area of low pressure. (Figs. 6, 7 and 8.)

Occurrences of Thunderstorms on Consecutive Days.

The areas of ill-defined low pressure frequently remain much the same for several days together, and so thunderstorms may occur on successive days, and often about the same hour.

Table IV. shows the occurrences of thunderstorms on consecutive days during the two years 1888 and 1889; from which it will be seen that there were two instances in each year of thunderstorms having occurred on 9 or more consecutive days. In July 1888 thunderstorms occurred on 15 consecutive days.

"Line" Thunderstorms.

In the preceding remarks I have almost entirely confined my attention to thunderstorms which are associated with ill-defined low barometric pressure. There are, however, two other types to which I must refer, viz. 1. "Line" thunderstorms; and 2. Thunderstorms accompanying large barometric depressions. These latter usually occur in winter, and are frequently associated with squalls.

I have already brought to the notice of the Society two instances on which a series of thunderstorms were tracked across England in a direct line from south to north for over 400 miles, the rate of progression being 50 miles an hour. These thunderstorms occurred during the night and early morning. It is remarkable that on each occasion thunderstorms which were both destructive and slow in motion prevailed during the following afternoon over a large area. (Figs. 10 and 11.)

These thunderstorms are so interesting that it seems desirable to quote the account of each from my previous papers.

TABLE IV.—CONSECUTIVE DAYS OF THUNDERSTORMS.

1888.	Consecutive Days.														
	1.	2.	3.	4.	5.	6.	7.	8.	9.	10.	11.	12.	13.	14.	15.
January	2	..	..	..	..	..	..	..	..	..	..	..	..	..	..
February	..	1	..	..	..	..	..	..	..	..	..	..	..	..	..
March ..	1	2	1	..	..	..	..	..	..	..	..	..	..	..	..
April	2	..	..	..	1	..	..	..	..	..	..	..	..	..	..
May	2	1	..	1	..	..	..	..	..	..	..	..	..	..	..
June	2	..	..	2	..	..	..	..	..	1	..	..	..	..	..
July	..	2	..	..	..	..	1	..	..	..	..	..	..	..	1
August ..	3	1	1	..	2	..	..	..	..	..	..	..	..	..	..
September	3	2	..	..	..	..	..	..	..	..	..	..	..	..	..
October ..	1	..	1	..	..	..	..	..	..	..	..	..	..	..	..
November	2	..	1	1	..	..	..	..	..	..	..	..	..	..	..
December	..	1	..	..	..	..	..	..	..	..	..	..	..	..	..
Totals ..	18	10	4	4	3	..	1	..	..	1	..	..	..	..	1
1889.															
January	1	..	..	..	..	..	..	..	..	..	..	..	..	..	..
February	4	..	1	..	..	..	..	..	..	..	..	..	..	..	..
March ..	2	..	..	..	..	..	..	..	..	..	..	..	..	..	..
April	1	..	1	1	1	1	..	..	..	..	..	..	..	..	..
May	1	1	1	..	..	..	1	..	..	..	1	..	..	..	..
June	4	2	2	..	..	..	..	..	..	..	..	..	..	..	..
July	1	..	..	..	..	..	..	..	2	..	..	..	..	..	..
August ..	1	2	1	..	..	..	1	..	..	..	..	..	..	..	..
September	1	1	1	..	..	..	..	..	..	..	..	..	..	..	..
October ..	3	1	..	2	..	..	..	..	..	..	..	..	..	..	..
November	2	..	..	..	..	..	..	..	..	..	..	..	..	..	..
December	1	..	..	..	..	..	..	..	..	.	..	..	..	..	..
Totals ..	22	7	7	3	1	1	2	..	2	..	1	..	..	..	..

MAY 18th-19th, 1888.

The storm on the night of the 18th-19th passed across England in a direct line from south to north, at the rate of 50 miles an hour.

Thunder was first heard at Christchurch, Hants, at 8.15 p.m. Lightning was first seen at Totton, near Southampton, in the south at 7.58 p.m. The storm then progressed in a northerly direction, thunder being heard at Beckford, near Tewkesbury, at 9.52, and at Worcester about 10.0. The storm passed a little to the west of Birmingham, where the lightning was incessant and very vivid between 10 and 11 p.m. Thunder was heard at Upper Tean at 10.40; at Manchester at 11.59; at Garstang at 0.30 a.m.; at Windermere about 1.30; at Kirkby Thore at 1.45; at Carlisle about 2.0; and at Edinburgh about 4. The storm evidently reached Cupar Fife at 4.5, as the Fife and Kinross Asylum was struck by lightning at that time and set on fire.

In addition to the reports of thunder given above, many observers in various parts of the country saw lightning during the evening and night of the 18th. Where they have given the time and direction in which the lightning was seen, it has been found that these agree precisely with the positions of the thunderstorm at those times, although the observers, in two cases at least, were more than 100 miles from the storm.

At Babbacombe, near Torquay, lightning was seen in the east-north east at 8.30 p.m., and in the north-east at 9.12; at Harestock, in the south-west, at 8.25, and in the north-north-west at 10.0 and later; at Mere, in the north-east, at 9.0; at Churchstoke, in the south-east at 9.45; at Berkhamsted, in the north-west at 10; at Upper Tean, in the south at 10.10, and in the north-west at 11.30; at the Kew Observatory, in the north-west at 10.30: at Manchester, in the north-west at 0.50 a.m.; at Chester, in the north at 1.0; and at Kirkby Thore, in the north at 3 a.m.

It will thus be seen that this thunderstorm came up from the English Channel about 8 p.m. on the 18th, passed across the country in a north by west direction, and reached the Firth of Forth by 4 a.m. on the 19th. The distance traversed was over 400 miles, the rate of progression of the storm being 50 miles an hour. (*Quarterly Journal*, Vol. XIV., p. 296.)

June 2nd, 1889.

On Sunday morning, June 2nd, a thunderstorm passed across England in a northerly direction from Wiltshire about 8 a.m., and reached Edinburgh at 10.44 a.m. The times of the occurrence of the first thunder at several places are given on the map (Fig. 11). From these it will be seen that the storm progressed at a nearly uniform speed over the 400 miles, the rate of travel being about 50 miles an hour. A few notices of thunderstorms in the east of Scotland during this day were published in the newspapers, but the times were not stated. If these referred to the storm under discussion, it is possible that it travelled still further north, and reached Kirkwall in the Orkneys at 3.37 p.m. If this should be the case, we have the very remarkable and interesting instance of a thunderstorm travelling from south to north in a straight path for fully 550 miles at the uniform rate of 50 miles an hour.

This storm was very similar to that which occurred on May 18th-19th, 1888.

Large hailstones fell at a few places, the following being the size of the largest stones :—

Droitwich.—One weighed over 3 ozs.

Wollaston.—Some were 1¼ in. and 1 in. in diameter.

Bolton.—2 to 3 ins. in circumference.

Meltham, Yorks.—About the size of marbles.

This storm was not very destructive, only four cases of damage by lightning being reported. (*Quarterly Journal*, Vol. XV. p. 219.)

The Weather Charts for 8 a.m. on May 19th, 1888, and June 2nd, 1889, are reproduced in Figs. 12 and 13. From these it appears that the atmospheric conditions were somewhat similar on both occasions.

Thunderstorms accompanying large Barometric Depressions.

Thunderstorms accompanying large barometric depressions usually occur in the south-east quadrant, and at some distance from the actual centre of the depression. An instance of this type was given in my paper "The Great Storm of January 26th, 1884," in which I stated :—

"Thunderstorms occurred on the south-eastern side of the depression, and travelled in an easterly direction at the rate of about 30 miles an hour across the South of Ireland and the greater part of England to the East Coast. These thunderstorms were most probably associated with a subsidiary depression, which was no doubt the cause of the bulging out of the isobars over the South of England." (*Quarterly Journal*, Vol. X., p. 115.)

Thunderstorm Formations.

Thunderstorm formations appear to be small atmospheric whirls—in all respects like ordinary cyclones. As the wind nearly always falls light or calm during their occurrence, while there is considerable and often violent motion in the clouds above, and as the thunder-clouds are of no very great altitude, it is most probable that the whirl is confined to a stratum of air at only a little distance above the earth's surface. The whirl may vary from one mile to ten miles or more in diameter. Sometimes a violent wind occurs during a thunderstorm; this probably takes place when the storm is of low altitude.

There are usually several whirls near together or following one another along the same track.

Dr. F. G. Smart, of Mount Ephraim, Tunbridge Wells, in a letter referring to several thunderstorms which occurred on two days in August 1891, writes: —

"There were five on each of the two occasions when they attracted my attention. They were on both occasions moving in an easterly or south-easterly direction. The first time, when I was longer on the tower and noticed them more particularly, there was one to the south of us, which passed away to the east; at the same time there was another over Crowborough, which followed it. A third was away to the north-east; a fourth was apparently following it along the southern slope of the Sevenoaks Hills; this was the most beautiful, so attracted my attention more than the others. There was bright sunshine on each side of the rain. The shower did not seem more than a mile wide, and was travelling rapidly. The fifth was to the north-west, and at first appeared to be following the last, but altered its course (or seemed to), and came over us, driving me from the tower. On the other occasion the positions were very similar, but none came over us."

Barometric Oscillations.

The numerous oscillations in the barometric curve are evidently due to the passage of a succession of atmospheric whirls. The Greenwich barographic record for the night of September 2nd and 3rd, 1889, contains a large number of oscillations, and by comparing these with the anemometer record it is seen that at the time the oscillations occurred in the barometer, changes took place simultaneously in the direction of the wind. (Fig. 14.)

It appears that lightning strokes occur most frequently when there are numerous oscillations in the barometric trace. A very good example of this took place on the night of September 2nd and 3rd, 1889, just referred to, when much damage by lightning occurred over Kent and Essex. (Fig. 15.)

I believe that probably heavy rain falls when the mercury in the barometer jumps up suddenly two, three, and even four hundredths of an inch, as it does sometimes in thunderstorms, especially at their commencement.

Movements of Clouds.

The movements of the clouds in thunderstorms have often puzzled the observers, and the reports have consequently been very meagre. But by carefully watching the clouds during the progress of a thunderstorm one can readily distinguish several different currents, which apparently circulate round the storm like an ordinary cyclone. Most people are familiar with what is called the "angry" appearance on the lower surface of the thundercloud. I have often watched this, and seen fragments of clouds form and grow. This is evidently due to an upward current of air. The upper part of the thundercloud usually appears like a hard massive cumulus. The summit of this cloud sometimes seems to spread out into a kind of cirrus, which may possibly be the outflow of the upward current already referred to. Above all this we frequently see other clouds, which are moving slowly in the direction of the general prevailing wind. The thunderstorm disturbance is therefore evidently below these clouds, and must, consequently, be confined to a stratum of air at no great distance above the surface of the ground. I have not been able to get any measurements of the altitude of these different currents, but I cannot help thinking that our average thunderstorms do not extend beyond 4,000 or 5,000 ft. above the earth's surface.

I must express my thanks to all those gentlemen who have kindly supplied me with information, especially to Mr. Scott, who has permitted me to examine the records in the Meteorological Office, to the Astronomer Royal for copies of the Greenwich barograms and anemograms, and to Mr. Horstman, my senior assistant, for the help which he has given me in this inquiry.

DISCUSSION.

Mr. BAYARD said that he had noticed that in the two instances mentioned of thunderstorms traversing the country from south to north, their path appeared to be along the great ridge of hills extending from Somerset to Cumberland. He should like to know whether these 'line' thunderstorms usually followed the summits of hills.

Mr. SYMONS said that the results of Mr. Marriott's investigation seemed to show that thunderstorms had a tendency to choose valleys rather than hills as their usual path; but there was hardly sufficient data to determine this question accurately. The course of a thunderstorm seemed to be guided by the distribution of the isobars, rather than by the contour of the hills. The original idea, as Mr. Marriott had stated, was to confine this investigation to the south-east of England, it being hoped that by securing a large number of observers over a comparatively small district, reliable and useful results would have been obtained. This hope had not been realised to anything like the extent desirable, and consequently there was by no means sufficient information to adequately discuss this important subject. Mr. Marriott had stated that it appeared that the average distance travelled by an individual thunderstorm was not more than 20 miles, and yet, in the case of two storms, lines of sequence of time were given, extending from the south of England to Scotland. The question was, did the actual storm travel, or were the conditions propagated as time passed on? What was wanted in an investigation of this character was an enormous number of observers close together. He thought that the national telegraph system, the police and other similar organisations could be profitably utilised in an inquiry such as that which the Society had endeavoured to conduct. When the loss of life, both human and animal, and the serious structural damage frequently occasioned by thunderstorms were considered, it appeared very desirable that our knowledge concerning them should be greatly increased, as such knowledge would probably make it possible to adopt measures which would in some degree lessen the injury and loss which were often wrought by thunderstorms. He thought that the data from the Royal Observatory, Greenwich, were of considerable value. The sudden oscillations in the barometric curve during the progress of thunderstorms were apparently independent of the electrical phenomena, and caused either by changes in the direction of the wind or by the fall of rain.

Mr. W. B. TRIPP inquired whether there was any part or configuration of the country which was more favourable for the origination of thunderstorms than other parts were.

Mr. M. JACKSON said that in his opinion the decision of the Society to investigate thunderstorms was a very bold undertaking, for they were so extremely capricious. Mr. Jackson gave an account of a severe thunderstorm which passed over Ramsgate and Margate on the early morning of June 7th, 1889.

Mr. INWARDS thought that we could also look for interesting results regarding thunderstorms from places where they were much more frequent than in the British Isles, and where they could be studied to greater advantage. He remembered that when he was visiting the Austrian Tyrol a thunderstorm was regularly experienced every afternoon for several weeks in succession.

Mr. BUCHAN said that Mons. Leverrier had stated that to carry out an investigation into thunderstorms thoroughly it would be necessary to have properly organised observations in every parish. He thought thunderstorms were more frequent in a large stretch of flat country, in fact it might be said the less hills the more thunderstorms. Perhaps this might explain the differing premiums charged by Hail Insurance Companies for different localities in the British Isles. He drew attention to the great concentration of heat and closeness of atmosphere which frequently accompanied thunderstorms, and instanced the case of a storm in the neighbourhood of Braemar, in which the temperature was greatly affected. He pointed out the necessity of drawing isobars for hundredths of an inch over a thunderstorm area, and showed, too, that it was desirable, where practicable, to give the barometrical pressure corrected for the height of the district covered by the storm, or to reduce the observations to a mean height of 500 or 800 feet above mean sea level.

Mr. LECKY said that he supposed that most persons agreed that thunderstorms were the effect of statical electricity. He thought that we could only enlarge our knowledge of thunderstorms by further studying the nature of this form of electricity.

Mr. MARRIOTT, in reply, said that the great difficulty he had met with in carrying out this inquiry was the lack of observations. As regarded 'line' thunderstorms, the two instances to which he had drawn attention were the only cases he had found throughout the whole series of observations. He was unable to say whether this type of thunderstorm always took much the same track, but could only state that the conditions of pressure distribution were very similar in each of the two cases. The origin of thunderstorms had yet to be learned: they appeared to occur mostly in ill-defined barometric depressions. He had endeavoured to prepare isobaric charts for a height of 500 feet above mean sea level; but the available material was so very scanty, that it was found impossible to construct satisfactory charts. He believed that the Italian Meteorological Office had done some work in this particular direction, but they, of course, had a comparatively large number of high-level stations, so that it became more easy to prepare charts of barometric pressure reduced to a suitable elevation. As regarded hail insurance, there was a small district near Somersham in Cambridgeshire, in which insurers were charged a heavier premium than in other districts; but so far as he knew there appeared to be no justification for this higher rate, as hail storms did not seem to be any more frequent or violent there than elsewhere. He had been in conversation with the Secretary of a Hail Insurance Society in Lincolnshire about five years ago concerning the question of the prevalence of hail storms, and had been promised copies of statistics bearing on the subject, but had never received this information.

Mr. SCOTT said that he too made inquiries concerning the question of insurance against damage to crops, &c. by hail, and had found that the Insurance companies were unwilling to give any information as to the basis upon which the premiums were charged, or as to the amount paid for damage in each district.

ON THE PREVALENCE OF FOG IN LONDON
DURING THE 20 YEARS 1871 TO 1890.

By FREDERICK J. BRODIE, F.R.Met.Soc.

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The discussions which have recently taken place as to the nature and origin of London fog have been so numerous and exhaustive that any attempt to reopen the question in these phases would require an amount of courage largely in excess of that possessed by the writer of this paper. The scope of the present inquiry is far more modest and restricted.

Notwithstanding all that has been written and said on the subject there appears to be a lack of precise data as to the prevalence of fog in the metropolis in different years and at different seasons of the year, and with the object of supplying this deficiency the actual number of days on which fog prevailed in the London district during the 20 years 1871 to 1890 have been extracted from the official records. The sources from which the information has been derived are mainly the observations given in the *Daily Weather Report* which refer to 8 a.m., 2 p.m. and 6 p.m. These are taken in the south-western parts of the Metropolis, either at Brixton or at Westminster, but in preparing the tables there have been included some few instances in which fog prevailed over a large portion of the London area, but in which it failed to affect the districts in question. Every endeavour has, in fact, been made to represent London as a whole; and as the same principle has been followed throughout the entire series of years the results are strictly comparable. No account has been taken of the density or length of duration of fog, but care has been exercised to eliminate cases in which the weather was only misty or hazy.

Table I. shows for each month, for each season, and for each year the number of days on which fog was reported during the 20 years, together with means for the entire period. The spring season comprises the months of March, April and May, the summer those of June, July and August, the autumn the months of September, October and November, and the winter those of December, January and February. The first winter given in the table is comprised within the months December 1871 and January and February 1872, and in all succeeding cases the year given at the head of the column represents the commencement of the winter season.

The popular notion that November is *par excellence* a month of fog is not confirmed by the figures given above. The number of fogs in that month is, if anything, slightly less than in October or January, and decidedly less than in December, the last-mentioned month being certainly the worst of the whole year. The latter part of the winter is not only less foggy than the earlier part, but is clearer than the autumn months. In February the average

TABLE I.—SHOWING THE NUMBER OF DAYS IN WHICH FOG WAS RECORDED IN LONDON IN EACH MONTH, IN EACH SEASON, AND IN EACH YEAR OF THE 20 YEARS 1871 TO 1890.

Months.	1871.	1872.	1873.	1874.	1875.	1876.	1877.	1878.	1879.	1880.	1881.	1882.	1883.	1884.	1885.	1886.	1887.	1888.	1889.	1890.	Means for the 20 years.
January	2	3	4	7	..	12	7	7	7	19	16	12	10	6	10	8	17	9	17	5	8·9
February	4	2	10	11	9	3	1	8	2	6	7	12	8	5	4	14	10	3	1	12	6·6
March	2	6	11	5	7	..	4	..	8	7	5	5	4	7	9	9	13	1	4	4	5·6
April	..	..	1	1	5	3	1	3	2	3	2	3	4	2	4	3	3	2	1	1	2·2
May	..	1	1	..	1	..	2	1	2	1	..	1	1	..	1	4	1	..	5	..	1·1
June	1	..	3	..	1	1	..	1	1	..	1	..	..	1	1	3	1	2	1	..	0·9
July	..	1	..	..	2	..	1	..	1	1	..	1	..	1	3	1	2	..	..	..	0·7
August	3	2	..	2	3	..	..	1	1	2	1	..	1	2	1	4	2	..	3	..	1·4
September	2	..	9	5	4	6	5	7	9	8	9	7	8	6	7	5	5	9	2	5	5·9
October	13	6	14	3	5	5	11	11	10	11	6	9	9	4	8	13	9	15	11	10	9·2
November	10	4	9	11	5	9	7	10	8	7	5	5	9	15	10	10	12	7	15	8	8·8
December	5	10	13	8	7	1	7	14	18	9	7	14	7	4	11	12	8	14	15	20	10·2
The Spring	2	7	13	6	13	3	7	4	12	11	7	9	9	9	14	16	17	3	10	5	8·9
The Summer	4	3	3	2	6	1	1	2	3	3	2	1	1	4	5	8	5	2	4	..	3·0
The Autumn	25	10	32	19	14	20	23	28	27	26	20	21	26	25	25	28	26	31	28	23	23·9
The Winter	10	24	31	17	22	9	22	23	43	32	31	32	18	18	33	39	20	32	32	50	26·9
The Entire Year	42	35	75	53	49	40	46	63	69	74	59	69	61	53	69	86	83	62	75	65	61·4

number of days with fog is only 6·6, as against 8·9 in January, 10·2 in December, 9·2 in October, and 8·8 in November. The greatest number of fogs experienced in any month of the 20 years was in December 1890, when there were as many as 20 days with fog, but January 1880 ran it very close, with 19 days, while December 1879 was not far behind, with 18 days. In the first of these months there was, it will be remembered, no appreciable amount of sunshine at Kew and Bunhill Row, and less than 2¼ hours at Greenwich. In December 1879 and January 1880 the amount of sunshine registered at Greenwich was, singularly enough, greatly in excess of the average, so that the days which were not foggy were evidently very fine for the time of year. During the spring season a rapid decline in the prevalence of fog occurs, the number of days in April being considerably less than half the number in March. The decrease continues steadily until July, which is the clearest month of the whole year; in fact, in ten of the 20 years no fog was recorded in July. Towards autumn the frequency of fog becomes more marked, the number of days in September being more than four times as great as in August.

As regards the seasons, it appears that the summer is, as has been indicated, the clearest time of the year, the number of fogs being only three. In spring this number increases to nine, while in autumn the number is more than two and a half times as great as it is during the spring months. The winter fogs are, however, very little more numerous than those of autumn, the numbers being respectively 26·9 and 23·9. The only season of the whole 20 years in which fog was entirely absent in the metropolis was the summer of 1890, while the worst season of the series was the winter of 1890-91, when as many as 50 days were recorded. The mean number of days of fog during the entire year is 61, the murkiest year of the 20 being 1886, with 86 days, and the finest year 1872, with only 35 days.

In a paper read before the Society last March on "Some Remarkable Features in the Winter of 1890-91."[1], attention was briefly drawn to the growth of fog in London within recent years. The winters of the past 20 years were there grouped into lustra, and the figures showed that in the course of the entire period a steady and perceptible increase in the amount of fog had taken place in London. This method of inquiry has now been extended to the other portions of the year, and in Table II. will be found the mean number of days of fog experienced during each 5-year period in each month, in each season, and in each year. A comparison has also been made between the numbers recorded in each successive lustrum; and, finally, the prevalence of fog in the last 5-year period has been compared with that observed in the first. The data employed in the preparation of the table are precisely the same as that given in Table I.

TABLE II.—Showing the Mean Number of Days of Fog in London for each Month, for each Season, and for each Year in each Lustrum of the 20 Years 1871 to 1890.

Months.	First Lustrum, 1871–75.	Second Lustrum, 1876–80.		Third Lustrum, 1881–85.		Fourth Lustrum, 1886–90.		
	Mean No. of Days of Fog.	Mean No. of Days of Fog.	Diff. from No. reported in First Lustrum.	Mean No. of Days of Fog.	Diff. from No. reported in Second Lustrum.	Mean No. of Days of Fog.	Diff. from No. reported in Third Lustrum.	Diff. from No. reported in First Lustrum.
January	3·2	10·4	+7·2	10·8	+0·4	11·2	+ 0·4	+ 8·0
February	7·2	4·0	−3·2	7·2	+3·2	8·0	+ 0·8	+ 0·8
March	6·2	3·8	−2·4	6·0	+2·2	6·2	+ 0·2	0·0
April	1·4	2·4	+1·0	3·0	+0·6	2·0	− 1·0	+ 0·6
May	0·6	1·2	+0·6	0·6	−0·6	2·0	+ 1·4	+ 1·4
June	1·0	0·6	−0·4	0·6	0·0	1·4	+ 0·8	+ 0·4
July	0·6	0·6	0·0	1·0	+0·4	0·6	− 0·4	0·0
August	2·0	0·8	−1·2	1·0	+0·2	1·8	+ 0·8	− 0·2
September	4·0	7·0	+3·0	7·4	+0·4	5·2	− 2·2	+ 1·2
October	8·2	9·6	+1·4	7·2	−2·4	11·6	+ 4·4	+ 3·4
November	7·8	8·2	+0·4	8·8	+0·6	10·4	+ 1·6	+ 2·6
December	8·6	9·8	+1·2	8·6	−1·2	13·8	+ 5·2	+ 5·2
The Spring	8·2	7·4	−0·8	9·6	+2·2	10·2	+ 0·6	+ 2·0
The Summer	3·6	2·0	−1·6	2·6	+0·6	3·8	+ 1·2	+ 0·2
The Autumn	20·0	24·8	+4·8	23·4	−1·4	27·2	+ 3·8	+ 7·2
The Winter	20·8	25·8	+5·0	26·4	+0·6	34·6	+ 8·2	+13·8
The Entire Year	50·8	58·4	+7·6	62·2	+3·8	74·2	+12·0	+23·4

The figures show very clearly that although the increase of fog has not been steady and continuous at all periods of the year, there has, nevertheless,

[1] *Quarterly Journal*, Vol. XVII., p. 155.

been a very decided rise in its prevalence, especially when we take the year as a whole.

In the second lustrum, comprising the years 1876-80, the mean number of foggy days per month was in excess of that observed during the first five years of the period in seven months out of the twelve. As regards the seasons there was a slight falling-off in the spring and summer, but a decided increase in the autumn and winter. The excess for the entire year was not very large. In the third lustrum, comprising the years 1881-85, the mean was in excess of that observed during the second lustrum in eight months out of the twelve, and in every season excepting the autumn, when there was a slight decrease. The mean number of foggy days for the entire year again showed a slight excess. In the fourth lustrum, comprising the years 1886-90, the monthly means were in excess of those recorded during the third 5-year period in nine months, while the seasonal means were all in excess. The very large increase shown in the winter was due in a great measure to the unusual fogginess of the season 1890-91. The mean number for the whole year showed a considerable increase on that observed in the previous period.

A comparison between the mean amount of fog recorded in London during the first five and the last five years of the 20 is given in the last column of the table. The values here are very significant. In nine months out of the twelve there was a more or less decided increase, the growth being most striking in January and December. In two other months, viz. those of March and July, the mean number in the last period agreed precisely with that in the first, while in August there was a slight falling-off. As regards the seasons, it appears that the growth of fog was very decided, the proportion of excess varying from 6 per cent. in the summer and 24 per cent. in the spring to 36 per cent. in the autumn and to as much as 66 per cent. in the winter. Taking finally the values for the whole year, we find that during the five years 1886-90 there was 46 per cent. more fog than in the five years 1871-75, or nearly half as much again.

DISCUSSION.

Mr. H. J. Marten, in a letter, forwarding a copy of a paper which he read before the Sanitary Institute at the Worcester Meeting in 1889, said:—

"You will see from the remarks therein that in the winter months upwards of 20,000 tons of coal a day are piled upon the 600,000 or 700,000 kitchen and other domestic fires within the Metropolitan District. Possibly your chairman may be able to tell you how many cubic miles of smoke will issue from the chimneys in the course of each day with a consumption of 20,000 tons of coal in the fire places connected therewith. It must be a very large number, and together with the innumerable particles of coal dust taken with the smoke into the foggy atmosphere, must add very greatly to the dark and dreary discomforts of such a state of the air."

Mr. Symons said that as far as he knew this paper was the first systematic analysis of observations of fog in London; he was only sorry that they did not extend further back than 1871, as twenty years was hardly a sufficiently long period on which to base reliable conclusions. He remembered that between 1840 and 1857, when he resided in the south-west of London, very dense fogs prevailed, and some years later, when he was living in Camden Square, fogs of equal intensity were experienced. He thought it would be found that fogs, like other meteorological elements, waxed and waned, and moved in some sort of ill-defined cycle, and that the prospect in the future was not so gloomy as Mr. Brodie would have us believe. The great increase in the paved area of London would have the effect of diminishing the watery particles in a London fog, for he had noticed that in large open spaces, such as Regent's Park, the fog was nearly always thickest; but as the number of houses had vastly increased, the fogs had doubtless become more smoky than they were in the past. He should like, if he could find time, to work up his own observations of fog as recorded at Camden Square from 1858 to 1891, and see how far the results agreed with those tabulated by Mr. Brodie.

Dr. Williams said that in a paper read by Dr. Russell at the Congress of Hygiene it appeared to be clearly shown that fogs in London were decidedly on the increase. He had always been taught in his childhood that November was the month of greatest prevalence of fog; but now another of the traditions of his childhood had departed, and he would look on December with more gloomy expectations. He should like to know whether there was any connection between the direction of the wind and the occurrence of fog. He had noticed that the fogs usually came from the east, and their density increased with proximity to the river and to open spaces, especially clay soils. At Chelsea and in the neighbourhood of the Hospital for Consumption at Brompton, the fogs were often very dense because of proximity to the river. He supposed Mr. Brodie had only included "brown" fog in the days of fog he had given. He presumed that, if London did not exist, the district would still be a very foggy one, from the large amount of low-lying ground north and south of the Thames; the only addition which London caused arising from the deleterious products of combustion in connection with the numerous household and other fires, which it was the duty of the Legislature to control.

Dr. Barnes drew attention to the interesting fact that this history of fog coincided in a very remarkable manner with the periods of prevalence of zymotic diseases, as demonstrated by Mr. Buchan in a valuable memoir in the *Journal of the Scottish Meteorological Society*. Following that memoir he had himself worked out the succeeding ten years, and found that the results of Mr. Buchan were fully confirmed. This memoir of Mr. Brodie should therefore be read in connection with Mr. Buchan's, and so both are doubly instructive. He had, some years ago, the duty of observing the working of two gas factories, and had noted that in fog and still winter atmospheres the sulphuretted hydrogen, carbonic acid, and other products lay in a stratum near the ground. There was no diffusive property in the air, and no purification until the air was scoured by rain or wind; so in like manner other noxious matters generated accumulated in the stratum of air in which we lived; so smoke did not make the fog, but was caught in it.

Mr. Scott said that he did not think that Dr. Russell had much old information regarding fogs. He had himself endeavoured to get such information for Dr. Russell some years ago, in order to ascertain whether fogs were increasing, and the only record he could hear of was one kept at Messrs. Meeking's, in Holborn Circus. Entries were made by one of the employés of the state of the weather as affecting the sales and number of customers; but on inquiry it was found that the books had been regularly burned each year, so that there was only the man's memory to rely upon, and he had stated that it was his belief that fogs were on the decrease.

Mr. Lecky remarked that the quantity of smoke emitted into the atmosphere of the City of London must have greatly increased in later years, owing to the conversion of dwelling-houses into blocks of chambers.

Mr. W. B. Tripp said he had heard of a gentleman who suffered from some complaint of the eyes and was unable to bear a strong light, who had stated that the only occasions when he was able to get about in any comfort were during the prevalence of London fogs.

Mr. Greatheed said that if investigation was carried back far enough, it reached a period when wood, perhaps exclusively, was used for fires. Fogs then must have been rare. Years ago he had experienced an escape from the gloom of London to Paris, where the atmospheric purity was attributed at the time to the prevalence of wood fires. He inclined to think that fogs of short duration often coincided with the "hang of the tide" in the Thames. The cessation of tidal influence assisted atmospheric steadiness, a necessary condition in fog production.

Mr. SYMONS remarked that wood was now much less used in Paris, a wood fire being reckoned a luxury, consequently the fogs in Paris were getting as bad as those in London, and in fact on foggy evenings the Paris police were stationed with torches at the intersections of the principal streets.

Dr. BARNES said that fifty years ago, when a student, he spent a year in Paris, and there he experienced the densest fog he ever saw.

Mr. C. HARDING said that Dr. Russell's paper, as printed in *Nature* in 1891, Vol. 45, pp. 10-16, was undoubtedly very valuable. Certainly, if consumption of coal caused fogs, then fogs must be on the increase in the Metropolis. He would like Mr. Brodie to say whether the 8 a.m. observations only had been utilised in compiling the tables; and if other hours were used a precise statement would add value to the paper. He said that the observations used classed light and dense fogs together, as the entries in the *Daily Weather Report* did not admit of any separation being made.

Mr. WHIPPLE asked whether it was not possible to have better agreement among meteorological observers as to what should be reckoned as fog. He narrated an experience he once had with a country observer who entered fog in his register because some hills about four miles distant were a little misty and not clearly discernible, while at the place of observation the weather was clear and sunny. He did not think there had been more fog in his own neighbourhood in recent years than formerly prevailed, and certainly did not believe that fogs had increased at Kew at anything like the rate quoted in the paper. At all events he did not detect it when preparing his paper in 1888 on "Non-Instrumental Meteorology," in which he included fogs.

Mr. BRODIE, in reply, said that he regretted that the period over which the observations extended was not longer. He could, of course, have obtained a much longer series of observations from the Greenwich records, but he did not consider that in respect of fog prevalence Greenwich fairly represented London, as the Observatory was placed on a hill some 150 feet in height. He quite believed that fogs were as dense in 1840 as at the present day; but he greatly doubted if they were as frequent then as now. He had not gone into the question of the connection between the direction of the wind and the prevalence of fog, but he was under the impression that there was very little, if any; indeed, it frequently happened that there was no wind at all when fog was prevalent. He had resided in both the south-west and north-east of London, and from his own observations he was of opinion that fogs were certainly getting more frequent in the district where he now dwelt than they formerly were. He had made use of the 8 a.m., 2 p.m., and 6 p.m. observations given in the *Daily Weather Report* in the compilation of the tables.

PROCEEDINGS AT THE MEETINGS OF THE SOCIETY.

NOVEMBER 18th, 1891.

Ordinary Meeting.

BALDWIN LATHAM, M.Inst.C.E., President, in the Chair.

Prof. CLEVELAND ABBE, Weather Bureau, Washington, U.S.A.;
HERBERT BERTRAM CAVELL, Fleet, Hants;
ALFRED CHANDLER, South Hill, Kingskerswell, Devon;
WILLIAM WALLACE COPLAND, Assoc.M.Inst.C.E., Sheerness-on-Sea;
WILLIAM L. DALLAS, Meteorological Department, Simla;
ROBERT ISAAC FINNEMORE, J.P., F.R.A.S., Durban, Natal;
Capt. WILLIAM GEORGE SQUARES, 96 Millbrook Road, Southampton;
Rev. FRANCIS TILNEY STONEX, Bredbury, Stockport;
WILLIAM STOREY, Thargomindale, Queensland;
ROBERT WILLIAM SWINNERTON, Assoc.M.Inst.C.E., Bolarum, Dekkan, India; and
BENJAMIN ARTHUR WHITELEGGE, M.D., B.Sc., Wakefield,
were balloted for and duly elected Fellows of the Society.

The following Papers were read :—

"REPORT ON THE INTERNATIONAL METEOROLOGICAL CONFERENCE AT MUNICH, AUGUST 26TH TO SEPTEMBER 2ND, 1891." By ROBERT H. SCOTT, M.A., F.R.S., Foreign Secretary. (p. 1.)

"ACCOUNT OF AN ELECTRIC SELF-RECORDING RAIN GAUGE." By W. J. E. BINNIE, B.A. (p. 6.)

"ON WET AND DRY BULB FORMULÆ." By Prof. J. D. EVERETT, M.A., F.R.S. (p. 13.)

"RESULTS OF METEOROLOGICAL OBSERVATIONS MADE AT AKASSA, NIGER TERRITORY, MAY 1889 TO DECEMBER 1890." By FRANK RUSSELL, F.R.Met.Soc. (p. 19.)

DECEMBER 16th, 1891.

Ordinary Meeting.

BALDWIN LATHAM, M.Inst.C.E., President, in the Chair.

REGINALD H. HOOKER, B.A., 9 Adelphi Terrace, Strand, W.C.;
ALEXANDER BAIRD MACDOWALL, M.A., Gadebridge, Coolhurst Road, Crouch End;
E. G. RAVENSTEIN, F.R.G.S., 91 Tulse Hill, S.W.; and
ROBERT HEDGER WALLACE, Maicscot, 88 Denbigh Road, Armadale, Melbourne,
were balloted for and duly elected Fellows of the Society.

Mr. J. S. HARDING and Mr. H. S. WALLIS were appointed Auditors of the Society's Accounts.

The following Papers were read :—

"REPORT ON THE THUNDERSTORMS OF 1888 AND 1889." By WILLIAM MARRIOTT, F.R.Met.Soc. (p. 23.)

"ON THE PREVALENCE OF FOG IN LONDON DURING THE TWENTY YEARS 1871-1890. By FREDERICK J. BRODIE, F.R.Met.Soc. (p. 40.)

CORRESPONDENCE AND NOTES.

Fog, Hoarfrost, and Rime in London, December 21st-25th, 1891. By William Marriott, F.R.Met.Soc.

Everyone who was in the neighbourhood of London during Christmas week had painful and ocular experience of the weather that then prevailed. Not only was the barometer high and the temperature low, but from Monday the 21st to Friday the 25th a dense fog settled down over the metropolis, making the day almost as dark as night, and greatly interfering with locomotion and railway traffic.

The air during that period was damp, and consequently there was a great deal of rime or hoarfrost. The rime became very thick on Wednesday, and continued to increase till Friday (Christmas) morning.

The following measurements of the thickness of the rime were made at West Norwood on the 23rd, 24th, and 25th :—

	23rd. 9 p.m. in.	24th. 3.30 p.m. in.	25th. 9 a.m. in.
Spider's thread hanging from thermometer screen and 3 ft. 8 ins. above the ground	·23	·43	·75
Wire (horizontal) ·07 in. in thickness and 4 ins. above the ground	·55	·88	1·07
Knob at end of solar thermometer ·48 in. in diameter, and 4 ft. above the ground	·80	1·11	...
Outer glass tube of solar thermometer ·78 in. in diameter and 4 ft. above the ground	1·20	1·42	1·51

The spider's thread was greatly attracted by the brass rule (cathetometer), just like a needle by a magnet.

A telegraph wire coated with rime looked like a good thick rope.

A little rain fell on Christmas morning, which on reaching the ground immediately froze and covered the roads and pavements with a sheet of ice ("glazed frost"), rendering locomotion difficult and dangerous.

By 2.30 p.m. the temperature had risen to 32°, and the rime began to melt and was all gone by about 6 p.m., when the fog had also cleared away. The temperature at 9 p.m. had risen to 40°.

The water in the rain gauge (the result of rime, fog, &c.) amounted to ·04 in., and was quite black, showing that the fog had been heavily charged with soot, &c.

Remarkable Rainbows seen in Kincardineshire. By Robert Lawson, LL.D., F.R.Met.Soc., Inspector-General of Hospitals.

Some ten or twelve years ago I had an opportunity on two occasions of seeing the rainbow repeated three times inside the principal bow, the outer edge of one being close to the inside of the next, and the colours in each showing the full spectrum from red to violet.

On the first occasion I was with a party shooting on a moor in 57° N, in Kincardineshire, at a point about 1,000 feet above the sea and 9 miles from it, about the middle of September. The wind was Westerly, when about 2 p.m. a heavy shower passed over us, which presented a well-defined rainbow. As it receded towards the east, inside this (the principal bow) at its centre and for some 5° on either side of that point, the three other bows appeared, as above described, and lasted for some twelve or fifteen minutes.

On the second occasion, three or four years afterwards, I was shooting in the end of September on the low ground about 6 miles south of the above-mentioned spot, and about the same distance from the sea, but only about 350 feet above it, when, with the wind Westerly about 2 p.m., there was heavy rain to the eastward, and a bright principal bow formed, presenting three subordinate features as in the first case, lasting for some ten minutes.

The sea was not visible from either of the points where these phenomena were seen,

SUPERNUMERARY RAINBOWS OBSERVED AT KIRKWALL, ORKNEYS, DECEMBER 26th, 1891. By M. SPENCE.

ON Saturday, December 26th, at 3.20 p.m., when the sun was on the horizon, I saw a very distinct rainbow; there was no trace whatever of the secondary bow, but between where it ought to have been and the primary one there were several patches of what are called "supernumerary" bows. The only colour I saw distinctly was the red.

This lasted for about four minutes, when finally a second bow appeared just inside the primary, with the colours arranged as in the primary; not reversed as the secondary. The space between the violet of the primary and this one was almost *nil*. The red next the violet of the primary was about as distinct as that of the primary. The orange and yellow were distinct also, but the others could hardly be seen. This was no doubt owing to the fading light of day, and to the dark colour of the clouds in the north-east, where the bows appeared. These lasted distinctly and complete for about one minute. The bows formed, as is well known, half a circle. The sun was setting behind land at the time, and the wind was blowing at the rate of 45 miles per hour, so that there could be no water reflection.

THE STORMS OF THE ARABIAN SEA.

MR. W. L. DALLAS has collected all the available information respecting storms in the Arabian sea from 1648 to 1889, and has prepared storm charts for the different months of the year in order to ascertain, so far as possible, whether the storms at different seasons followed definite tracks and were confined to definite portions of the sea.[1]

The conclusions which he has arrived at from this investigation are: 1. That cyclones originating over the Arabian Sea are formed on the northern limits of the South-west Monsoon, so that the place of origin undergoes an annual oscillation, agreeing with those limits. 2. That when the northern limits of the Monsoon reach the land of India and Southern Asia, no cyclones are formed over the Arabian Sea. 3. That when the North-east Monsoon extends, uninterruptedly from Southern Asia to the equator, *i.e.* from December to March no cyclones are formed over the Arabian Sea. 4. That the epochs of greatest cyclone frequency are the beginning of June and the beginning of November. 5. That during the pre-monsoon period the progressive motion of cyclones is carried out along a curved path, the commencement of which is near the Maldive or Laccadive Islands, the vortex about opposite Bombay, and the conclusion near the Kooria Mooria Islands. 6. That during the post-monsoon period the progressive motion of cyclones is along a curved path originating near the Maldives or Laccadives, the first part of which runs to north-west, the central portion to north-west and through north to north-east, and the concluding portion to east, and ending on the Konkan or Katthiawar coasts. 7. That the diurnal progression of the vortex, when first produced, is irregular, but that it subsequently becomes steady, though the rate of advance always shows some decrease when the system is curving through north. 8. That the initial stages of a cyclone are often characterised by the appearance of an abnormal Northerly wind and fine weather, but not by long continued calms. 9. That the barometric fall is gradual and equal on all sides, and that it is only near the centre that the mercury falls fast; that a depression of 0·25 in. below the normal average pressure of the place of observation is indicative of the existence of a cyclone in the neighbourhood of that place. 10. That when the hurricane is well out at sea, gusty strong winds are felt for several hundred miles around the centre, but that when the storm is in confined waters the gale may burst with great suddenness. 11. That the most tempestuous winds are felt on the margin of the calm area. 12. That a ship or steamer not using her engines, will enter and leave the calm centre with winds from opposite directions. 13. That heavy rain is experienced on all sides of the storm focus, but is heaviest on its northerly octants. 14. That a cross

[1] *Cyclone Memoirs*, Part IV. Calcutta, 1891.

confused sea accompanies the cyclone, and is felt 300 or 400 miles away from the storm centre. 15. That occasionally cyclones appear to enter the Arabian Sea from the Indian Peninsula; that when this occurs the effects are very little felt over the strip of sea close to the coast, where the mountains on the west coast are close to the sea, but that where the mountains are at some distance inland, all the phenomena of a passing cyclone are experienced. 16. That the north of the Arabian Sea is liable, during the prevalence of the North-east Monsoon, to be disturbed by small cyclonic storms descending from the highlands of Persia and Baluchistan. 17. That the whole of the south-west of the Arabian Sea, though liable to South-west gales during the summer Monsoon, and to strong North-east winds during the winter Monsoon, is free from cyclones.

RECENT PUBLICATIONS.

American Meteorological Journal. A Monthly Review of Meteorology and Medical Climatology. Vol. VIII. Nos. 6-8. October to December 1891. 8vo.

The principal articles are:—Professor William Ferrel: by A. McAdie (3 pp.). In addition to a brief memoir of the late Prof. Ferrel, this contains a complete list of his scientific papers.—Cloud observations at sea: by Prof. Cleveland Abbe (15 pp.). This is an interesting account of some valuable observations on the form and motion of clouds at sea, which were made during the cruise of the *Pensacola* during the U.S. Expedition to West Africa in 1890.—Four balloon voyages: by Prof. H. A. Hazen (12 pp.).—Meteorology at the French Association: by A. L. Rotch (2 pp.).—Features of Hawaiian climate: by C. J. Lyons (7 pp.). The main features of the climate are the trade wind, and the phenomena caused by the mountains. The local climates, however, are many, more than will often be found in like contiguity.—Meteorological work of agricultural experiment stations and agricultural colleges, and their relations to the Weather Bureau: by M. W. Harrington (2 pp.).—New High Level Meteorological Observatories in France: by A. L. Rotch (9 pp.). This contains an account of the observatories on the Mont Ventoux in Provence (6,250 feet), the Aigoual in the Cevennes (5,150 feet), the Eiffel Tower at Paris (980 feet), and Mont Blanc (15,780 feet).—Meteorology of Australasia; Account of the operations of the Chief Weather Bureau: by C. L. Wragge (4 pp.).—The December No. is almost entirely devoted to memorial articles on the late Prof. Ferrel, the writers being Prof. S. Newcomb, E. Goodfellow, Prof. C. Abbe, Prof. W. M. Davis, Dr. F. Waldo, and A. Ashley.

Annals of the Astronomical Observatory of Harvard College. 4to.

Vol. XIX. part 1, contains:—Meteorological observations made at the Harvard College Observatory during the years 1840 to 1888 (157 pp.).

Vol XXI. part 1, contains: Observations of the New England Meteorological Society in the year 1888 (99 pp. and 3 plates).

Vol. XXII. contains: Meteorological observations made on the summit of Pike's Peak, Colorado, height 14,134 feet, January 1874 to June 1888 (475 pp.). This is a most interesting volume, as it contains not only the daily observations made at the highest observatory in the world, but also has copious extracts from the observer's daily journal.

Vol. XXX. part 2, contains: Observations made at the Blue Hill Meteorological Observatory, Massachusetts, U.S.A., in the year 1890, under the direction of A. L. Rotch (201 pp.). This also includes a summary of the meteorological records during the lustrum 1886-1890.

Annual Meteorological Report for the year 1890 of the Meteorological Central Observatory, Tokio, Japan. 4to. 1891.

In addition to the results of observations at the observatory, this also contains a paper on the frequency, motion, and depth of areas of low barometer in Japan, by E. Knipping. The period used for this discussion is the 7 years 1883-9.

The average number of depressions is 78 per annum, with a decided maximum in the spring, and an equal number in each of the other seasons. The depressions are generally deeper over the sea than over the land. From October to May the lines of equal depth are in general very similar to the isobars in the respective months, and less so in the warm months June to September. In June, depressions become deeper in passing out on the east coast, while in the sea of Japan lines of depth are similar to the isobars. Depressions coming from the sea in the south become decidedly shallower over the land in Southern Japan from July to September. On reaching the sea of Japan they show in July, when the temperature in Eastern Siberia is highest, a tendency to proceed north with a little change in depth, and in August their depth increases uniformly towards the north. In September, however, when the sea is warmest, they go with the same or probably increased depth towards the north or north-east, become shallower in passing Northern Japan, and deeper again whilst passing out to the warm current off Eastern Hokkaido.

Daily Weather Charts for the period of Six Weeks ending June 25, 1885, to illustrate the Tracks of Two Cyclones in the Arabian Sea. Published by the Authority of the Meteorological Council, 1891. 4to.

The Gulf of Aden and the northern portion of the North Indian Ocean are rarely visited by typhoons; but in consequence of the occurrence in these waters in the summer of 1885 of a violent cyclone causing the loss of several vessels, the Meteorological Council decided to prepare daily charts for the North Indian Ocean, not only for the interval during which the storm occurred, but also to include a second cyclone which appeared in the Arabian Sea in June, in quick succession to the Aden cyclone. The number of logs utilised in the preparation of the charts was 239.

How to use the Aneroid Barometer. By Edward Whymper. 8vo. 1891. 61 pp.

This work is divided into four sections. The first records comparisons of the aneroid against the mercurial barometer in the field; the second is concerned with experimental research in the workshop; the third is occupied by practical considerations upon the facts recorded; and the fourth is composed of a recapitulation of the principal points which are dwelt upon in the previous parts. Mr. Whymper's investigations have extended over 11 years, and in his travels at great elevations in the equatorial regions of South America he made a number of comparisons of the aneroid against the mercurial barometer at low pressures. As the indications of the aneroids were not satisfactory, he made a number of experiments with aneroids which are detailed in the present volume. He finds that with aneroids of the present construction it is unlikely that decent approximations to the truth will be obtained at low pressure, even when employing a large number of instruments. He considers that the test which is commonly applied of comparing for brief periods (minutes or hours) aneroids against mercurial barometers under the air pump, is of little or no value in determining the errors which will appear in aneroids used at low pressures for long periods (weeks or months).

Indian Meteorological Memoirs. Published under the direction of J. Eliot, M.A., Meteorological Reporter to the Government of India. Vol IV. Part III. 1891. 4to.

This part contains two articles, viz. 1. The Arabian Sea cyclone of the 4th to the 13th June 1887, with a demonstration of the practicability of foretelling storms by the method of abnormals two or three days sooner than by the ordinary method of actuals: by F. Chambers (110 pp. and 12 plates). The author says that the provisional rule for finding the direction of motion of cyclones in the Arabian Sea in May and June from the direction of the normal wind is now modified as follows:—"The direction of motion of cyclones in the Arabian Sea in May and June is about eight points to the left of the direction towards which the normal monsoon wind blows. This rule is subject to a possible error of two points either way; that is to say, the inclination of the path to the left of the normal wind may vary between six and ten points."—On the meteorology and climatology of Northern Afghanistan: by W. L. Dallas (23 pp.).

Meteorological Charts of the portion of the Indian Ocean adjacent to Cape Guardafui and Ras Hafun. Published by the Authority of the Meteorological Council. 1891.

The area dealt with in these charts extends in longitude from the coast to nearly two degrees eastwards of the Cape, and in latitude to nearly two degrees from Cape Guardafui southward, thus taking in Ras Hafun. The elements discussed are sea-surface temperature, wind, current, sea disturbance, and mist or haze.

Meteorologische Zeitschrift. Redigirt von Dr. J. Hann und Dr. W. Köppen. October to December 1891. 8vo.

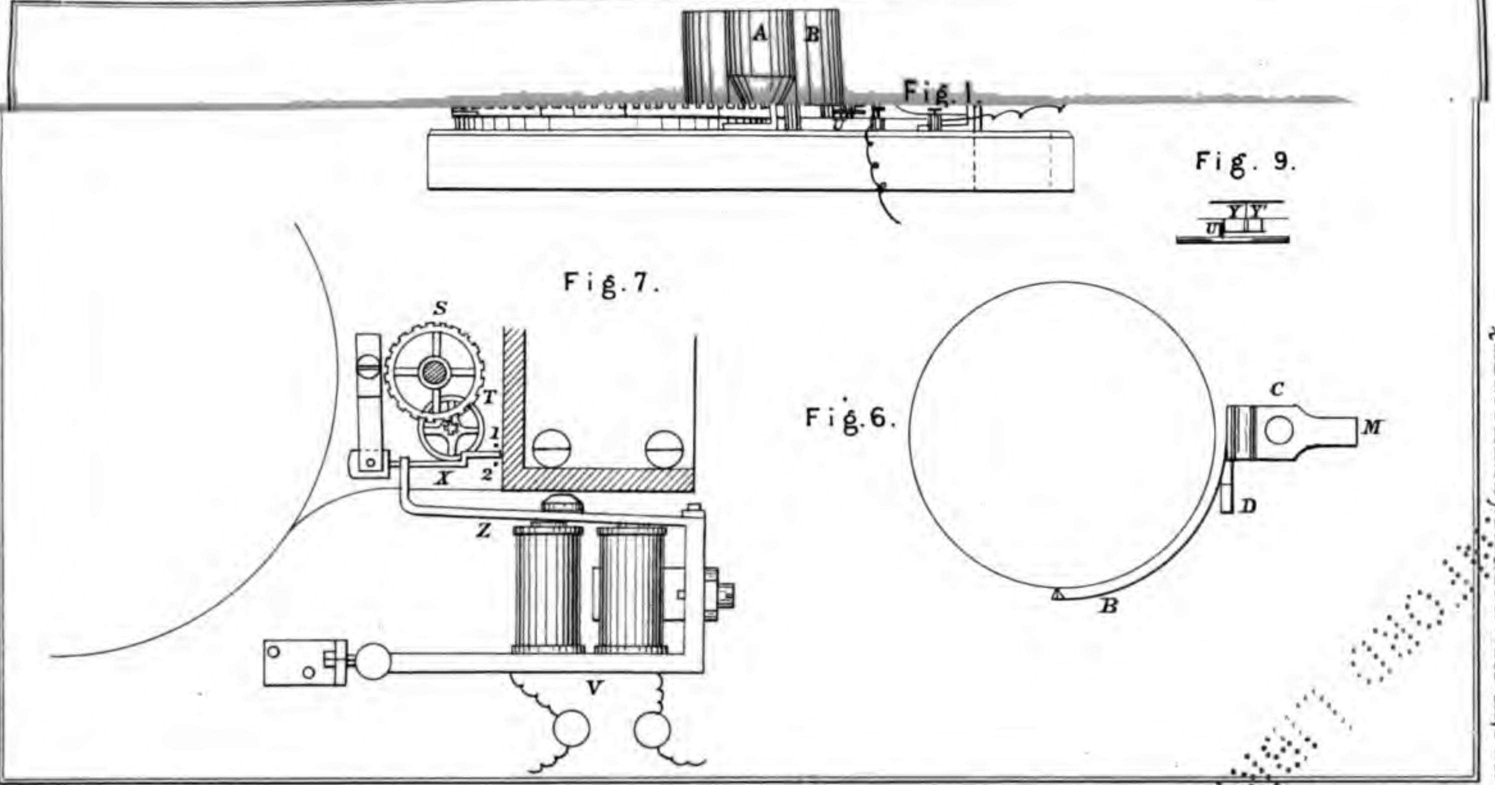
Die Zugstrassen der barometrischen Minima nach den Bahnenkarten der Deutschen Seewarte für den Zeitraum 1875-1890: von Dr. W. J. van Bebber (6 pp.). This is a revision of the results obtained some years ago by Dr. van Bebber, and is accompanied by twelve small maps showing the tracks of depressions over Europe for each month of the year.—Anwendung des Carnot'schen Satzes auf die Kreisläufe in der Atmosphäre: von N. Ekholm (6 pp.).—Ueber den Hagelschlag im Kanton Thurgau am 6 Juni, 1891: von Dr. K. Hess (10 pp.). This is an account of a remarkable hailstorm which devastated part of the north-east of Switzerland in June. In some particulars it resembled a tornado, but the wind was not so violent. The most remarkable fact about it was that it did not, as generally anticipated, spare forests. The author says that the belt of greatest damage swayed about within the region affected; and was influenced by the position of the patches of wood situated therein, being attracted by them. The hail stones fell without any rotatory motion; they were irregular in shape; had no kernel of snow; and, from internal evidence on section, appeared to have been produced by sudden cooling of superfused water, which would account for the frequency of air bubbles in them. In fact the appearance was like that of a drop in Leidenfrost's experiment.—Ueber Winde und Windverhältnisse in Pola: von Lieut. E. R. von Kneusel-Herdliczka (6 pp.).—Untersuchung über die Periodicität des Niederschlages im Königreich Sachsen: von Dr. P. Schreiber (10 pp.).—Temperatur-Mittel für Italien: von Prof. B. Busin (11 pp.).—Die internationale Conferenz in München, 26. August bis 2. September 1891: von F. Erk (8 pp.).

Symons's Monthly Meteorological Magazine. October to December 1891. Vol. XXVI. Nos. 809-811. 8vo.

The principal contents are:—Underground Temperature (3 pp.).—Rain Making (3 pp.).—The Climate of the British Empire during 1890 (2 pp.). The highest temperature in the shade from the stations included in the tables was 105°·6 at Calcutta on April 24th, and the lowest,—39°·4 at Winnipeg on January 17th.—Low Barometer, October 13th-14th, 1891 (2 pp. and plate). The lowest reading recorded was 27·96 ins. at 1.15 a.m. on the 14th, at Cawdor Castle, Nairn.—Meteorological Bibliography (2 pp.).—The Munich Conference (2 pp.).—Inside a Waterspout (1 p.).—The Rainfall of October and of the first ten months of 1891 (3 pp.).—The Temperature and Rainfall of Brazil (6 pp.).—The Martinique Cyclone of August 18th, 1891 (2 pp.).—The United States Weather Bureau (2 pp.).

Quart. Journ. Roy. Met. Soc. Vol. XVIII, Pl. 1.

BINNIE'S ELECTRIC SELF-RECORDING



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BINNIE'S ELECTRIC SELF-RECORDING RAIN GAUGE.

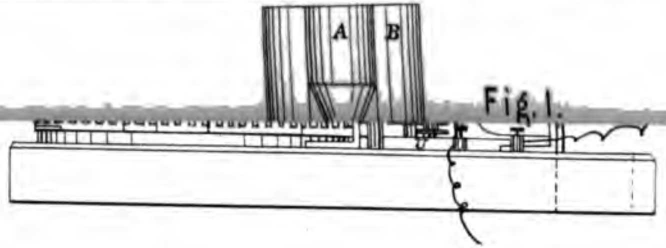


Fig. 1.

Fig. 9.

Fig. 7.

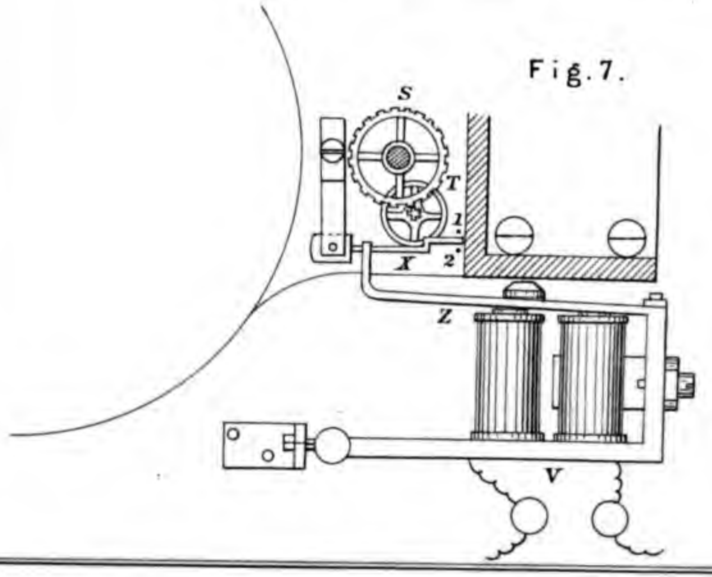
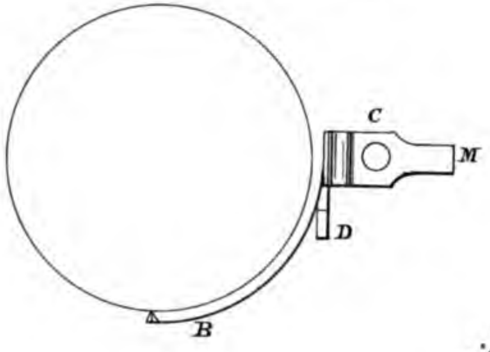


Fig. 6.



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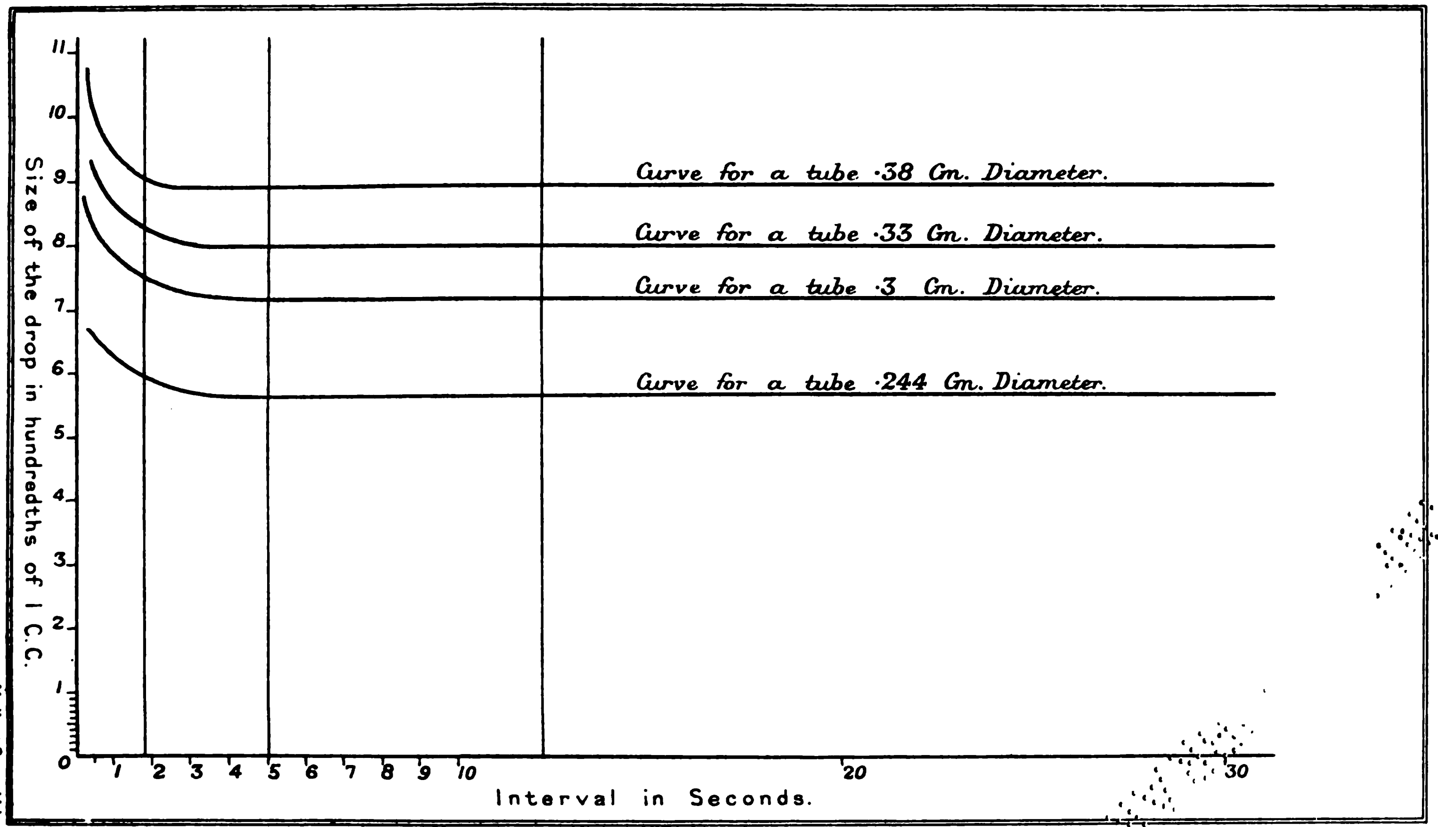
VARIATIONS IN THE SIZE OF DROPS OF WATER FALLING FROM TUBES.



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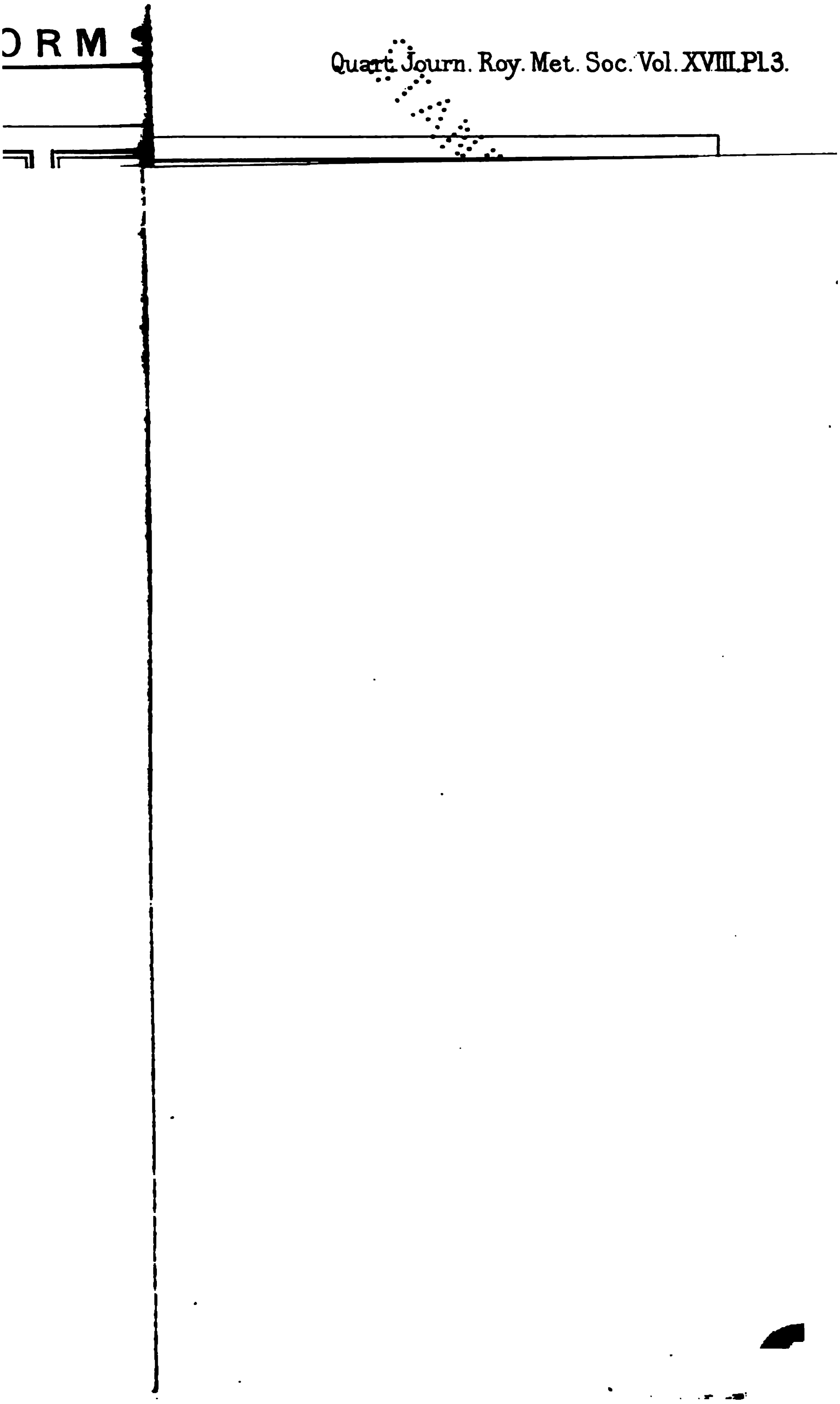

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EVAPORATION AND CONDENSATION.

An Address delivered to the Royal Meteorological Society, January 27th, 1892.

By BALDWIN LATHAM, M.Inst.C.E., F.G.S., PRESIDENT.

In the spring of last year an Exhibition of Instruments, relating to Rainfall and Evaporation, was held under the auspices of this Society. Owing to my absence from England at the time, I was unable to prepare an address dealing with the instruments exhibited; however, one part of the subject—that referring to rain gauges and their history—was very ably dealt with by our Secretary, Mr. G. J. Symons, F.R.S.

I propose on the present occasion to direct attention to the very important subject of evaporation and condensation. The rainfall of the country is very efficiently looked after by Mr. Symons, who has also taken up the subject of evaporation; and in *British Rainfall* there are to be found a number of records giving the result of evaporation, but whilst the number of observers of rainfall can be counted by thousands, those who are conducting efficient evaporation experiments may be counted upon the fingers. In this Society, we possess no records that give year by year the amount of evaporation or condensation. There are only three papers in the published records of the Society dealing with the subject of evaporation, one in 1855 by Dr. George Buist, F.R.S.; another in 1870 by Mr. George Dines; and the third in 1871 by Dr. R. J. Mann.

The question of evaporation is of as great importance as the study of the precipitation of water on the face of the earth, for the available water supply of the country depends entirely upon the differences between these two sets of observations. The earth receives moisture by means of rain, dew, hoar-frost, etc., and by direct condensation. It loses moisture very rapidly by evaporation. According to the dynamic theory, evaporation and condensation are constantly taking place. The rate of evaporation in calm air was shown by Dalton, over 90 years ago, to be due to the difference between the vapour tension due to the temperature of the evaporating surface of the water and the vapour tension due to the temperature of the dew-point ($V-v$).

Although evaporation mainly depends upon the difference between the tensional force of the vapour due to the temperature of the evaporating surface and the tensional force of the vapour already in the atmosphere, yet it is largely influenced by the movement of the air and by the dryness of the air, that is, the difference between the dew-point and the actual temperature, the largest amount of evaporation taking place when there is the greatest difference between the temperature of the evaporating water and that of the dew-point, when this action is aided by a brisk motion and great dryness of the air. A sudden fall of the temperature of the air in very hot weather when the water is warm will produce a large amount of evaporation, and, as a rule, all the large daily amounts of evaporation occur under such conditions. Evaporation goes on at night so long as the water surface is warmer than the dew-point. The quantity of water evaporated under the same conditions is directly proportional to the exposed surface; the increase of temperature in the liquid is attended with increase of evaporation, but is not directly proportional to the temperature. The atmosphere obstructs the free diffusion of vapour, and any movement of the air tends to produce induced currents in the vapour as it leaves the evaporating surfaces, and thus materially aids the amount of evaporation, for vapour rises only by virtue of its elasticity, and no more can be produced until that which is incumbent upon the liquid has its tension reduced or is withdrawn by some means.

It has been pointed out with reference to the experimental stage of evaporation, that evaporators differing in size, in the depth of rim above the water, and in their position as to being shaded from air currents or the contrary, will not give the same results. It was also shown by the late Mr. Geo. Dines, that the density of the water has an influence upon evaporation, and that with sea water the evaporation was about 4½ per cent. less than with rain water, while with water saturated with common salt the evaporation was 15 per cent. less than with rain water.

Some 16 years ago I entered upon an investigation to determine, if possible, the quantity of water which was yielded by a large area of the chalk formation, and to aid me in rightly understanding the various processes at work during the period of this investigation, I carried out a number of evaporation experiments at Croydon, which throw some light upon the conditions which promote or check evaporation, and which tend to increase or diminish the quantities of water evaporated, and also upon the common errors by which the results of evaporating gauges are influenced.

An evaporating gauge 1 foot in diameter made of copper, and containing 1 foot in depth of water, which was floated by means of a hollow copper ring placed 6 inches distant from the body of the evaporator, and attached to it by four radial arms, was adopted as a standard evaporator. This form of evaporator was found extremely convenient in carrying on all evaporation experiments; it was floated on a tank 4 feet in diameter, containing 30 inches depth of water. During the period of 13 years, from January, 1879, up to the present time, this evaporator has never once been out of order, or been interfered with in the slightest degree by frost, which is the scourge of evaporators. The water line within the floating evaporator and the water line outside the evaporator, by reason of the power of flotation of the evaporator, was preserved at a nearly constant level. This uniformity of water level, within and without the evaporator, secures the integrity of the evaporator in time of frost, there being practically the same strain on the inner and outer walls of the gauge, so that frost does not interfere with its form. The strain which the expansive force of ice throws upon the sides of a tank is very considerable, and tanks are liable to alter in form and area, or to be injured and leak from this cause, but by the use of a floating evaporator these difficulties are obviated.

In conjunction with the floating evaporator I have a number of other evaporators, 5 inches in diameter and 1 foot in depth, being similar to the pattern of an ordinary Symons' rain gauge, and containing not less than 9 inches in depth of water. These were supported by means of a socket on the bottom of the evaporator, resting on an iron pedestal ¾ of an inch diameter, and, consequently, were freely exposed all round the sides and bottoms. One of these 5 inch evaporators was exposed to atmospheric influences, and others were placed in the same water tank as the floating evaporator.

Experiments were made with some of these 5 inch evaporators as to the effect of colour on the amount of evaporation, one being painted white, another black, and the results given by these gaugings were compared with those of a copper gauge exposed under similar conditions. The results given by these particular gauges when compared with those of a copper gauge not painted, showed that the greatest errors in evaporating gauges arise from capillarity, the water rising on the sides of the gauge and thus inordinately increasing the amount of evaporation. Consequently a small gauge having a larger amount in proportion of side area than a large gauge, indicates a very much larger amount of evaporation. It is essential, therefore, in all evaporation experiments that a standard size should be insisted upon for all evaporating gauges that are to be compared. As a rule, capillarity extends half an inch up the sides of a copper evaporating vessel. In a 5 inch evaporating gauge this capillarity adds nearly 40 per cent. to the water area of the gauge, whereas in a gauge 1 foot in diameter, the influence of capillarity is less than half that of a 5 inch gauge, whilst in a gauge 6 ft. in diameter or 6 ft. square, the influence of capillarity is only one-sixth part of that of a 1 foot gauge, as shown by Table A.

TABLE A.—Proportion of Vessels affected by Capillarity, assuming ½ inch all round to be the limit of area affected.

Size.	Area.	Area Wetted by Capillarity.	Influence of Capillarity relative to 1 foot Evaporator.	Percentage of Area affected by Capillarity to actual Water Area.
	In.	In.		
5 inches Circular	19·64	7·855	2·40	39·995
12 inches „	113·1	18·850	0	16·667
3 feet Square	1296·	72·00	1/3	5·556
6 feet Circular	4071·5	113·10	1/6	2·777
6 feet Square	5184	144·00	1/6	2·777

The experiments with the evaporators at Croydon were carried on for the first portion of the period at an elevation of 255 ft. above Ordnance Datum, but since September, 1889, they have been carried on with the same gauges at a level of 205 ft. above Ordnance Datum. In all these experiments rain water was used for the evaporation.

Table I. shows the actual amount of water evaporated monthly for a period of 13 years by the floating evaporator of 1 foot diameter, the records in all cases being the result of daily observations. No deductions have been made for condensations, which have been kept separate, and are shown in Table II.. Table III. gives the result of the 5 inch evaporator freely exposed

TABLE I.—Evaporation from 12 in. Evaporator floating in Water.

Year.	January.	February.	March.	April.	May.	June.	July.	August.	September.	October.	November.	December.	Total.
	In.	In.	In.	In.	In.	In.	In.	In.	In.	In.	In.	In.	In.
1879	..	·165	·825	1·420	2·200	2·780	2·235	2·430	1·710	·890	·360	..	15·015
1880	·095	·300	1·440	2·370	3·480	3·040	3·710	2·800	2·130	·745	·345	·320	20·775
1881	·177	·298	1·185	2·575	3·655	4·000	4·675	2·995	1·215	·970	·505	·155	22·405
1882	·250	·425	1·440	2·270	3·665	2·990	3·545	2·870	1·495	·740	·615	·085	20·390
1883	·340	·405	·990	2·140	3·280	3·885	3·815	3·635	1·430	·875	·365	·380	21·540
1884	·400	·570	1·355	1·995	3·955	3·035	4·000	4·315	1·650	·930	·295	·355	22·855
1885	·220	·355	1·115	2·310	2·700	4·145	4·825	3·235	1·615	·935	·255	·065	21·775
1886	·290	·200	·640	2·065	2·910	3·675	3·970	2·545	1.940	·705	·335	·065	19·340
1887	·030	·355	·750	2·225	2·320	4·275	4·960	3·955	1·745	·815	·280	·165	21·875
1888	·080	·375	·560	1·655	3·350	2·715	2·095	2·530	1·110	·455	·510	·090	15·525
1889	·040	·235	·660	1·535	2·695	3·605	3·370	2.735	1·705	·810	.505	·256	18·151
1890	·660	·430	1·280	1·850	3·510	2·840	3·120	2·745	1·510	1·315	·880	·230	20·370
1891	·450	·375	1·620	1·775	2·255	3·315	3·095	2·590	1·580	1·135	·590	·535	19·315
Average	·233	·345	1·066	2·014	3·075	3·408	3·647	3·029	1·603	·871	·449	·208	19.948

TABLE II.—CONDENSATION IN 12 IN. EVAPORATOR FLOATING IN WATER.

Year.	January.	February.	March.	April.	May.	June.	July.	August.	September.	October.	November.	December.	Total.
	In.	In.	In.	In.	In.	In.	In.	In.	In.	In.	In.	In.	In.
1879	·020	·055	·005	..	..	·075	..	·025	..	·020	·025	360	·585
1880	·020	·070	·010	..	..	..	..	..	..	·185	·100	·075	·460
1881	·010	·045	·005	..	..	..	..	..	..	·035	·040	·110	·245
1882	·120	·030	·005	..	..	..	..	..	..	·050	·025	·155	·385
1883	·085	·070	..	..	..	..	..	..	..	·020	·025	·030	·230
1884	·070	·015	·030	..	..	..	..	..	..	..	·025	·110	·250
1885	·150	·055	..	·005	..	..	..	..	..	·040	·035	·130	·415
1886	·020	·050	·005	..	..	..	..	..	..	·065	·040	·040	·220
1887	·045	·020	·005	..	..	..	..	..	..	..	·050	·060	·180
1888	·070	..	·030	..	..	..	..	..	..	·020	·050	·145	·315
1889	·115	·020	·055	..	..	..	..	..	..	·015	·030	·040	·275
1890	·055	..	..	..	..	..	..	..	..	·005	·055	..	·115
1891	..	·030	·015	..	..	..	..	..	..	·025	·045	·210	.325
Average	·060	·035	·013	..	..	·006	..	·002	..	·037	·042	·113	·308

TABLE III.—EVAPORATION FROM 5 IN. EVAPORATOR IN AIR.

Year.	January.	February.	March.	April.	May.	June.	July.	August.	September.	October.	November.	December.	Total.
	In.	In.	In.	In.	In.	In.	In.	In.	In.	In.	In.	In.	In.
1879	1·000	1·250	1·080	2·370	4·795	4·635	4·660	4·930	3·340	1·365	·660	·520	30·605
1880	·745	1·890	3·140	3·995	5·630	4·670	4·475	4·535	4·775	1·220	1·195	1·065	37·335
1881	1·210	·690	3·620	4·015	6·800	6·350	8·335	5·095	2·315	2·075	1·625	·805	42·935
1882	·745	1·265	3·255	4·220	6·355	4·890	5·835	4·910	3·050	1·935	1·920	1·040	39·420
1883	1·055	1·340	2·015	4·570	5·810	6·665	6·195	6·545	3·430	2·165	1·250	1·175	42·215
1884	1·335	1·675	3·350	3·645	7·185	5·515	6·985	8·985	4·225	2·360	1·070	1·200	47·530
1885	·715	1·315	3·035	5·485	5·020	7·415	8·565	5·725	3·625	1·775	·770	·580	44·025
1886	·555	·450	1·490	4·165	5·810	6·445	7·230	5·495	4·510	2·320	·935	·515	39·920
1887	·325	1·200	1·715	4·315	3·940	6·955	8·390	7·135	3·205	1·465	·720	·590	39·955
1888	·620	·580	1·450	3·205	6·050	4·480	3·745	4·295	2·530	1·310	1·320	·545	30·130
1889	·540	1·000	2·135	3·655	6·045	6·455	5·810	5·425	3·715	1·615	·730	·630	37·755
1890	1·455	1·230	3·050	4·720	5·620	4·100	4·600	3·785	3·080	1·960	·945	·510	35·055
1891	·810	·910	2·490	3·250	3·960	4·805	4·155	3·170	2·585	1·565	·865	·970	29·535
Average	·855	1·138	2·448	3·970	5·617	5·645	6·075	5·387	3·414	1·779	1·077	·780	38·185

to air in the same periods. The results show that by actual measurement of the floating gauge, the annual average amount of water evaporated in these 13 years was 19·948 inches. In the same gauge, however, it was found that, as a rule, for six months in every year, from January to March, and from October to December, there were certain occasions when condensation was measured. The amount of these condensations in 13 years averaged ·308 inch per annum. The result with the 5 inch evaporating gauge freely exposed to atmospheric influence, gave in the same period as the other gauges, an average annual depth of evaporation equal to 38·185 inches. It should be stated that in this gauge, freely exposed to the atmosphere, condensation was very rarely measured, the reason being that the water in the gauge soon acquired a temperature approaching that of the surrounding air, whereas, in the larger gauge floating in the tank, a sudden change of temperature from cold to warm always gave an amount of condensation. The same law governs condensation as evaporation, so that when the temperature of the water in the evaporator is lower than that of the temperature of the dew point, a sensible amount of condensation takes place both on a water surface and also on the surface of the earth.

As to the effects of colour on evaporation from gauges, three 5-inch gauges were used, viz. one copper, another enamelled white, and a third black. The gauges were all allowed to stand in water in a tank up to the level of the water within the gauge. It will be seen from Tables IV., V. and VI., that in three

TABLE IV.—EVAPORATION FROM 5 IN. COPPER EVAPORATOR STANDING IN WATER.

Year.	January.	February.	March.	April.	May.	June.	July.	August.	September.	October.	November.	December.	Total.
	In.	In.	In.	In.	In.	In.	In.	In.	In.	In.	In.	In.	In.
1879	..	1·065	1·100	1·760	2·355	3·535	2·940	2·880	2·110	1·025	·665	·475	19·910
1880	·595	·430	1·990	2·785	4·680	3·920	4·655	3·695	4·095	1·320	·415	·385	28·965
1881	1·405	1·630	2·200	2·655	4·910	6·380	6·255	4·145	1·745	1·315	1·815	·370	34·825
Average	·667	1·042	1·763	2·400	3·982	4·162	4·617	3·573	2·650	1·220	·965	·410	27·900

TABLE V.—EVAPORATION FROM 5 IN. BLACK EVAPORATOR STANDING IN WATER.

Year.	January.	February.	March.	April.	May.	June.	July.	August.	September.	October.	November.	December.	Total.
	In.	In.	In.	In.	In.	In.	In.	In.	In.	In.	In.	In.	In.
1879	..	·525	1·040	1·620	2·175	3·065	2·500	2·770	2·000	·910	·515	·425	17·545
1880	·435	·360	1·750	2·635	4·230	3·530	4·105	3·335	3·695	1·070	·325	·255	25·725
1881	·315	..	1·780	2·155	4·310	5·630	5·165	3·235	1·175	·975	·505	·380	25·625
Average	·250	·295	1·523	2·137	3·572	4·075	3·924	3·113	2·290	·985	·448	·353	22·965

TABLE VI.—EVAPORATION FROM 5 IN. WHITE EVAPORATOR STANDING IN WATER.

Year.	January.	February.	March.	April.	May.	June.	July.	August.	September.	October.	November.	December.	Total.
	In.	In.	In.	In.	In.	In.	In.	In.	In.	In.	In.	In.	In.
1879	..	·500	·910	1·490	2·615	2·865	2·420	2·600	1·950	·890	·565	·415	17·220
1880	·595	·290	1·700	2·545	4·250	3·240	3·975	2·535	3·395	·980	·255	·255	24·015
1881	·255	..	1·560	1·975	3·950	5·600	4·985	2·965	1·085	·895	·505	·200	23·975
Average	·283	·263	1·390	2·003	3·605	3·902	3·793	2·700	2·143	·922	·442	·290	21·736

years the average evaporation from the copper gauge standing in water was 27·90 ins., from the black 22·97 ins., and from the white 21·74 ins., whilst a gauge of the same dimensions freely exposed in the atmosphere gave, in the same period, 86·96 ins., and the 1 foot floating evaporator in the same period gave 19·40 ins. The 5-inch copper gauge gave a larger amount of evaporation than a gauge painted black. The reason for this is found to be due to the effect of the black paint which restricted capillarity and so to the water in a painted gauge not rising so high up the sides of the gauge. This apparent discrepancy led me to make an experiment as to the effect of an attempt to restrict capillarity by slightly greasing the inside of one of the copper evaporating gauges. With this object the gauge was emptied of water every week and the inside of the gauge was slightly rubbed with grease which was then removed, a sufficient amount only being left to greatly retard capillarity without any grease appearing upon the surface of the water to retard evaporation.

An experiment to test the influence of capillarity was carried on for 5½ years, from April 1884, to September 1889, with three 5-inch gauges standing in a tank of water. The monthly results are shown in Tables VII., VIII. and IX., and gave the following average annual amount of evaporation :—

Copper	... ...	27·22 ins.
White	... ...	23·90 ,,
Copper (slightly greased)		21·70 ,,

TABLE VII.—Evaporation from 5 in. Copper Evaporator standing in Water.

Year.	January.	February.	March.	April.	May.	June.	July.	August.	September.	October.	November.	December.	Total.
	Ins.	Ins.	Ins.	Ins.	Ins.	Ins	Ins.	Ins.	Ins.	Ins.	Ins.	Ins.	Ins.
1884	—	—	—	2·595	4·565	4·285	5·440	5·615	2·360	1·480	·595	·635	27·570
1885	·395	·660	1·700	3·220	3·150	4·855	5·735	4·035	2·220	1·365	·405	·430	28·170
1886	..	·700	1·295	2·895	4·255	5·160	5·755	3·205	2·920	1·115	·520	1·710	29·530
1887	·210	·745	1·880	3·280	3·015	5·335	5·910	4·970	2·460	1·465	·230	·445	29·945
1888	·435	·890	1·120	2·135	4·460	3·535	2·530	3·685	1·495	·770	·650	·140	21·845
1889	·240	·470	1·000	2·110	3·540	4·650	4·020	3·400	1·980	—	—	—	21·410
Average	·256	·693	1·399	2·706	3·832	4·637	4·898	4·152	2·239	1·259	·480	·672	27·223

TABLE VIII.—Evaporation from 5 in White Evaporator Standing in Water.

Year.	January.	February.	March.	April.	May.	June.	July.	August.	September.	October.	November.	December.	Total.
	Ins.	Ins.	Ins.	Ins.	Ins.	Ins.	Ins.	Ins.	Ins.	Ins.	Ins.	Ins.	Ins.
1884	—	—	—	2·175	3·385	3·455	4·520	4·835	2·050	1·290	·505	·425	22·640
1885	·075	·440	1·270	2·650	3·000	4·505	5·475	3·795	1·860	1·227	·265	·060	24·[illegible]22
1886	..	·435	1·045	2·225	3·865	4·280	4·905	3·005	2·440	1·525	·280	1·700	25·705
1887	·120	·595	1·290	2·760	2·715	5·055	5·760	4·830	2·220	2·025	+	·235	27·605
1888	·445	·700	·860	1·850	3·900	3·215	1·950	3·275	1·625	·750	·610	·220	19·400
1889	·220	·410	·930	1·930	3·110	4·230	3·690	3·060	1·850	—	—	—	19·430
Average	·172	·516	1·079	2·265	3·329	4·123	4·383	3·800	2·008	1·363	·332	·528	23·898

TABLE IX.—EVAPORATION FROM 5 IN. COPPER EVAPORATOR (SLIGHTLY GREASED) STANDING IN WATER.

Year.	January.	February.	March.	April.	May.	June.	July.	August.	September.	October.	November.	December.	Total.
	Ins.	Ins.	Ins.	Ins.	Ins.	Ins.	Ins.	Ins.	Ins.	Ins.	Ins.	Ins.	Ins.
1884	—	—	—	2·055	4·205	3·225	4·220	4·525	1·910	1·110	·353	·225	21·828
1885	·235	·370	1·150	2·470	2·820	4·345	5·035	3·425	1·650	·175	·205	·195	22·075
1886	+	·760	1·030	2·415	2·795	3·940	3·865	2·855	1·850	·795	·400	1·802	22·507
1887	+	325	·745	2·760	2·550	4·665	5 480	4·510	2·080	1·075	+	+	24·190
1888	·205	·665	·760	1·615	3·810	3·085	2·070	3·100	1·595	·620	·560	·010	18·095
1889	·170	—	·650	1·750	3·010	4·200	4·020	2 950	1·810	—	—	—	18·560
Average	.122	·424	·867	2·178	3·198	3·910	4·115	3·561	1·816	·755	·304	·446	21·696

The 1 foot floating evaporator gave in the same period an average annual evaporation of 19·68 inches. It will be seen, therefore, that the effect of slightly greasing the interior of the walls of the evaporating gauge was to reduce the evaporation in a copper gauge of identical pattern by 5·52 ins. per annum, or over 25 per cent. Having regard to the relative area of the water surface and the wetted perimeter, and assuming that the same loss occurs in the 1 foot floating evaporator, in order to get the true evaporation from the water surface a correction would require to be made by way of deduction of 2·33 ins.; the correction for the 3 feet evaporator would be about ·776 in. per annum, while for a 6 feet evaporator a correction would have to be made of ·383 in.

The error of capillarity, however, is balanced by an error existing in the opposite direction when computing the deductions to be made for rainfall, as I find upon making experiments that some of the *pluses* which occurred in the evaporation readings were due to excess of rain measured in the evaporator over that of the rain gauge. This led me to investigate how much rain adhered to the surfaces of the rain gauge and was lost in the gaugings and I found that both in the 5 inch rain gauges of the Symons pattern (of which I use a large number), and also in the 8 inch rain gauge of the Glaisher pattern, the loss from this cause averaged ·005in. every time the rain fell, and the gauge was wetted and subsequently emptied. Having regard to the number of days on the average when precipitation took place in the 13 years over which the experiment extended, it was found on the average that precipitation of one kind or another occurred upon 2,421 occasions, which is equivalent to a loss of ·93in. in depth per annum to the evaporator, so that the error due to capillarity would be reduced in the 1 foot evaporator to 1·40 in., making the actual annual evaporation from the water surface in the 13 years 18·5 ins. In the case of larger evaporating gauges, instead of a deduction, an addition would be required by reason of this error, due to the insufficient record of the rain gauge, as the error due to capillarity is less than the rain which is lost by adhesion to the rain gauge. The corrections for evaporating gauges will differ in most cases, and each station must be dealt w th on its own merits. The actual number of times the rain gauge was alternately wetted and dried was greater than the numbers given, and after every separate shower loss would be sustained owing to rain adhering to the gauge.

It is a well-known fact, and will be seen from the observations, that there is an enormous discrepancy between a gauge fully exposed to atmospheric influences and one floating on or immersed in water; and some observations were made to determine the temperature of the water in the respective gauges, when it was found, on an experiment extending over five years, that the temperature of the water of the gauge fully exposed to the air was 50°·16 at 9 a.m., while the floating evaporator in the same period had a temperature of 48°·46. On an average of two years the temperature taken at 9 a.m., between 1 and 2 p.m., and again at 9 p.m., showed that both at morning and at midday the temperature of the water of the gauge in the air was much higher than that of the gauge in water, while the temperatures taken at 9 p.m. showed that the temperature of the gauge in water was higher than that of the gauge in the air, the average for the two years being:—

		°
Temperature taken at 9 a.m.	Gauge in air	51·2
,, ,,	Floating gauge	48·1
Temperature taken between 1 and 2 p.m.	Gauge in air...	57·7
,, ,, ,,	Floating gauge	52·2
Temperature taken at 9 p.m.	Gauge in air	46·4
,, ,,	Floating gauge	48·3

On one occasion (July 3rd, 1887) the water in the evaporator in the air reached a temperature of 100°·2, while the temperature of the water in the floating evaporator did not exceed 76°·4, this latter reading occurring on the same day that the air evaporator arrived at its maximum temperature.

Regarding the comparison between the temperatures of the water of the evaporators and the ordinary atmospheric temperatures, I have found that on an average of 13 years the temperature of the air at Croydon at 9 a.m. was 48°·91, while the temperature of the water of the floating evaporator at the same hour was 48°·43. The average temperature of the air in the same period was 48°·75, so that, in all probability, the temperatures which were taken at 9 a.m. differ but slightly from the average mean temperatures both of the air and water for the place of observation.

In the figures representing evaporation no deduction whatever has been made for condensation, which has been kept quite separate and distinct, as otherwise it would not be possible to compare the tensional differences which tend to produce evaporation or condensation. I find that in the course of 13 years the tensional difference, or the difference of the respective heights of a column of mercury represented by the vapour tension due to the temperature of the dew-point at 9 a.m., and that due to the temperature of the water under evaporation at the same hour was ·364 in.—·291 in., or ·073 in. The monthly differences of vapour tension are shown in the following table:—

January.	February.	March.	April.	May.	June.	July.	August.	September.	October.	November.	December.	Average.
In.	In.	In.	In.	In.	In.	In.	In.	In.	In.	In.	In.	In.
·014	·014	·027	·071	·129	·166	·177	·136	·065	·036	·011	·014	·073

the least being in November The maximum evaporation recorded was greatest in July and least in December. It must not, however, be supposed that the evaporation of water is solely due to the tensional differences, as direct experiments which I have made show this is not the case.

In the course of my experiments I was very desirous of ascertaining if any evaporation took place below the surface of the ground, so as to diminish the volume of the water which had already passed by percolation into the subsoil. With this view I determined to carry out a series of experiments in a cellar entirely below the ground, having no external opening and arched with brickwork, the only opening in it being the doorway, and the observations were recorded once a week, extending from May 4th, 1887, to September 25th, 1889, or for a period of 876 days. In this time the amount of evaporation taking place from a small glass evaporator 1·5 inch diameter and freely exposed to the air, was only 1·966in.; the mean temperature of the water evaporated, as determined at the time of the weekly inspection, was found to average 53°·1 for the whole period, the mean temperature of the air of the cellar, as arrived at from a registering maximum and minimum thermometer, being 53°·5. The temperature of the dew-point, as determined by weekly observations, was 50°·8, and the tensional difference between the water and the dew-point was ·033in. The highest temperature recorded during the experiments was 66°, and the lowest temperature 40°·3. The tensional difference in this case exceeds that of the month of March in the ordinary floating evaporator, while the amount of evaporation taking place was at a rate not more than 1-12th part of that which occurs in the month of March. A second experiment of this character was made in another cellar below the ground level, but in which there was an external opening at the top 9 inches by 6 inches, and also in the inner wall a corresponding opening, which tended to create a slight air current through the cellar. These openings were, however, some 4 or 5 feet above the level of the evaporators. The ceiling of this cellar was lath and plaster. The experiments commenced on October 6th, 1889, and terminated on January 3rd of the present year, lasting for a period of 820 days, a 5 inch copper evaporator being used, similar in all respects to the one freely exposed to the atmosphere. In that time the total amount of evaporation amounted to 5·48 ins., the mean temperature of the water evaporated, as arrived at by weekly observations, was 52°·6. The mean temperature of the air of the cellar, as arrived at from the mean of the maximum and minimum registering thermometers, was 53°·2; the mean temperature of the dew-point was 50°·8, or identically the same as in the former experiments, the tensional difference between the dew-point and water being ·026 in. The highest temperature recorded in the cellar was 63°·6; the lowest 40°·2. It will be seen, therefore, from these experiments, that although the conditions are less favourable so far as tensional differences and temperature are concerned, the amount of evaporation is at least three times as great as that in the case of the cellar, which has no provision for air currents passing through it.

These experiments show the enormous influence of the movement of air in aiding evaporation. In all evaporation experiments, however, it is extremely difficult to determine what is the proper factor to use in any formulæ which may be adopted for calculating the evaporation from tensional differences and movements of the air. The movement of the air over the ground is considerably less than that which is recorded by an anemometer fixed at a considerable altitude above the ground. In some experiments which were made by Mr. Desmond Fitzgerald, at the Water Works, Boston, U.S.A., he records the fact that he found the air motion at the ground level was about one-third of that given by the ordinary anemometer. I may mention that the experiments made at Strathfield Turgiss during 10 years, 1873 to 1882 (which have been worked out by the late Mr. Charles Greaves), show that the velocity of the wind on a low anemometer was but 2·4 miles per hour, which would probably not be more than a fourth of that which would have been given by an anemometer at the usual altitude above the ground. By comparing the wind observations which were taken by Mr. Edward Mawley, F.R.Met.Soc., at Croydon, with evaporation in the same years, the movement of the wind alone will not account for the difference in evaporation, for in the year 1879 there was about the same amount of wind movement as in the year 1884, yet in 1879 the floating evaporator gave but 15·02 ins. of evaporation, whilst in 1884 we had 22·86 ins. The difference of temperature in these years was considerable, the mean being nearly 4° higher in 1884 than in 1879, which was an unusually cold year. The largest average velocity of wind occurred in 1882, and taking individual months, as, for example, November of that year, the average velocity of the wind was 13 miles per hour; the temperature of the water of that month was 41°·5, or below the average temperature, while the evaporation for the month was much above the average. The month of September is that in which there is the least amount of wind, and in this month evaporation rapidly declines; and although the temperature of the water in September is considerably higher than in May, the amount of evaporation is considerably less in September than in May.

With reference to the influence of sunshine and cloud upon evaporation, both these influences are to be felt to a limited extent. The largest evaporation, it will be seen, occurred in the year 1884; that was the year in which there was the least average amount of cloud. The largest monthly evaporation occurred in July 1887, and in that month there was the least amount of cloud of any month during the whole series. As to bright sunshine, referring to observations carried on by Mr. Mawley at Addiscombe, Croydon, and comparing them with the result of evaporation in the same years, or between

1880 and 1884, the largest amount of bright sunshine occurred in the month of May 1882, and in that month there was a particularly large evaporation from the water surface, in fact the largest recorded in May for the whole series of years during which the observations were going on. The least amount of sunshine, however, does not accurately accord with the least amount of evaporation, but this occurs, of course, at periods of the year when the least amount of evaporation does take place.

A series of percolation experiments were carried on simultaneously with the evaporation experiments; two percolating gauges were used, each 3 feet square and 3 feet deep, one gauge being filled from a section of one of the chalk downs in the neighbourhood of Croydon (Riddlesdown), and the other with gravel soil of the valley of the old Town of Croydon. Each gauge had its natural growth of grass upon the surface. The growth of grass on the chalk percolating gauge was shown to be considerably less in weight than that which was obtained from the gravel percolating gauge from time to time. The result of 13 years experiments, from January 1879 to December 1891, show that the average amount of evaporation (being the difference between the rainfall and percolation) ascertained in this way from the chalk gauge was 15·05 ins., and taking 12 years, commencing in October and terminating at the end of September, the average evaporation was almost identical with that given by the foregoing figures, as it was found to be 15·09 ins. The gravel percolating gauge in the same 13 years gave an evaporation of 15·13 ins., whilst in the 12 years ending September it was 15·03 ins. The amount of water, however, evaporated from the ground depend very much upon the nature of the soil, as to whether, or not, it is retentive of moisture. This is clearly shown by the evaporation and percolation experiments of the late Mr. Charles Greaves. The average amount of evaporation arrived at by a floating gauge 3 feet square at Lea Bridge in 23 years, 1860 to 1882 inclusive, after deducting the *pluses* due to condensation, was 19·35 ins. A ground percolating gauge gave 18·17 ins., whilst a sand percolating gauge in the same 23 years gave an evaporation of only 3·78 ins. A similar set of experiments made by Mr. Greaves at Old Ford in 10 years—1873 to 1882—gave an evaporation from a 3 feet water surface of 19·65 ins., from a ground percolation gauge of 21·72 ins., and from a sand percolation gauge, 6.69 ins. The result of 35 years experiments with the ground percolation gauge of Messrs. Dickenson and Evans gave in that period an evaporation of 21·16 ins. It is obvious, therefore, that percolating gauges cannot always be relied upon to give a true amount of evaporation, as at certain periods they are so dry that the evaporation is restricted by the dryness of the percolating medium in the gauge. In a percolating gauge no water is allowed to accumulate in the subsoil, and in this respect it differs essentially from ground in its natural state. As to whether or not evaporation does increase with the depth of the soil is a matter upon which there can be no doubt. The only experiments of this kind have been taken at the laboratory of Sir John Bennet Lawes, Bart., F.R.S., and Dr. Gilbert, F.R.S., at Rothamsted, in which they have had percolation gauges 20 ins., 40 ins., and 60 ins. deep at work for a number of years, but, unfortunately, these gauges are not filled with the same material. This is an essential point in judging of the influence of depth, as the slightest difference in the quality of the soil very much affects the result, as will be seen from the extraordinary difference in the results given by the sand and earth gauges already referred to. However, they do show that in 21 years—from January, 1871, to December, 1891,—the 20 in. percolation gauge gave an evaporation of 15·71 ins., the 40 in. gauge, 14·90 ins., and the 60 in. gauge, 16·30 ins.

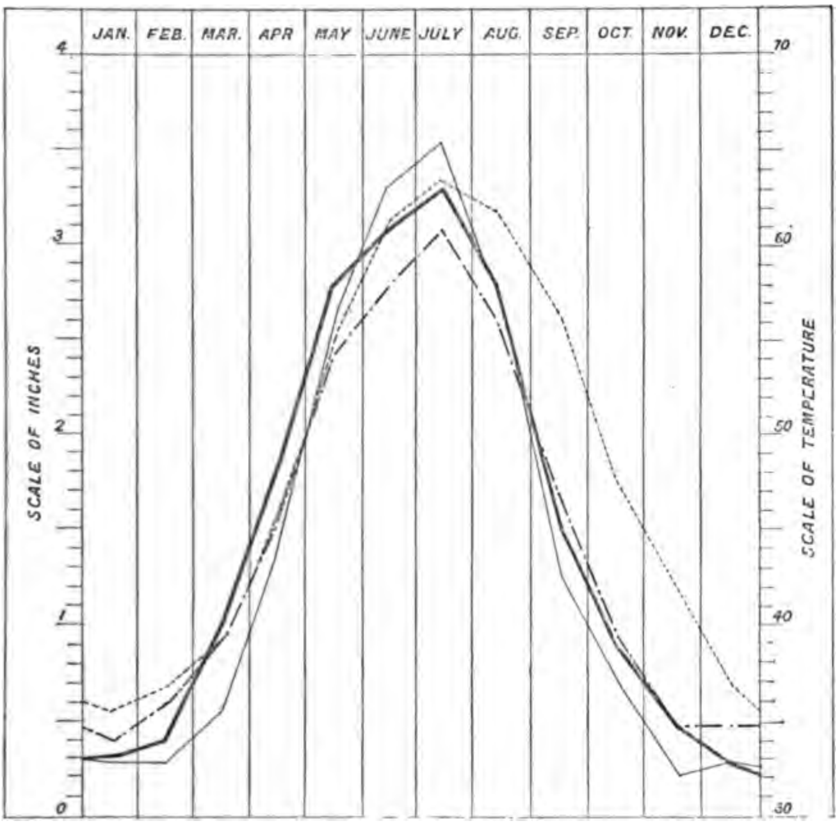
The great object which I had in view in conducting these experiments was to determine really the amount of water which was yielded by the chalk formation. With this object 29 rainfall stations were established on an area of 20 square miles of chalk formation, at an elevation varying from 180 feet to 870 feet above Ordnance Datum, forming the drainage area of the Croydon branch of the River Wandle, and, at the same time, the quantities of water flowing from this area have been determined by continuous gauging for some years. Owing to difficulties, however, arising from the inequality of the volumes of water stored in the ground, the commencement of the year is not a suitable period for determining the amount of evaporation taking place from such areas. I selected, in the first instance, 12 years—commencing October, 1880, and terminating at the end of September, 1891—and found that in this period the actual difference between the rainfall and the quantity flowing off, representing evaporation, was 20·28 ins. But the real evaporation was something more than this, as in October, 1880, there was more water in the ground than at the end of September, 1891; consequently, by selecting a period in which there was the same quantity of water in the ground, I found that at the commencement of the month of November, 1878, there was about the same quantity of water in the ground as there was at the end of July, 1891, the evaporation taking place between these dates being equal to 21·5 ins. per annum.

It is necessary to compare these gaugings with another series of gaugings in the drainage area in which my observations were carried on, viz. in the drainage area of the River Graveney, which contained 8·35 square miles before the year 1882, but by the construction of a railway cutting through Park Hill, Croydon, part of the area has been diverted, so that afterwards it contained but 7·8 square miles. This drainage area has an elevation varying from 40 feet to 280 feet above Ordnance Datum, the soil of which consists mainly of London clay, with patches of pervious material lying upon it, in some parts, the whole of the water from which finds its way into the stream. The result of seven years daily gauging of this stream—from January, 1879, to December, 1885—showed that the evaporation was 19·69 ins. There were periods when this stream was absolutely dry, so that the evaporation, unlike that in the chalk district, was restricted at certain periods of the year, and this may account for the fact that the evaporation was less than that given by the larger chalk area.

With reference to the subject of condensation, I found that not only did condensation take place on the surface of the water whenever its temperature was lower than that of the dew-point, but I constructed an earth hygrometer, consisting of three perforated cylinders, each containing 21·34 lbs. of earth when dry, and which, when fully saturated, weighed 29·026 lbs. The cylinders were suspended at the end of a balanced arm, which recorded the differences in the quantity of water present in the soil at any time. One cylinder was suspended at 1 foot below the surface of the ground, a second 2 feet, while the third was suspended in the air, protected from rain by a double louvre screen. The results recorded by this instrument show that in the day-time, on every warm day—that is, when the earth itself is colder than the external atmosphere—a sensible amount of condensation takes place in the soil; but at night, when the temperature of the atmosphere falls below that of the earth, evaporation takes place, so that, as a rule, in hot weather the two cylinders in earth are heavier at 9 o'clock at night than they are at 9 o'clock in the morning. The exact opposite to this occurs with the cylinder which is suspended in the atmosphere, for on every warm day it sensibly lost weight in the day-time, and every night it increased in weight. The quantities, however, are very slight, as the particular earth used had not such good hygrometric qualities as some other soils, but it was the same soil as surrounded the instrument in the early periods of observation. A difference, due to condensation, of ·05 per cent. was not an infrequent amount recorded, and this was equal to 65 gallons of water on the first foot in depth per acre, but more frequently the quantity recorded in very hot weather was twice or even more times as much.

In the course of my observations on the flow of underground water, I have observed that at certain particular seasons of the year it was possible to indicate the direction and volume of the flow of underground streams, even when they were at a considerable depth below the surface, owing to the formation of special lines of fog. Upon comparison with underground temperatures, which were taken at the same period, it was found that the temperature of the ground for most months in the year exerted an effectual check against the escape of the vapour arising from water in the ground, as the ground acted as a condenser, for, as a rule, except between September and November, there is always some stratum of the ground within 25 feet of the surface which is colder than the temperature corresponding to the tension of the vapour given off by the ground water; but about the months of September or October there are limited periods when no part of the ground between the ground water line and the surface is colder than the ground water, consequently, in these short periods vapours readily escape from the ground, and when accompanied by cold air and a clear sky, as often happens in September and October, these particular fog lines then appear which indicate the presence of ground water and the direction in which it is flowing. It seems that in nature there are constant checks supplied against the inordinate loss of water from the surfaces which receive it, and very dry surfaces are often compensated to a considerable degree by the moisture which is condensed in them, owing to the difference of temperature between their surface and that of the atmosphere; whilst with the deeper waters, as long as the vapours can serve the uses of vegetation, an effectual check by the temperature of the ground is provided, so that these vapours are condensed within a limited distance from the surface of the ground, and sufficiently near to be brought up by capillarity to serve the requirements of the growing plant. Possibly it is by reason of this provision in nature that our great chalk downs, containing the subsoil water at considerable depth below the surface, do not suffer so much in a dry season as other lands in which there is no subsoil water.

The diagram shows in graphic form the amount of evaporation and the conditions influencing it. The tensional difference in this diagram is measured in inches of mercury, the vertical scale being 20 times the natural scale.



EVAPORATION NATURAL SCALE ....
TENSIONAL DIFFERENCE 20 TIMES NATURAL SCALE
DITTO AIR & DEW POINT 20 DITTO ...
TEMPERATURE WATER ....

REPORT OF THE COUNCIL

FOR THE YEAR 1891.

THE Council, in presenting their Report for the year 1891, are happy to inform the Fellows that they have at last succeeded in providing better accommodation for the library and offices of the Society. They appointed a House Accommodation Committee which made inquiries as to offices in the neighbourhood of Westminster, Burlington Gardens, Hanover Square, and Adelphi Terrace, the members of which committee personally inspected several premises in those localities. It was considered that the suite of three rooms on the second floor at No. 22 Great George Street was the most suitable for the Society, being accessible, commodious, and well-lighted, and also in the immediate vicinity of the Institution of Civil Engineers, whose hospitality the Society has so long enjoyed. As soon as these rooms had been viewed by the Council, and kindly surveyed on behalf of the Society by Mr. Ernest Turner, F.R.I.B.A., arrangements were made for taking them on lease from March 25th, at a rental of £180 per annum. The necessary fittings for the accommodation of the library, stock of publications, and other documents, and the furnishing of the rooms, were carried out under the direction of the Committee. As these preparations required some time, the whole of the library was not removed from the old offices at No. 30 Great George Street until June 24th, when the Society's tenancy of those rooms ceased. Although the removal threw much extra work upon the Society's officers, and caused arrears in the issue of the publications, it has been on the whole beneficial, as leading to a thorough examination of the papers and documents preserved by the Society, to the elimination of many duplicate and non-meteorological books and pamphlets, and to an improved classification, which will render the library even more generally useful than formerly.

The Council believe that the acquisition of these new offices marks a very important advance in the history of the Society, and trust that their action will be heartily approved by the Fellows.

The Council have much satisfaction in announcing that the subscriptions promised to the New Premises Fund now amount to £1,168 8s. 6d., of which £1,089 5s. 6d. has been paid, and invested in South Australia 3½ per cent. Inscribed Stock. The Council hope that they may receive further contributions from the Fellows to this Fund, as the interest of its investment is, for the present, to be applied towards defraying the increased rental, which will form a considerable charge on the finances of the Society.

Annual Exhibition of Instruments.—A large and interesting Exhibition of Rain Gauges, Evaporation Gauges, New Instruments, &c., was arranged in the rooms of the Institution of Civil Engineers in time for the reception given by the President of the Institution, Sir John Coode, on Tuesday, March 3rd, and remained open until Friday, March 20th. There were 124 exhibits, which were classified as follows: 1. Old Pattern Rain Gauges; 2. Experimental Rain Gauges; 3. New Pattern Rain Gauges; 4. Mountain Rain Gauges; 5. Storm Gauges; 6. Registering and Recording Rain Gauges; 7. Foreign Rain Gauges; 8. Miscellaneous Rain Gauges; 9. Evaporation Gauges; 10. Instruments not previously exhibited; 11. Photographs, &c.; and 12. Maps and Diagrams.

In connection with this Exhibition Mr. Symons read an interesting paper entitled "A Contribution to the History of Rain Gauges" at the meeting on March 18th, and under the head of New Instruments, or rather New Methods of Observation, Mr. Clayden exhibited and described a series of lantern slides illustrative of the work of the British Association Committee on the application of Photography to the elucidation of Meteorological Phenomena.

Stations.—Observations have been accepted from the following Climatological stations:—Addington Hills, Surrey; Appleby, Westmoreland; Bexhill, Sussex; Northwich, Cheshire; Plymouth, Devon; Ravensthorpe, Northamptonshire; Sheerness-on-Sea, Kent; Sutton Coldfield, Warwickshire; and Windermere, Westmoreland. The observations have been discontinued at Ramsgate, Kent; and Southbourne-on-Sea, Hants. Hopes are entertained that Southbourne may be replaced by Bournemouth.

Copies of detailed monthly returns and annual summaries of results from a number of stations have been supplied as usual to the Meteorological Office.

Inspection of Stations.—All the stations south of latitude 52° N, which had not been inspected during the last two years, were visited, and were found to be on the whole in a satisfactory condition. Mr. Marriott, in his Report (which will be found in Appendix I. p. 71) has called attention to the want of uniformity amongst observers in the use of the Jordan Sunshine Recorder. The Council have considered the matter, and recommend all observers who employ this form of instrument to comply with the following instructions:—

1. Only the sensitised papers as furnished by the manufacturers are to be used. Care must be taken to keep them in a dry and dark place. Not more than three or four months stock of papers should be procured at once.

2. The papers must fit the cylinder perfectly, and the apertures be kept free from dirt.

3. In order to fix the record, the paper must be placed in cold water with its face upwards; four minutes immersion will be sufficient; then it must be dried between sheets of blotting paper.

4. The papers must be fixed and dried as above, *before* the record is measured for tabulation.

Wind Force Experiments.—Mr. Dines is still carrying on an extensive series of experiments with various forms of anemometer, the cost of which is being defrayed by the Meteorological Council. Several members of Council and Fellows of the Society interested in the subject visited Oxshott on Saturday, December 12th, to see the anemometers at work and the new arrangements which Mr. Dines has adopted for recording their indications.

International Meteorological Conference.—This Conference was held at Munich from August 26th to September 2nd, on which occasion the Foreign Secretary, Mr. Scott, acted, as usual, as the representative of the Society. His Report of the proceedings at this Conference was read at the November meeting, and will be found at p. 1 of the present volume.

Congress of Hygiene.—Dr. Marcet and Dr. Tripe were nominated by the Council as delegates from the Society to the General Committee of the International Congress of Hygiene and Demography, which was held in London from August 10th to 17th. Mr. Mawley (Member of Council) acted as one of the Secretaries of the Meteorological Section. The Council voted the sum of five guineas towards the expenses of the Congress.

Thunderstorm Investigation.—The discussion of the Thunderstorm Observations for 1888 and 1889 has been completed. The results have been communicated to the Society in a Report by Mr. Marriott, which was read at the December meeting, and which will be found at p. 23 of the present volume.

Donations.—Considerable additions have been made to the Library during the year, a list of which will be found in Appendix VI. The Hon. Ralph Abercromby has presented to the Society a Breguet Barograph and a Standard Fortin Barometer. A large and interesting collection of cloud photographs has been received from Dr. Riggenbach, of Basle.

Quarterly Journal and Meteorological Record.—These publications have been continued as usual, although the issue of the *Record* has been considerably delayed, owing to the time of the staff having been taken up by the removal from the old to the new premises, and the work was further interrupted for some weeks during the autumn by the illness of two members of the staff.

Dinner.—In commemoration of the entrance of the Society on its New Premises, a Dinner was held at the Holborn Restaurant on Tuesday, July 7th, and was attended by a number of the Fellows.

Committees.—The Council have been assisted by the following Committees:—

General Purposes Committee.—The President, Secretaries, Foreign Secretary, Treasurer, Messrs. Bayard, Brewin, Ellis, Inwards, and Williams.

Editing Committee.—Messrs. Blanford, Inwards, and Scott.

House Accommodation Committee.—The President, Secretaries, Messrs. Bayard, Inwards, Scott, and Williams.

Annual Exhibition Committee.—The President, Secretaries, Messrs. Bayard, Ellis, Scott, and Strachan.

Thunderstorm Committee.—The President, Secretaries, Messrs. Blanford, Clayden, Ellis, Inwards, and Scott.

Stations Committee.—The President, Secretaries, Messrs. Bayard, Ellis, C. Harding, Mawley, and Scott.

Wind Force Committee.—The President, Secretaries, Messrs. Chatterton, Dines, C. Harding, Laughton, Munro, and Scott, with Mr. Whipple representing the Kew Committee.

Fellows.—The changes in the number of Fellows during the year are shown in the following Table:—

Fellows.	Annual.	Life.	Honorary.	Total.
1890, December 31st...	406	133	16	555
Since elected	+33	+1	...	+34
Since compounded	− 1	+1	...	0
Deceased	− 7	−3	−1	−11
Retired	−24	...	...	−24
Defaulters	− 4	...	...	− 4
1891, December 31st...	403	132	15	550

Deaths.—The Council have to announce with much regret the deaths of ten Fellows and one Honorary Member. The names are:—

Henry Ford Barclay	elected June 18, 1862.
Capt. William Chimmo, R.N., F.R.A.S.	,, Jan. 16, 1861.
William Ferrel, M.A. (Honorary Member)	,, Dec. 20, 1882.
John Graham	,, May 7, 1850.
John Merrifield, LL.D., Ph.D., F.R.A.S.	,, Nov. 20, 1872.
George Wareing Ormerod, M.A., F.G.S.	,, Nov. 18, 1874.
The Right Hon. Earl of Powis	,, April 16, 1879.
Thomas William Stone, Assoc.M.Inst.C.E.	,, Dec. 18, 1889.
Herbert Coupland Taylor, M.D., J.P.	,, Feb. 17, 1886.
Nicholas Whitley	,, Mar. 19, 1862.
Robert Stodart Wyld, Jun., M.Inst.C.E.	,, Nov. 19, 1890.

APPENDIX I.

INSPECTION OF THE STATIONS, 1891.

I have inspected during the year all the stations south of 52° N. which had not been visited during the past two years, and found them to be on the whole in a very satisfactory condition.

The changes in the zeros of the thermometers were not very numerous; but at two stations where the thermometers had, owing to breakage, been replaced by others, the corrections of the dry and wet bulbs were found to vary considerably from those which were being used.

At Ventnor, there have been two or three changes in the observers since my last visit; and the present observer, who had been in charge for about two months, had not been instructed in the method of observing. I found that the maximum thermometer was being read and set at 3 p.m., instead of at 9 a.m., and that the bulb of the wet thermometer was inside the bottle containing the water. At Exeter I also found that the grass had been taken up, and the enclosure covered with cinders. I at once requested that the cinders should be cleared out and grass laid down again.

At Old Street, London, the rain gauge was completely worn out, having been eaten away by the noxious smoke, &c., in the London atmosphere. A new outer casing had only been put on three years ago, but this was also eaten through. I at once ordered a new gauge of galvanized iron, which I hope will more successfully withstand the action of the London atmosphere.

There is frequently very great difficulty in securing a full exposure for the Sunshine Recorder, and I fear that at some of the stations the instruments do not record the whole of the sunshine. In two or three cases trees have grown up since the recorder was first put into position, and now cut off some of the sun's rays. It is not an uncommon thing for observers to purchase a Sunshine Recorder without first ascertaining whether they have a convenient and suitable site for exposing it.

The Jordan Sunshine Recorder, in its present form, does not seem to be a very satisfactory instrument. The papers probably are not all of the same sensitiveness, and on being fixed do not always come out of the water with the same degree of clearness. The Society's observers are instructed to fix the papers by immersion in water before reading off the trace. I find, however, that some others use different methods, *e.g.* some measure the trace without being fixed at all, while others fix the papers with a solution of sulphuric acid, instead of water. I think it very desirable that the Council should determine what is the best method to be adopted for working the Jordan Sunshine Recorder, so that strictly comparable results may be obtained by all observers who use this form of instrument.

William Marriott.

October 20th, 1891.

NOTES ON THE STATIONS.

Addiscombe, *October 9th.*—The thermometer screen required painting and the legs renewing.

Beddington, *October 9th.*—All the instruments were in good order. An apple tree on the south-south-east required cutting back.

Bennington, *September 11th.*—This station was in good order. A Jordan Sunshine Recorder and an earth thermometer at 1 foot have been added since the last inspection.

Berkhamsted, *October 1st.*—All the instruments were in good order.

Bexhill-on-Sea, *September 23rd.*—The instruments are placed on a lawn in a very well exposed situation. The thermometers required rearranging in the screen. The Jordan Sunshine Recorder is mounted on a post at the Coastguard Station, and is about 8 feet above the ground.

Brighton, *September 22nd.*—I found that the thermometer screen had been painted green, and that the door was off its hinges. I requested that this should be repaired, and that the screen should be painted white. I also requested that the rain gauge should be moved about 15 feet east of the thermometer screen, and that some branches should be taken off the surrounding trees.

CASTLE HILL, *July 16th.*—This station, which is about 3 miles west of South Molton, and 8 miles east-south-east of Barnstaple, is in somewhat of a valley running from north-west to east, and is near Castle Hill House. The instruments are placed in the kitchen garden of the School House. The minimum thermometer had gone up 0°·3.

CHELMSFORD, *September 4th.*—The instruments are placed on the lawn, which has some fruit trees in it. The exposure is satisfactory. The rain gauge was not fixed in the ground, as it was moved about when tennis was played, and at the time of my visit was nearly under one of the trees. I selected a new site for the gauge, and recommended that it be a fixture with the rim 1 foot above the ground.

CROMER, *October 24th.*—This station was not in a satisfactory condition. The thermometer screen required shifting round so that the door should open to the north. The minimum thermometer was out of order, the column of spirit being broken up. The thermometers were only read to whole degrees. The rain gauge I found had not been attended to daily. I adjusted the instruments, and put them in working order, and also instructed the observer in the method of reading them.

EASTBOURNE, *September 23rd.*—The large tree that was on the south-south-west, referred to in the last Report, had been cut down some time previous to my visit. On examining the thermometers it was found that the wet bulb had gone up 0°·2, and that the minimum had gone down 0°·2.

EXETER, *July 17th.*—This station was not in a satisfactory condition. All the grass had been taken up from the enclosure and cinders laid down. I strongly urged that these should be cleared out at once, and grass relaid. The thermometer screen required painting.

GUERNSEY, *July 18th.*—The tube of the minimum thermometer was loose and required fixing. The rain gauge had been moved about 3 feet south-east of its former position. The Jordan Sunshine Recorder is on the roof of the house. The exposure appeared to be clear all round except on the west-north-west, where the ridge of the house might possibly intercept the evening rays.

HARESTOCK, *July 23rd.*—The instruments were all clean and in good order.

LONDON, OLD STREET, *October 13th.*—As the rain gauge was completely worn out, I forthwith ordered a new galvanised iron gauge, which was to be placed about 2 feet south of the former site. Owing to an accident to the dry and wet bulb thermometers, another pair of thermometers were sent to the observer in March 1890. On comparing these thermometers it was found that the dry had risen 0°·8 and the wet 1°·0 above the Kew corrections of 1883.

LYNSTED, *September 16th.*—This station is about 3 miles south-east of Sittingbourne. The instruments are placed in the kitchen garden. The thermometer screen required strengthening and painting. I recommended that grass should be laid down round the thermometer screen. On comparing the thermometers it was found that the maximum had gone up 0°·2.

MARGATE, *September 15th.*—This station was in good order. On comparing the thermometers it was found that the earth thermometer at 2 feet had gone up 0°·2. Mr. Stokes has a Richard Barograph at work, and contemplates starting a Sunshine Recorder.

MARLBOROUGH, *July 13th.*—The thermometers were all in good order. The earth thermometers, however, required some adjusting, as they were not quite at their proper depths.

PORTSMOUTH, *September 21st.*—The instruments are in the grounds of the Milton Hospital and are well exposed, the situation being open and the ground flat. In addition to the usual instruments, Dr. Mumby has a Jordan Sunshine Recorder, earth thermometers at 1 and 4 feet, and a Robinson anemometer. The Sunshine Recorder was mounted on the top of the thermometer screen, and evidently did not get all the sunshine. I recommended that it should be placed on the roof of the stable, and also that the thermometer screen should be painted white instead of stone colour.

RAVENSTHORPE, *October 2nd.*—This station is 9 miles north-west of Northampton. The instruments are placed in an enclosure in a field belonging to the Northampton Corporation Waterworks. The ground slopes to the north-east. The exposure is very open. The thermometers are mounted on a stand which is open to the north. I recommended that an additional board should be fixed on the south side, with a few inches air space between it and the present board, and that some holes should be made in each board; also that the stand should be painted white instead of slate colour. I gave the observer full instructions as to the management of the wet bulb and the other instruments.

REGENT'S PARK, *October 13th.*—A garden minimum thermometer was being used temporarily, as the column of spirit in the ordinary minimum thermometer had been broken. This, however, I set right. A new 8-in. rain gauge has been started, and the records agree with those from the other gauge.

ROUSDON, *July 15th.*—The instruments have been placed in a large enclosure in a field near the Astronomical Observatory. The exposure is very good. The thermometers were all correct except the minimum, which had gone down 0°·3. Mr. Peek has a Richard self-recording Rain Gauge, the funnel being above the roof of a shed, and the recording part inside. A 5-in. check gauge is also mounted at the same level. Rousdon is on a hill over 500 feet above sea level, between Seaton and Lyme Regis, and is only a short distance from the cliff, which is very precipitous. The whole place is often enveloped in fog, while the air is clear at 200 or 300 feet below.

SOUTHAMPTON, *July 17th.*—No change has taken place in the thermometers. The Rev. H. Garrett adopts the plan of filling the bottom of the tubes of the earth thermometers with oil, in which he immerses the bulbs.

SOUTHBOURNE, *July 22nd.*—I found that the observations had been discontinued some months previously, and that Dr. Compton had gone into the country. As there was no prospect of the observations being continued by any one else at Southbourne, I called upon several gentlemen in Bournemouth with the view of inducing the Corporation to start a Climatological station in that town, which they have since done.

STOWELL, *July 14th.*—No change had taken place in the thermometers. The earth thermometer being on Negretti and Zambra's plan, and imbedded in wax, could not be tested. The Sunshine Recorder was mounted on a post 4 feet above the ground, and was not satisfactorily exposed. I recommended that it be moved to the field on the north-west and placed on a post 8 or 10 feet high, where it would be much better exposed.

STRATHFIELD TURGISS, *July 25th.*—The instruments were in the same position as at the last inspection. On comparing the thermometers it was found that the proper corrections had not been used for the dry and wet, which, however, had both gone up, the dry reading 0°·6 and the wet 0°·7 too high.

SWARRATON, *July 24th.*—No change had taken place at this station.

TUNBRIDGE WELLS, *August 31st.*—All the instruments were in good order. Dr. Smart has two solar black bulb thermometers, one fixed against a white wall, and the other against a black wall; the former usually reads higher than the latter. He is also making experiments with a black bulb and a white bulb solar thermometer on the tower of his house.

VENTNOR, *September 19th.*—This station was not in good order, as the observer had only been in charge a few months and had received no instruction. I found that the maximum thermometer had been read and set at 8 p.m., instead of at 9 a.m. The wet bulb was not working properly, as there was very thick muslin and thread round it, and the bulb was enclosed in a bottle containing the water. The dry and wet bulb thermometers had gone up 0°·1. I gave the observer full instructions in the management of the wet bulb and the other instruments.

WEYMOUTH, *July 22nd.*—There was no change in the instruments. The amount of cloud seemed to be under estimated.

WORTHING, *September 21st.*—This station was in good order. The minimum thermometer had 1°·1 of spirit up the tube. Mr. Harris has a Richard Barograph which works very well.

WRYDE, *October 23rd.*—The instruments were in good order. The readings are entered on a slate and copied off weekly. I recommended that a note book should be used instead of a slate.

APPEN-

STATEMENT OF RECEIPTS AND EXPENDITURE

RECEIPTS.

	£ s. d.	£ s. d.
Balance from 1890	339 0 0	
Less sum due to New Premises Fund	37 11 0	
		301 9 0
Subscriptions for 1891	687 13 4	
Do. former years	17 0 6	
Do. paid in advance	30 3 0	
Life Compositions	42 0 0	
Entrance Fees	30 0 0	
		806 16 10
Meteorological Office—Copies of Returns	90 18 7	
Do. Grant towards Inspection Expenses	25 0 0	
		115 18 7
Dividends on Stock (including £36 5s. 4d. from the New Premises Fund)		102 10 9
Sale of Publications		36 13 6
		£1363 8 8

DIX II.

FOR THE YEAR ENDING DECEMBER 31st, 1891.

PAYMENTS.

	£ s. d.	£ s. d.
Journal, &c.:—		
Printing Nos. 77 to 80	135 5 6	
Illustrations	24 8 9	
Authors' Copies	13 7 0	
Meteorological Record, Nos. 39 and 40	30 11 6	
Registrar-General's Reports	8 8 0	
		212 0 9
Printing, &c.:—		
General Printing	21 14 6	
Stationery	15 15	
Books and Bookbinding	23 5 9	
		60 16 0
Office Expenses:—		
Salaries	367 0	
Rent and Housekeeper	128 15 3	
Fitting up New Offices	140 17 3	
Furniture	40 3 8	
Removal Expenses, Coals, Insurance, &c.	18 11 2	
Postage	48 0 10	
Petty Expenses	16 1 8	
Refreshments at Meetings	15 11 1	
Exhibition of Instruments	12 10 10	
International Congress of Hygiene	5 5 0	
		792 17 9
Observations:—		
Inspection of Stations	41 18 9	
Observers at Old Street and Seathwaite	7 2 0	
Instruments	0 15 7	
Thunderstorm Discussion	23 13 0	
		73 9 4
		1139 3 10
Balance:—		
At Bank of England	214 11 2	
In hands of the Assistant-Secretary	9 13 8	
		224 4 10
		£1363 8 8

Examined and compared with the Vouchers, and found correct,

J. S. HARDING, JUNR., } *Auditors.*
H. SOWERBY WALLIS, }

January 14th, 1892.

APPEN-

ASSETS AND LIABILITIES

Liabilities.

	£	s.	d.
To Subscriptions paid in advance	30	3	0
„ Grant for Thunderstorm Inquiry, unexpended	3	1	6
	33	4	6
„ Excess[1] of Assets over Liabilities	2566	12	1
	£2599	16	7

[1] This excess is exclusive of the value of the Library and Stock of Publications.

NEW PREMISES FUND,

	£	s.	d.	£	s.	d.
Amount paid to the Society's Funds towards the increased rent of the New Premises				36	5	4
Invested in purchase of £100 2¾ per cent. Consols	97	7	6			
Do. Do. £934 14s. 6d. South Australian 3½ per cent. Inscribed Stock	907	17	6			
Do. Do. £128 4s. 11d. Do.	124	11	8			
Do. Do. £69 8s. 9d. Do.	64	1	6	1194	15	2
				£1231	0	6

DIX II.—Continued.

ON JANUARY 1st, 1892.

ASSETS.

	£ s. d.	£ s. d.
By Investment in M. S. and L. R. 4½ Debenture Stock, £800 at 138	1104 0 0	
,, Investment in N. S. W. 4 per cent. Inscribed Stock, £654 18s. at 106½	697 9 4	
,, Investment in 2¾ per cent. Consols, £250 at 95¼	238 2 6	
		2039 11 10
,, Subscriptions unpaid, estimated at	25 0 0	
,, Entrance Fees unpaid	9 0 0	
,, Interest due on Stock	31 19 11	
		65 19 11
,, Furniture, Fittings, &c.	200 0 0	
,, Instruments	70 0 0	
		270 0 0
,, Cash in hands of Bank of England	214 11 2	
,, Do. ,, the Assistant Secretary	9 13 8	
		224 4 10
		£2599 16 7

J. S. HARDING, Junr., } *Auditors.*
H. SOWERBY WALLIS, }
WILLIAM MARRIOTT, *Assistant Secretary.*

January 14*th*, 1892.

DECEMBER 31st, 1891.

	£ s. d.
Balance from last Account	41 11 8
Contribution of Fellows	238 18 6
Sale of £951 5s. 8d. 2¾ per cent. Consols	907 17 6
Interest received on Investments	42 12 10
	£1231 0 6

J. S. HARDING, Junr., } *Auditors.*
H. SOWERBY WALLIS, }
WILLIAM MARRIOTT, *Assistant Secretary.*

January 14*th*, 1892.

APPENDIX III.

Subscriptions promised towards the New Premises Fund.

DECEMBER 31ST, 1891. (SECOND LIST).

	£	s.	d.
Amount already promised	1,110	18	0
Mr. P. Bicknell...	5	5	0
Mr. R. W. P. Birch, M.Inst.C.E.	5	0	0
Dr. C. H. Blackley	2	2	0
Col. C. K. Brooke	1	1	0
Mr. G. Chatterton, M.A., M.Inst.C.E.	5	5	0
Mr. S. Dixon	2	2	0
Miss E. A. Dymond	2	2	0
Mr. H. S. Eaton, M.A....	10	0	0
Right Hon. Lord Ebury (2nd donation)	3	3	0
Mr. R. Foster	2	2	0
Mr. R. Inwards, F.R.A.S.	5	0	0
Mr. R. J. Lecky, F.R.A.S.	2	0	0
Mr. R. C. Mossman	1	2	6
Hon. F. A. R. Russell, M.A.	10	0	0
Mr. J. Stokes	1	1	0
	£1,168	3	6

APPENDIX IV.

OBITUARY NOTICES.

Capt. William Chimmo was born in the year 1828, and entered the Royal Navy in 1841, when only thirteen years old. He obtained the rank of lieutenant in 1850, and of commander in 1864. He served in the first and second China wars, against pirates in Borneo, and for six-and-a-half years was engaged in the *Herald* in the search for Sir John Franklin. Afterwards, as lieutenant of the *Juno* he led the successful search for the lost expedition of Mr. Gregory and his party in Torres Straits, and assisted in the magnetic observations during the voyage of the *Royal Charter* to Australia. In command of the *Sea Gull* he was engaged in the survey of the west coast of Scotland, and as commander of the *Gannet* in the survey of Trinidad and the exploration of Labrador. He also explored the Sulu Islands, where he had three officers and two men wounded in the attack upon a nest of pirates, of whom 190 were killed.

From 1856 to 1858 Captain Chimmo was secretary to the Hydrographer of the Admiralty. The greater portion of his life was devoted to the Hydrographic Survey, and he wrote several papers on the result of the deep-sea soundings in the Atlantic, on which he was employed.

After his retirement from the Navy, with the rank of post-captain, in 1878, he settled at Weymouth, where he died, October 30th, 1891, at the age of sixty-four. He was a Fellow of the Linnean, Royal Geographical, and Royal Astronomical Societies.

He was elected a Fellow of this Society on January 16th, 1861.

Prof. William Ferrel was born in Bedford County, Pennsylvania, U.S., on January 29th, 1817. During his boyhood he was kept rather closely at work on his father's farm, and with the first money he earned he bought a copy of Park's *Arithmetic.* Having also a liking for astronomical studies, he used to draw a number of diagrams upon the doors of his father's farm, describing circles with the prongs of a pitchfork. In 1839, he entered one of the Colleges in Pennsylvania, and graduated at Bethany College in 1844.

In 1857 he became an assistant in the office of the *American Ephemeris and Nautical Almanac*, and subsequently entered the U.S. Coast Survey and the Signal Office, from which last he retired in 1886. He was elected a member of the National Academy of Sciences in 1868.

Ferrel is described as an extremely diffident man, and he never once sought appointment; every official position he occupied having been offered to him. His first paper bearing directly on meteorology was published in 1856, with reference to the deflective effects of the earth's rotation upon the motions of the atmosphere; and this paper, which has done much towards establishing meteorology on a scientific basis, was subsequently revised and reprinted as one of the Professional Papers of the Signal Service, under the title *Motions of Fluids and Solids on the Earth's Surface.* In this treatise he proposed a complete analytical investigation of the general motions of the fluids surrounding the earth. These papers received considerable attention and discussion soon after publication, especially in France; in America and England they were overlooked until recent years, but they are now recognised as fundamental propositions in the study of meteorology. He also wrote various articles on the tides, which are of equal importance with those on the motions of the atmosphere, and he constructed a "maxima and minima tide-predicting machine," which is now in use at the Coast Survey Office in Washington. The last of his numerous works upon meteorology was a *Popular Treatise on the Winds*, published in 1889. In this work he has explained at length, and with great clearness, many points which in his other writings have been too mathematical to allow of their being generally understood.

He died at Maywood, Kansas, on September 18th, 1891.

He was elected an Honorary Member of this Society on December 20th, 1882.

John Merrifield, LL.D., Ph.D., was born August 24th, 1834, at Peter Tavy, on the borders of Dartmoor. He received his early education at the Tavistock National School, and after passing two years at the Exeter Training College, was appointed elementary schoolmaster at Mary Tavy. His spare time was devoted to surveying and chemistry, and he was much sought after as an analyst. His natural love for mathematics, however, led him in 1862 to leave Mary Tavy for Plymouth, to become the founder and head master of the Plymouth Navigation School, thenceforward occupying himself with astronomy, meteorology and kindred subjects.

In 1860 he published, in conjunction with Mr. Evers, a *Treatise on Navigation and Nautical Astronomy*. In 1876 he published a work on *Magnetism and the Deviation of the Compass*, and in 1887 a *Treatise on Nautical Astronomy*, in which he introduced his own method of clearing the lunar distances. In 1888 he received the Bronze Medal of the Falmouth Polytechnic Exhibition for an artificial horizon for sea use.

Dr. Merrifield's interest in education was shown by the science classes conducted by him, in most cases for the love of teaching, in which students were instructed in the elements of mathematics. He made and tabulated regular meteorological observations for nearly twenty-seven years. At the time of his death he was engaged in preparing for publication a work on *Climate and Health.*

Dr. Merrifield died June 27th, 1891, having been in failing health for nearly two years.

He was elected a Fellow of this Society on November 20th, 1872.

George Wareing Ormerod was born October 12th, 1810, and was the second son of George Ormerod, F.R.S., the well known historian of Cheshire. After leaving Dr. Burney's school at Greenwich and a private tutor's he entered Brazenose College, Oxford. He afterwards settled as a solicitor at Manchester, where as agent for his father's property at Tyldesley and to the Astley estate, he (with his brother, Henry M. Ormerod, who had joined him) had much to do with the drainage of Chat Moss, and took a prominent part in all scientific and charitable Institutions, and especially in the inquiry respecting the disaster at Holmfirth.

Immediately after taking his degree he became a Fellow of the Geological Society, and he contributed many papers to that Society and to the British Association, whose meetings he constantly attended for many years, being acquainted with the leading geologists of his time.

Mr. Ormerod was specially consulted on the salt fields of Cheshire both by the Committee of the House of Commons many years ago and in these last few years about the sinking of the ground in the neighbourhood of Northwich. About 1856 he moved from Manchester to Chagford on Dartmoor, and after some years to the milder climate of Teignmouth.

He was always a popular man amongst his neighbours, and occupied himself with scientific, antiquarian and local pursuits, frequently writing pamphlets or longer papers, including the classified Index to the *Quarterly Journal of the Geological Society.*

He died at Teignmouth from a sudden chill affecting the heart, January 6th, 1891, aged 80.

He was elected a Fellow of this Society on November 18th, 1874.

The Earl of Powis was the son of the second Earl of Powis (of the Clive family) by the third daughter of the third Duke of Montrose. He was born at Pershore, Worcestershire, in 1818, and was educated at Eton, and at St. John's College, Cambridge. The University conferred the honorary degree of LL.D. upon him in 1842 and elected him High Steward in 1863. Lord Powis succeeded to the title on the death of his father in 1848. He was a Deputy Lieutenant and county Alderman for Salop, and Lord Lieutenant of Montgomeryshire; he was also Lieutenant-Colonel Commandant of the South Salop Yeomanry Cavalry. As Viscount Clive he represented the northern division of Shropshire in Parliament from 1843 to 1848.

He was elected a Fellow of this Society on April 16th, 1879.

Herbert Coupland Taylor, of Todmorden Hall, Lancashire, M.D. Edinburgh, and J.P. for Lancashire and Yorkshire, who died at Torquay, September 14th, 1891, was the son of Dr. James Taylor, of Todmorden Hall, and Culverlands, Berks, one of the well-known Whitworth doctors who attained great fame in the north of England during the latter part of the 18th century and the first half of this century.

Dr. Taylor was born at Culverlands in August 1855. He was educated chiefly at Cheltenham College, whence he proceeded to King's College, London, and subsequently to the University of Edinburgh. He took the degrees of M.B. and C.M. at King's and the M.D. of Edinburgh (with commendation).

From an early age he had shown great interest in the study of meteorology, his attention having been probably attracted to the subject by the careful records which were kept at Culverlands through many years for the use of his uncle, the well-known astronomer, Mr. Dawes.

He very quickly saw the importance of meteorological work in his profession, and the subject of his thesis for the degree of M.D. was "The Ocean as a Health Resort in Phthisis," which in an enlarged and amended form appears in his book published in 1890, and entitled *Wanderings in Search of Health, or Medical and Meteorological Notes on various Health Resorts.*

He contributed papers from time to time to the *British Medical Journal*, but the above-mentioned book, which is a most useful and practical work, founded on actual experience of the various health resorts now chiefly in vogue and described therein, was his chief contribution to the combined sciences of Medicine and Meteorology.

During his residence at Todmorden he was the Meteorological Registrar for that district, and took regular observations until ill-health forced him to live abroad. His interest in Meteorology continued unabated to the last.

The last three years of his life were spent in Madeira, where he made careful and systematic observations, the results of which he published in his "Wanderings."

In June 1891 he contributed a paper to this Society on the "Leste," or "Hot Wind of Madeira;" but he did not live to see it printed in the *Quarterly Journal*, as he passed away at Torquay a few months afterwards.

He was elected a Fellow of this Society on February 17th, 1886.

NICHOLAS WHITLEY was born at Tregony, on March 10th, 1810, and was the eldest son of Mr. Daniel Whitley.

In 1830 he removed to Truro, where he practised as a civil engineer, and agent, and surveyor for many years, and in these capacities was well known throughout the west of England.

In 1845 he was appointed surveyor to the Cornwall Railway, and purchased the whole of the land required for the construction of the main line, as well as that for the St. Ives branch.

He was land agent to Sir William Williams, Bart., for his North Devon Estates, and constructed for him the Heanton Embankments, which enclosed a large quantity of rich marsh lands in the estuary of the river Taw. He was also land agent for the Hope estates in Cornwall, and land agent and surveyor for the Gilbert estates in Cornwall and Sussex. In the latter capacity he designed and laid out for building purposes a large portion of the town of Eastbourne, and also constructed the necessary roads and sewers.

He was employed by Lord Clinton with regard to Trefusis and other property; Kimberley Park, at Falmouth, was laid out from Mr. Whitley's designs, as also were Arwenack Manor at Falmouth, and Alverton at Penzance. As engineer, he carried out the improvement of the river Camel from Wadebridge to Padstow, and other works in the west of England.

In all matters of business Mr. Whitley was trusted alike for his soundness of judgment, and his strict integrity.

In scientific matters, more particularly geology and meteorology, Mr. Whitley took a deep interest, and by his death the Royal Institution of Cornwall has lost a most useful and valued member, who for more than half a century contributed papers to its Transactions. He was elected a Secretary in 1859, and served the Institution in that capacity for twenty years; and, after his resignation, he was elected a Vice-President. Mr. Whitley was Honorary Member of the Geological Society of Cornwall and of the Edinburgh Geological Society.

In 1843 he published a work on the *Application of Geology to Agriculture*, and in 1850 his paper on the *Climate of the British Islands and its effects on Cultivation*, won the prize of £50 offered by the Royal Agricultural Society of England. The pages of the *Bath and West of England Agricultural Journal* contain several papers from his pen, amongst them, "On the Temperature of the Sea and its Influence on the Climate and the Agriculture of the British Islands," and another on the "Development of the Agricultural Resources of Cornwall."

In his later years Mr. Whitley turned his attention to the Antiquity of Man and the Palæolithic Age, and wrote several papers on this subject, in which he criticised modern views with much independence of thought and vigour of language.

He died suddenly at his residence, Penarth, Truro, on his eighty-first birthday, March 10th, 1891.

He was elected a Fellow of this Society on March 19th, 1862.

Robert Stodart Wyld, Jun., was born on March 12th, 1855, at Queensferry. His father had been trained as a Writer to the Signet; but giving up the practice of the law, had settled at Queensferry, of which for many years he was the much respected Provost. Robert Wyld received his education at the Academy and University of Edinburgh. Having made choice of engineering as his profession, he served a pupilage of five years, from 1872 to 1877, under Messrs. J. and A. Leslie, whose extensive practice gave him an early experience in many kinds of engineering operations. On the completion of his articles he was appointed by Messrs. Leslie as Resident Engineer at the waterworks then being constructed for supplying the town and district of New Cumnock. After some months he was transferred to Midlothian, and placed in charge of a section, 18 miles long, of the pipe-line conveying a new water-supply to the City of Edinburgh from the Moorfoot Hills, with all the reservoirs, bridges, and other works connected with it.

At the beginning of 1879 he was appointed Resident Engineer on the Scarborough Harbour Improvement Works, which consisted of the deepening of two harbours, widening and extending a pier, underbuilding old quay-walls, and other operations. This undertaking occupied him for two years, and in January, 1881, he returned to Scotland to superintend for Messrs. Leslie the construction of the Acreknowe Reservoir on the Hawick Waterworks. A few months later, namely, in October, 1881, he was selected to take charge of an important section of the Vyrnwy Waterworks of the Liverpool Corporation. The portion of this great engineering undertaking more especially under his supervision consisted of 35 miles of the main aqueduct, including all the special works connected therewith. From the nature of the ground these were of a multifarious kind, and calculated to fully tax the resources of an engineer. They included reservoirs and tanks, with earthen embankments as well as with concrete and brickwork walls, filters, clear-water tank, valve-houses, cottages, new roads, bridges, culverts, crossings over rivers, canals, and railways, and also three tunnels, having an aggregate length of about 4 miles. The cost of that portion of the great work with which he was connected exceeded £300,000. On the eve of its completion he was struck down by illness. A chill caught in March developed into rheumatic fever, which closed his career, on the 17th of April, 1891.

Mr. Wyld was remarkable for a singular gentleness and modesty, combined with a straightforward frankness, which gained him the respect and goodwill of all who came into close personal contact with him. His energy and enthusiasm in the discharge of his duties were unflagging. His professional skill and fertility of resource marked him out as one who, had he lived, would doubtless have gained a high place among the hydraulic-engineers of this country.

Mr. Wyld was a Member of the Institution of Civil Engineers and a Fellow of the Geological Society.

He was elected a Fellow of this Society on November 19th, 1890.

APPENDIX V.

BOOKS PURCHASED DURING THE YEAR 1891.

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APPENDIX VI.

DONATIONS RECEIVED DURING THE YEAR 1891.

Presented by Societies, Institutions, &c.

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APPENDIX VII.

REPORTS OF OBSERVATORIES, &c.

THE METEOROLOGICAL OFFICE.—Lieut.-Gen. R. Strachey, R.E., C.S.I., F.R.S., Chairman of Council; Robert H. Scott, M.A., F.R.S., Secretary; Nav.-Lieut. C. W. Baillie, F.R.A.S., Marine Superintendent.

MARINE METEOROLOGY.—*Current Charts for all Oceans.*—This work continues to make steady progress. All the information contained in the Office logs has already been entered on the charts, and during the year 1891, 4,597 logs of H.M. ships, obtained from the Record Office, have been consulted. The work has progressed so far that along the most frequented tracks the monthly course of the currents has been sufficiently determined, and the efforts of the Office are now directed to the collection of information from the less usually visited regions of the ocean. Three of the publications relating to the Meteorology of the Indian Ocean, which were noticed last year, have appeared:—The *Aden Cyclone Charts*, the *Meteorology of Cape Guardafui*, and *Dr. Meldrum's Cyclone Tracks for the South Indian Ocean.*

The Meteorology of the Red Sea.—These charts have not yet gone to the engraver, but it may be said that the work is practically complete and will ere long be published.

The Meteorology of the South Sea.—This investigation is making solid and rapid progress. The number of logs of H.M. ships which have been consulted during the year is 529, and in addition, logs have been obtained from some of the great Companies owning the regular lines of steamers to Australia and New Zealand.

WEATHER TELEGRAPHY.—The only change in this department has been the establishment of a reporting station at the New Signal Station, erected by Lloyds at the North Foreland. The information thence derived as to the weather at the mouth of the Thames will be of great importance.

The Office is publishing means of various elements from the *Daily Weather Report*, which will, it is hoped, be found useful.

LAND METEOROLOGY OF THE BRITISH ISLES.—The Volume of the *Quarterly Weather Report* for 1880 is now complete. The volumes of the *Hourly Mean Readings* for five day periods, as explained in last Report, have been published for 1887 and 1888, and that for 1889 is in a very forward state.

The Harmonic Analysis of the Hourly Observations made at British Observatories by General Strachey has been issued. The volume of *Observations from Stations of the Second Order* for 1887 has appeared, and it is anticipated that that for 1888 will be out before Midsummer.

In addition, the Registrar General for Ireland has been as usual supplied with returns from 11 stations for his Quarterly Reports.—*February* 1892.

ROYAL OBSERVATORY, GREENWICH.—W. H. M. Christie, M.A., F.R.S., Astronomer Royal; Departmental Superintendent, William Ellis, F.R.A.S.; Assistant, William C. Nash. No change of importance has been made in either the instruments or methods of observation during the past year.

The vane of the Osler anemometer, which had been in use since the year 1841, began in the last autumn to show signs of weakness. This afterwards increased, and during the gale of November 11 it was found that the tail piece had broken adrift from the pointer. A scaffold was erected, and the vane, which is more than 9 feet long, was removed for examination. It was thoroughly repaired and reinstated in position before the end of the year. A collar on the vane shaft bears on anti-friction rollers, rendering the vane very sensitive to changes of direction of wind. These portions of the apparatus, which had been in action for many years, were, it was satisfactory to find, in excellent condition.

In the month of June last the thermometers for ascertaining the temperature of the water of the River Thames became deranged, and in October we were informed by Dr. Collingridge that the Port of London Sanitary Authority had decided that these observations should be discontinued. Observations of the temperature of the river in this locality were first commenced in the year 1844. This series was interrupted in 1879. In 1883 a further series was commenced, which has now also come to an end, and there seems to be no other convenient place in this neighbourhood where thermometers could similarly be suspended in mid-stream.

In the year 1889 Mr. Dines very kindly tested our two Robinson anemometers on the whirling machine then erected at Hersham. One instrument is by Negretti and Zambra, and was in use until the year 1866, the other is by Browning, and has been used since that year. The dimensions of the parts of these instruments are as follows :—

Instrument.	Diameter of cups.	Distance between centres of opposite cups.
Negretti and Zambra.	3¾ inches.	13·45 inches.
Browning.	5 „	30·00 „

Twenty-three experiments were made, each lasting for 15 minutes. The instruments were exposed simultaneously, but, being placed in different positions on the whirler, it follows that the Negretti and Zambra instrument was tested from an actual velocity on the whirler of from 7 miles to a little above 30 miles per hour, and the Browning instrument from 10 miles to 50 miles per hour. There was a little wind during some of the experiments, the influence of which has not been regarded. Calling the recorded and measured hourly velocities v and V in each case respectively, the results were found to be well represented by the following expressions :—

Negretti and Zambra instrument ... $1·472 + ·8407 \times v = V$
Browning instrument ... ... $3·976 + ·6605 \times v = V$

On the understanding that the velocity recorded (v) is three times the motion of revolution of the cups, these expressions indicate that the factor is considerably less than 3 at high velocities. Or otherwise, when the inertia of the instrument, represented by 1½ miles hourly for the Negretti and Zambra instrument, and 4 miles hourly for the Browning instrument, is overcome, the factor is sensibly the same for all velocities within the range of the experiments. Details of the experiments are given in the Greenwich volume for the year 1889.

The reduction on one system of the magnetic records 1865 to 1882, spoken of last year, is nearly complete. The reduction of the photographic records of the thermometers having been now completed for the whole period since 1849, the mean daily values, each one depending on 24 hourly readings, have been tabulated according to days for the whole year, adding thereto the daily values 1841 to 1847 as depending on 12 two-hourly eye observations, and those for 1848 as depending on 6 readings daily, including values for Sundays during the period 1841 to 1847 found from eye observations, and afterwards also for other days on which, principally in early years, there was photographic or instrumental failure. The tabulation extends from 1841 to 1890, from which daily mean values, depending on the 50 years' results, are being formed. The daily maximum and minimum eye readings given by the self-registering thermometers have been also tabulated for the same period, in order to form corresponding mean daily values. —*February* 10*th*, 1892.

ROYAL OBSERVATORY, EDINBURGH.—Ralph Copeland, Ph.D., F.R.A.S., Astronomer Royal for Scotland.

At the Edinburgh Royal Observatory the meteorological work of former years has been continued without material change. The quarterly returns, based on observations at 55 stations of the Scottish Meteorological Society, together with monthly summaries for eight of the chief towns in Scotland, have been prepared for the Registrar General for Scotland as previously. The daily readings at the Observatory have also been continued, as well as the weekly record of the earth thermometers.

The old rain gauge on the Observatory roof, 370 feet above the sea, registered only 17·17 inches for the whole year, while another instrument of the same aperture on the grass, 23 feet lower down, caught 25·05 inches. Unfortunately, neither of the gauges is in a favourable position, the various buildings, monuments and trees on Calton Hill producing eddies in the wind which it is impossible to avoid.

THE KEW OBSERVATORY OF THE ROYAL SOCIETY, RICHMOND, SURREY.—G. M. Whipple, B.Sc., Superintendent.

The several self-recording instruments for the continuous registration respectively of atmospheric pressure, temperature, and humidity, wind (direction and velocity), bright sunshine, and rain have been maintained in regular operation throughout the year, with the exception of the wet-bulb thermograph.

The readings of the last-named instrument during the winter of 1890-91 became irregular, and it was found to vary considerably from its accompanying standard. It was accordingly decided to dismount the thermometer and to replace it by a new tube, which was done in July last. On examination, the bulb showed the existence of a crack, which eventually extended completely around it. The scale value of the new tube has been determined by means of nearly 300 comparative readings, and new glass and ivory tabulating scales for it have been constructed at the Meteorological Office. For controlling these values, an experimental determination of the zero of the instrument was made by means of melting ice.

Experiments were made, unsuccessfully, to use a Richard pen with the Beckley rain gauge, but a BBB black-lead pencil was found to be more reliable in its indications than such a pen.

The standard eye observations for the control of the automatic records have been duly registered.

The tabulations of the meteorological traces have been regularly made, and these, as well as copies of the eye observations, with notes of weather, cloud and sunshine, have been transmitted, as usual to the Meteorological Office.

Tables of the monthly values of the rainfall and temperature have been regularly sent to the Meteorological Sub-Committee of the Croydon Microscopical and Natural History Club for publication in their Proceedings. Detailed information of all thunderstorms observed in the neighbourhood during the year has been forwarded to the Royal Meteorological Society, soon after their occurrence.

The electrograph has been maintained in action during the greater portion of the year. The records were, however, lost for forty-eight days on account of the freezing of the water-jet during frost in winter. The instrument has failed in sensibility during the last year owing to the large extent of diminution which the 60-cell chloride of silver battery has experienced in its charge, the potential of which has apparently diminished by one-half. This having been reported to the Meteorological Council, it was decided by them to obtain the opinion of experts on the subject of the measurement of Atmospheric Electricity, and, meanwhile, to continue the instrument in action in its present condition.

The copies of the observations of Violle's actinometer made during 1890 were duly forwarded to the Meterological Office in January, and, as the Committee understand, have been handed over by that Office to Mr. H. F. Blanford, who will report on the subject to the Solar Physics Committee.

The Committee have had under trial on the roof of the Observatory two new forms of wind registering instruments, the anémo-cinémographe of MM. Richard Frères, of Paris, and the sight-indicating velocity meter of Munro, of London.

The first-named instrument is an improved form of the old wind-mill vanes anemometer which was used by Smeaton after Rouse and Robins, but is best known as Whewell's. The anemo-cinemograph is similar to that which was employed on the top of the Eiffel Tower at Paris, and the vanes, by running constantly against a train of clock-work, record directly on a sheet of paper the velocity of motion of the wind at any time. Continuous records were obtained for six months, and the result given would seem to show that the indications of the Kew Beckley anemograph are in excess of those given by the new instrument. These are 20 per cent. less than those of the anemograph with winds blowing at 40 miles or upwards per hour, and 12 per cent. less with light winds which blow at from 6 to 10 miles per hour. A reduction of the Robinson factor from 3 to 2·5 would serve to render the readings of the two instruments more nearly comparable. As the Richard instrument is designed to record the velocity of the wind in gusts as well as the total run during any definite interval, no detailed comparisons with the Robinson indications are possible; but it may be noted that during the period the cinemograph was under observation gusts of 45 and 43 miles per hour were recorded, whilst simultaneous curve readings of the Robinson gave hourly rates of 55 and 52 miles for quarter of an hour intervals.

The Munro sight-indicating anemometer is a sensitive Robinson cup arrangement, which drives, by means of a small centrifugal pump, a column of oil up a glass tube. Its height above a fixed zero mark, as shown on a divided porcelain scale at the side, indicates the velocity of rotation of the cups when converted into miles per hour of wind movement. The divisions of the scale have been laid down in accordance with Mr. Dines' experimental deduction. When the instrument was originally set up, it was found incapable of recording a velocity of more than 40 miles per hour, but, during a gale in November, velocities were attained during several gusts of over 70 miles per hour, and accordingly Mr. Munro has found it desirable to change the gearing of the pump so as to enable the higher values to be indicated. The comparisons with the new gearing are not sufficient in number to furnish results suitable for quotation at the present time, but they appear to show, during gusts, rates fully 20 per cent. higher than the cinemograph gives. The instrument as fitted at present fails to work during frost, owing to congelation of the oil employed.

The operations with the cloud cameras have been conducted during the past year solely according to the simplified method of zenith observation, as described in last year's report, and results were obtained on 24 days. A joint paper by General Strachey and the Superintendent, describing the plan of working, was read before the Royal Society in June, and was fully illustrated by photographs shown in the optical lantern.

Particulars, with specimens of cloud pictures, were also supplied to Mr. Rotch, of the Blue Hill Observatory, for communication to the Committee of the International Meteorological Conference at Munich.

Experiments were also made with several new lenses kindly lent by Mr. Dallmeyer, in order to select one suitable for giving pictures covering a wider field of view than the R.R. lens hitherto employed, which confines the observer to clouds within 15° of the zenith. The results of these experiments, as well as others with Eastmann films used instead of glass plates, have been communicated to the Meteorological Council.

In compliance with the request forwarded by Mr. Clayden, secretary to the British Association Committee on Meteorological Photography, for copies of photographs illustrating meteorological phenomena, or their effects, the Committee forwarded a selection of duplicate cloud and other photographs to be added to the collection which has been formed.

M. Benoit, the Director of the Conservatoire des Poids et Mesures, Paris, having completed his examination of the three standard thermometers, and submitted his report upon them to the Committee, who have placed it in the hands of Professor Rücker for discussion, proceeded to examine the low-range alcohol thermometer which accompanied them. Whilst conducting this operation, M. Carpenter, the observer, was so unfortunate as to break the tube. M. Benoit, having strongly advised that further comparisons at low temperatures should be made by means of thermometers filled with toluene instead of with alcohol, has been requested by the Committee to order such an instrument of M. Tonnelot, the maker, and compare it with the Sèvres standards before its delivery in England. The mercurial standards were safely returned to the custody of the Observatory by M. Carpenter in May last.

In the preliminary operations necessary to conduct the satisfactory examination of photographic lenses, Major L. Darwin, late R.E., has been associated with Captain Abney, and, in accordance with his suggestions, a special camera, capable of working with lenses of 6 inches aperture and 30 inches focal length, has been constructed by Mr. Meagher, and fitted up at the Observatory. A photometer, on Abney's principle, 13 feet long, has also been fitted for use in the testing operations. A detailed account of the apparatus and methods employed is in course of preparation by Major Darwin for publication. Meanwhile circulars, respecting the proposed scheme of examination and preliminary certificates, have been printed, and 200 distributed amongst the leading opticians, manufacturers, and secretaries of all the best known photographic societies, both at home and abroad, to call their attention to the intended plan of examination. —*April* 1892.

RADCLIFFE OBSERVATORY, OXFORD.—E. J. Stone, F.R.S., Radcliffe Observer.

The following is a report on the meteorological work of this Observatory for the year 1891 :—

The observations have been made on the same general plan as that mentioned in the Report for 1890.

The self-registering instruments have worked satisfactorily throughout the year ; they have been cleaned as usual, but have not required any repairs. The argentic gelatino-bromide paper has been used since February 1890, and gives satisfaction.

Weather Reports have been sent, as in previous years, daily (by telegram) to the Meteorological Office ; bi-monthly to the United States Signal Office ; monthly to the Registrar General and local newspapers ; and yearly to Symons's *British Rainfall* ; also to the Chief Engineer to the Oxford City Council, and to others by request.

The eye observations, and the rainfall and sunshine records, are reduced to date, and have been published under different forms. The Rainfall records for 1815 to 1891 have been collected for publication.

The mean temperature of the air for the year 1891 was 47°·6, or 1°·6 below the average for the last 36 years. The total amount of bright sunshine was 1,362 hours. The maximum temperatures, in the shade, recorded on February 27th and 28th, 1891, were very exceptional, being 62°·2 and 63°·3 respectively ; and no higher readings than these were recorded from October 14th, 1890, until May 7th, 1891. The previous records of the Observatory do not show so high a temperature in the shade for the month of February as 60°.

The mean reading of the barometer (reduced to 32° F.) for the month of February, 1891, is the highest monthly mean for this Observatory since the year 1828 ; and, although the earlier records have not yet been completely discussed, it appears to be the highest monthly mean since 1809, when the three readings daily were first regularly made and recorded.

No measurable quantity of rain fell during the month of February. The prevalence of calms and light airs during the month was also very exceptional.

The maximum temperatures of the months of June, July, and August were generally low. The highest temperature in June was 75°·8 on the 19th, in July, 77°·1 on the 17th, and in August only 72°·3 on the 14th. The absolute maximum was 80°·8 on September 11th, and the absolute minimum was 12°·1 on January 11th and 19th.

The photographic meteorological work has been generally under the charge of Mr. F. A. Bellamy.—*March* 10*th*, 1892.

REPORT ON THE

PHENOLOGICAL OBSERVATIONS FOR 1891.

BY EDWARD MAWLEY, F.R.Met. Soc., F.R.H.S.

(Plates V. and VI.)

[Read February 17th, 1892.]

As the present Report differs in many respects from the series on the same subject which have preceded it, it will be advisable to preface it with a few explanatory remarks.

It has long since been decided by this Society that if meteorological observations are to be of any climatological value, they must be carried out at all the stations on one strictly uniform plan. Now the same principle must surely hold good when, instead of instruments of precision like thermometers, rain gauges, &c., we have to deal with plants, birds, and insects. In order, therefore, to make the Society's Phenological returns as comparable as the conditions under which they are taken will allow, the observers are required under the new regulations to note each year the flowering of the same individual trees and shrubs, and in the case of herbaceous plants, those situated in the same spots. As a further precaution in the same direction, the observers have also been instructed to select for the purposes of observation plants growing in fairly open positions; and even of those so situated, to reject any which, from some peculiarity of the soil, or other disturbing influence, come into flower abnormally, either early or late, for the district the climate of which they are required to indicate.

With a view to reduce as far as practicable the element of uncertainty, which is unfortunately inseparable from observations of this character, however carefully they may be made, the localities from which observations are sent in cannot well be too numerous. The number of observers has, therefore, been considerably increased. During the past year returns have been received from 92 observers in England, from 7 in Scotland, and from 6 in Ireland—or from 105 observers in all. From the map (Plate V.) showing the positions of the different stations, it will be seen that additional observers are much wanted in the north of England, as well as in all the Scotch and Irish districts. The only district altogether unrepresented is Scotland East (J.).

Another distinctive feature of the present system is the great reduction that has been made in the number of plants selected for observation. But for this reduction it would have been almost impossible to find sufficient observers competent and willing to carry on the work. In making the selection three objects have been kept in view:—1. To insert on the list no more plants than were absolutely necessary. 2. To confine the choice to the most familiar wild flowers. 3. To take care that the average dates of their blossoming should occur at fairly regular intervals during the entire flowering season.

The duties of an observer are now so simple and easy, when once he has selected the particular plants he has decided to observe, that there should be little difficulty in his finding a reliable deputy observer to undertake the observations during his absence.

There is one other point I should like to mention, and that is, the necessity of adopting average dates of flowering for all the plants on the list with which to compare the observations recorded. Otherwise the dates given in the tables are meaningless and of little value. Averages are also required for the dates of the appearance of the birds and insects. I have, however, as yet only had time to obtain averages for the different plants, and these must be regarded as only approximately correct, owing to the difficulty of finding sufficient reliable data from which to compute such averages. After making numerous calculations, and instituting many bewildering comparisons, I at last decided to adopt as a standard the excellent set of observations, extending over 20 years, made at Marlborough by my worthy predecessor in office, the Rev. T. A. Preston. Although Marlborough is situated in a cold hilly district, I find that during the early spring especially the recorded dates of flowering are among the earliest in the country. No doubt the number of natural history observers found among the boys at the college, who are constantly scouring the surrounding country in search of wild flowers, &c., may in a great measure account for the earliness of the Marlborough dates. I have also made use of the 14 years' All England means given in the Floral Calendar of the *Natural History Journal*, as well as the 8 years' observations made at Croydon by my friend Mr. W. F. Miller, for many years one of the Society's most trustworthy observers.

The districts into which the British Isles have been divided are the same as those adopted by the Meteorological Office. They are arranged in the order of their mean temperatures, beginning with the warmest and ending with the coldest districts, and are distinguished by capital letters instead of numbers.

My best thanks are due to Mr. G. J. Symons, F.R.S., for the kind assistance he has given me in the preparation of this Report, and also to the Society's staff of observers—many of whom have sent in during the past year very satisfactory returns.

Twelve of the Natural History Societies in connection with the British Association are represented by one or more members on the following list of observers.

LIST OF OBSERVERS.

District and Station.	County.	Height above sea-level.	Observer.
A.		Ft.	
Penzance (Marazion)	Cornwall	40	F. W. Millett
Liskeard	Cornwall	400	S. W. Jenkin, C.E.
Torquay (Babbacombe)	Devon	290	E. E. Glyde, F.R.Met.Soc.
Tiverton	Devon	270	Miss M. E. Gill
Bideford (Westward Ho)	Devon	100	H. A. Evans
Wells	Somerset	140	Miss M. A. G. Livett
Weston-super-Mare (Sydcot)	Somerset	260	E. G. Aldridge, F.R.Met.Soc.
Bristol	Gloucester	200	J. F. Wood
Bristol (Clifton)	Gloucester	300	G. C. Griffiths, F.E.S.
Bristol (Clifton)	Gloucester	250	R. M. Prideaux
Cardiff (Penarth)	Glamorgan	120	G. A. Birkenhead
Cardiff	Glamorgan	40	A. Pettigrew
Cardiff (Castleton)	Glamorgan	80	F. G. Evans, F.R.Met.Soc.
St. Davids	Pembroke	220	W. P. Propert, LL.D. F.R.Met.Soc.
B.			
Killarney	Kerry	100	Ven. Archdeacon Wynne, F.R.Met.Soc.
Wicklow	Wicklow	10	Miss S. S. Wynne
C.			
Charmouth (Whitchurch Canonicorum)	Dorset	150	Miss Mules W. Rendall
Wincanton (Buckhorn Weston)	Dorset	290	Miss H. K. H. D'Aeth
Lymington (Pennington)	Hants	100	Miss E. S. Lomer
Winchfield (Strathfield Turgiss)	Hants	200	Rev. C. H. Griffith
Hastings (Bexhill-on-Sea)	Sussex	10	H. Le Mesurier Dunn
Canterbury	Kent	50	Dr. J. Reid
Sittingbourne (Lynsted)	Kent	140	R. M. Mercer, F.R.Met.Soc.
Rochester	Kent	..	L. Dale
Ewhurst (Coneyhurst)	Surrey	600	J. Russell
Godalming	Surrey	..	G. Waller
Cranleigh (Winterfold)	Surrey	580	R. Turvey
Cobham	Surrey	100	C. H. Hooper, F.S.A.
Weybridge (Addlestone)	Surrey	100	C. U. Tripp, M.A., F.R.Met.Soc.
East Molesey	Surrey	40	Mrs. M. S. Jenkyns
Salisbury (Farley)	Wilts	..	Miss Henderson
Salisbury	Wilts	150	E. J. Tatum
Salisbury	Wilts	150	W. Hussey
Salisbury (Denton)	Wilts	..	Mrs. A. E. Audland
Devizes (Potterne)	Wilts	390	H. A. Wadworth, F.R.G.S.
Marlborough	Wilts	480	E. Meyrick, B.A., F.Z.S.
Lambourne	Berks	420	R. C. Mawley
Reading (Whitchurch)	Oxford	150	Rev. J. Slatter, M.A., F.R.Met.Soc.
Henley-on-Thames	Oxford	500	H. Goadby
Henley-on-Thames	Oxford	..	C. U. Tripp, M.A., F.R.Met.Soc.
London (Hampstead and Highgate)	Middlesex	..	J. H. Salter, B.Sc.
D.			
Oxford	Oxford	200	F. A. Bellamy, F.R.Met.Soc.
Burford (Great Barrington)	Oxford	420	B. W. Mason
Cheltenham	Gloucester	250	M. L. Evans
Tewkesbury (Beckford)	Gloucester	120	F. Slade, F.R.Met.Soc.
St. Albans	Herts	380	J. Hopkinson, F.R.Met.Soc.
St. Albans	Herts	300	Miss E. F. Smith
St. Albans	Herts	380	H. Lewis
Berkhamsted	Herts	400	Mrs. E. Mawley
Harpenden	Herts	370	J. J. Willis T. Wilson, F.R.Met.Soc.
Ross	Hereford	210	H. Southall, F.R.Met.Soc.
Evesham	Worcester	120	Rev. D. Davis, B.A.

LIST OF OBSERVERS—*Continued.*

District and Station.	County.	Height above sea-level.	Observer.
D.		Ft.	
Northampton	Northampton	320	H. N. Dixon, M.A., F.L.S.
Churchstoke	Montgomery	550	P. Wright, F.R.Met.Soc.
Thurcaston	Leicester	250	Rev. T. A. Preston, F.R.Met.Soc.
Melton Mowbray (Rotherby)	Leicester	250	J. Hames
Uppingham	Rutland	300	G. W. S. Howson, M.A.
Walsall	Stafford	450	W. F. Blay, F.R.Met.Soc.
Burton-on-Trent	Stafford	160	J. G. Wells
Burton-on-Trent	Stafford	60	Rev. C. F. Thornewill, F.E.S.
Stoke-on-Trent (Tean)	Stafford	470	Rev. G. T. Ryves, F.R.Met.Soc. M. G. B. Ryves
Beeston	Notts	210	G. Fellows, F.R.Met.Soc.
Worksop (Hodsock)	Notts	60	Miss Mellish, F.R.H.S.
Bakewell	Derby	400	Miss E. Taylor
Macclesfield	Derby	500	J. Dale
Grantham (Belton)	Lincoln	200	Miss F. H. Woolward
Harrogate	Yorks	340	J. Farrah
Huddersfield	Yorks	800	S. L. Mosley
E.			
Hertford	Herts	140	W. Graveson
Hitchin	Herts	230	J. E. Little, M.A.
Braintree	Essex	240	H. S. Tabor, F.R.Met.Soc.
Colchester (Lexden)	Essex	90	Miss Carver
Saffron Walden	Essex	..	J. H. Salter, B.Sc.
Ipswich (Sproughton)	Suffolk	30	Rev. A. Foster-Melliar
Wymondham (Tacolneston)	Norfolk	190	Miss E. J. Barrow
Wryde	Northampton	10	S. M. Egar
F.			
Chester	Cheshire	70	R. Newstead, F.E.S.
Parkgate (Heswall)	Cheshire	..	J. Sherwood
Rochdale	Lancashire	..	T. S. Smithson
Caton (Claughton)	Lancashire	80	Mrs. Kent Green
Settle	Yorks	500	S. S. Burlingham Miss F. P. Thompson
Settle (Giggleswick)	Yorks	500	E. Peake
Ambleside	Westmoreland	320	S. A. Marshall
Egremont	Cumberland	160	J. Sherwen
Douglas	I. of Man	150	H. S. Clarke, F.E.S.
Orry's Dale	I. of Man	70	Miss C. G. Crellin
Ramsey	I. of Man	70	P. M. C. Kermode
G.			
Edgeworthstown	Longford	270	J. M. Wilson, B.A.
Loughbrickland	Down	350	Rev. H. W. Lett, M.A.
Saintfield	Down	310	Rev. C. H. Waddell, M.A.
Antrim	Antrim	70	Rev. W. S. Smith
H.			
Dalry (Dalshanghan)	Kirkcudbright	500	T. R. Bruce
Penpont (Auchenhessnane)	Dumfries	540	T. Brown
Tynron	Dumfries	520	J. Shaw
Thornhill	Dumfries	300	J. Fingland
Jardington	Dumfries	100	J. Rutherford
Helensburgh	Dumbarton	100	Miss Muirhead
I.			
Ulceby (Great Cotes)	Lincoln	..	J. Cordeaux
Doddington	Lincoln	90	Rev. R. E. Cole
Driffield	Yorks	80	J. Lovel, F.R.Met.Soc.
Thirsk	Yorks (N. R.)	120	A. B. Hall
Darlington (East Layton)	Yorks (N. R.)	570	Mrs. E. O. Maynard Proud
Durham	Durham	350	H. J. Carpenter
Hexham (Bingfield)	Northumberland	..	J. Coppin (the late)
K.			
Garve (Inverbroom)	Rossshire	50	J. A. Fowler

The Winter of 1890-91.

Throughout England the weather continued extremely cold during December, but in Ireland the mean temperature was only about 3° below the average. During January the same relative conditions again prevailed. Taking the variations in the mean temperature from the average at all the stations for which these are given in Mr. C. Harding's paper[1] on "The Great Frost of 1890-91," I find the departures from the average for the 59 days during which the frost lasted (November 25th—January 22nd) to have been as follows—*England*, South —9°·2, East —9°·1, Midlands —7°·8, South-west —7°·7, North-west —5°·6, North-east —4°·9, *Ireland*, South —4°·0, North —3°·7; *Scotland*, West—3°·0,—East 2°·3, North—1°·9. Even if the mean temperatures themselves be taken, the contrast between those of the South of England and the North of Scotland is very striking—that of the former being only 29°·9, while that for the North of Scotland comes out as 36°·7, or nearly 7° warmer.

Seldom has vegetation been kept for so long a period at a complete standstill. Where the frosts were most severe many tender shrubs, like the arbutus, bay, common laurel, and euonymus were killed outright. On the farms the destruction of swedes and turnips appears to have been very general, while in the gardens the frost committed sad havoc amongst winter vegetables of all kinds. Of the latter, the first to succumb were brocoli, while Brussels-sprouts may be mentioned as being among those least injured. Owing to the prolonged cold, thousands of birds were either starved or frozen to death in the Southern, Midland, and Eastern Counties of England. On the other hand wild ducks were unusually plentiful, also many birds rarely seen in this country during ordinary winters, such as the bittern, the great bustard, Bewick's swan, the whooper, &c. In November and December immense flocks of small birds were occasionally to be seen making their way westwards. Their destination is thought to have been the South of Ireland, where there had not been at the end of the year a single week's hard frost, and where roses and other flowers were still in blossom after Christmas Day. In the North of Scotland our observer states that there was never enough frost to bring the woodcocks down to the springs for water during either December or January. February proved everywhere mild, dry and bright. In England, however, the mean temperature was only about 1° above the average, whereas in Ireland it was 2°, and in the North of Scotland as much as 4° in excess of it.

This cruel winter as regards vegetable life possessed, at least, three redeeming features: (1) It was one of the driest on record; (2) The ground was protected with snow during its most intense frosts; and (3) It left the land in a better condition for working than either farmers or gardeners of the present generation have perhaps ever known before. In many cases the soil could be harrowed and drilled immediately after ploughing. Treating the

[1] *Quarterly Journal*, Vol. XVII. p. 93.

averages given in Table II. as approximately correct, the hazel was, in most districts, from 10 days to three weeks late in coming into flower.

Observers' Notes.

DECEMBER, 1890.—*Throwleigh, Devon* (A.). An extraordinary flight of birds was observed in many parts of Devon on December 21st, after the first heavy fall of snow. Continuous stream of skylarks flying westward. Over 500 were counted in three minutes, and the cloud of birds seemed endless in every direction.—Rev. E. C. Spicer, in *Zoologist*. *New Ross (Co. Wexford)* (B.). The flocks of birds seen at Brighton, Lyme Regis, and in Devonshire, were making for the S.E. of Ireland. Skylarks were numerous here at the end of December and beginning of January. 25th. Redwings and fieldfares extremely numerous. 30th. Hundreds of flocks of plover and golden plover. We have not had here a week's continuous hard frost.—G. E. H. Barrett-Hamilton, in *Zoologist*. *Wicklow* (B.). 20th. Nasturtiums killed by frost. 26th. Gathered roses, Christmas roses, sweet scented geraniums and laurustinus to make a wreath. *Castle Townsend (Co. Cork)* (B.). 31st. During the whole day a continuous stream of birds, chiefly starlings, with fieldfares, finches and other small birds, kept passing westward across the harbour, amidst the blinding snow.—R. J. Usher, in *Zoologist*. *Lyme Regis, Dorset* (C.). 29th. Vast flocks of larks and starlings, with fieldfares, redwings, lapwings and linnets, with other small birds, passed over us flying west in an almost continuous stream.—A. Lister, in *Zoologist*.

JANUARY, 1891.—*Babbacombe* (A.). Owing to the absence of snow to cover the ground, vegetation was much injured by the prolonged frost. *Sydcot* (A.). 31st. Saw three wild snowdrops (one partly open), three small primroses, one lesser celandine, and one blue scented violet, and some partly expanded leaves of honeysuckle. *Wicklow* (B.). 29th. Snowdrop in flower. *Lyme Regis, Dorset* (C.). 8th. The rigorous weather has killed off thrushes and blackbirds in numbers altogether unprecedented in my experience. The dead redwings and song-thrushes in many fields might be counted almost in hundreds.—A. Lister, in *Zoologist*. *Strathfield Turgiss* (C.), 28th. Rooks commenced building their nests. *Canterbury* (C.). 26th. Crocus first in flower. 27th. Christmas rose (Heleborus niger) only now in flower, generally out during the second week in December. *Cobham* (C.). 3rd. Rabbits thin and very keen after food. They eat the bark of newly planted apples and peaches, also wallflowers and veronicas. 11th. Rabbits nibbled bark of holly, laurel, ivy, &c. 14th. Pigeons shot with acorns in crop. 16th. Brecoli killed. 31st. Sweet violets in flower in garden. *Great Barrington* (D.). 14th. Saw an Alder in leaf in the middle of a coppice. *Hodsock* (D.). 23rd. The long frost first broke up. 29th. Snowdrop in flower. *Colchester, Essex* (E.). 10th. We have been visited by many species of birds we rarely see in milder winters—Common bitterns, Bewick's swans, Bean geese, Eiders and Smews, from *Zoologist*. *Bingfield* (I.). Brocoli and parsley killed by frost. *Inverbroom* (K.). Not enough frost to bring the woodcocks down to the springs during either December or January.

FEBRUARY.—*Wells* (A.). The effect of the long frost, followed by drought, is seen in the Celandine, which came into flower on the 28th, quite 2½ weeks later than its average. *Sydcot* (A.). 11th. Yellow crocuses, snowdrops, white arabis and daphne mezereum in flower. *Frome, Somerset* (C.). Great destruction of bird life during the past winter. Have lost nearly all our owls, also a great many partridges, rooks and small birds.—M. A. Mathew, in *Zoologist*. *Pennington* (C.). Green vegetables, roots and tender shrubs much damaged by the winter frosts. Many thrushes and redwings killed. Wild ducks and geese very plentiful, but some of the usual winter visitors, such as green and golden plover, fieldfares and gulls, were absent. 3rd. Crocus first in flower. 22nd. Frog-spawn first seen. *Strathfield Turgiss* (C.). 28th. Moles once more busy again. *Cranleigh* (C.). 1st. Snowdrop in flower. 12th. Yellow crocus in flower. *Cobham* (C.). Many ivy, holly, laurel and cedar leaves falling, owing to severe and dry winter. 3rd. About 350 dead trout in a lake, out of 1,000 imported. 12th. Crocus in flower. *Great Barrington* (D.). Numbers of frogs killed by the frost were found dead in the ponds. Many acres of turnips and swedes have been destroyed by frost, in some cases not a single sound root has been left in the ground. *Beckford* (D.). Brocoli and Winter cabbage destroyed by frost, also three-fourths of the swedes and turnips. 1st. Snowdrop first in flower—a later date than in any year since 1881. *St. Albans* (D.). The effect of trees in conveying moisture to the ground was at times very marked, quite a shower falling from them, and water running off the roads into the side ditches, while the dust was blowing on other parts of the road. *Berkhamsted* (D.). 11th. Winter aconite in flower. *Ross* (D.). 27th. The bat was first seen. The earliest previous appearance during the last eight years being March 1st, 1883, and the latest April 2nd, 1882. *Northampton* (D.). 17th. Yellow crocus first in flower. I could not see a sign of Whitlow grass on walls where it has been frequently in flower early in January. *Churchstoke* (D.). No damage seems to have been done to shrubs by the hard winter. The farmers say they have hardly ever known the land work so well. 25th. The pied wagtail returned from the south. *Walsall* (D.). 27th. The effect of underground heat is well exemplified near Birmingham, where tunnels run under the fields, for there groundsell, daisies, chickweed and gorse were in full flower on January 17th, although the first and third were not seen elsewhere until February 8th, and the second and fourth not yet seen here. *Hodsock* (D.). No Catkins in flower on Hazel until two days after the first fertile flowers. Do not find that much injury has been done by the frost. The evergreens have not suffered except a few shoots of Bay and Escallonia. Most of the wallflowers are killed. *Hitchin* (E.). 28th. Vegetation in the woods very backward—no primroses, no violets, no celandine. *Tacolneston* (E.). 28th. Lesser Celandine in flower. *Giggleswick* (F.). Fieldfares and redwings appeared in exceptionally large numbers during the past winter, the former fared well on the large store of berries, but of the latter many died. Wild-geese and an unusual number of wild-ducks frequented the Ribble during the frost. *Orry's Dale* (F.). 28th. Violets flowering profusely owing to dry winter. *Dalshangan* (H.). 7th. Curlew heard. 24th. Crocus in flower. *Driffield* (I.). The complete disappearance during the winter, through birds, of all kinds of berries, including hawthorn, cotoneaster and wild rose, was remarkable. Some song-thrushes and a redwing and fieldfare found dead near the house. *East Layton* (I.). Brocoli has scarcely been injured at all here, but at Darlington the plants were all killed. *Durham* (I.). During the winter frosts wild-ducks were plentiful, and I saw several wild-geese.

The Spring.

We have seen that during the winter the weather was colder in England than in either Ireland or Scotland. During the Spring months, however, these conditions were reversed, although in not nearly so marked a degree. As compared with their respective averages, the mean temperatures were rather lower in Scotland than in Ireland, and rather lower in Ireland than in England, the mean defect for the British Isles amounting to about 2°·5. Not only was this Spring quarter a cold one, but it was also dry and sunless.

Vegetation was everywhere singularly backward. Trees were late in coming into leaf, fruit trees were late in blossoming, while all farm and garden crops made but little growth. On March 9th and 10th there occurred in the South-west of England a severe snowstorm and gale. The loss of sheep and lambs in the snowdrifts is said to have been very great, while much damage was done in the orchards by the violence of the wind. During April the scarcity of keep for cattle and sheep was almost everywhere greatly felt, also the absence of green vegetables in the gardens. In the early part of the month the arrival on the East Coast of our ordinary Spring visitors, such as the wheatear, swallow and cuckoo, was somewhat delayed by the inclemency of the weather.

In May the show of blossom on fruit trees of all kinds was remarkably

TABLE I.—DATE (DAY OF YEAR) OF FIRST FLOWERING OF PLANTS, 1891.

District and Station.	Hazel.	Coltsfoot.	Wood Anemone.	Blackthorn.	Garlic Hedge Mustard.	Horse Chestnut.	Hawthorn.	White Ox Eye.	Dog Rose.	Black Knapweed.	Harebell.	Greater Bindweed.	Ivy.
A.													
Penzance (Marazion)	..	..	..	99	..	..	139	..	157	203	..	202	..
Liskeard	..	..	105	102	125	..	..	..	..	..	..	..	..
Torquay (Babbacombe)	42	60	..	103	..	129	146	133	168	173	..	(233)	293
Tiverton	30	54	96	114	117	136	141	152	166	177	..	203	296
Bideford (Westward Ho)	..	75	..	..	102	..	142	166	161	..	..	176	..
Wells	31	63	59	111	119	131	143	154	166	..	..	..	..
Weston-super-Mare (Sydcot)..	56	59	62	108	117	131	143	161	170	175	..	184	..
Bristol	..	..	..	..	..	141	151	..	..	..	210	..	..
Bristol (Clifton)	..	..	..	117	..	134	148	..	..	..	..	..	..
Bristol (Clifton)	32	63	101	125	..	134	146	153	..	200	180	221	280
Cardiff (Penarth)	54	..	..	..	..	..	..	..	..	..	..	..	..
Cardiff (Castleton)	..	..	101	..	..	126	147	..	..	..	..	186	..
St. David's	..	46	..	115	..	..	..	..	..	..	..	..	..
B.													
Killarney	41	60	59	68	..	124	131	151	164	194	190	187	254
Wicklow	29	49	68	63	104	127	131	135	164	189	..	210	265
C.													
Charmouth (Whitchurch Canonicorum)	34	56	82	112	114	136	132	146	168	168	..	177	282
Wincanton (Buckhorn Weston)	47	55	97	119	114	133	139	143	168	172	..	179	272
Lymington (Pennington)	34	82	103	118	127	133	137	151	162	(208)	168	206	285
Winchfield (Strathfield T.) ..	59	82	103	121	121	132	146	150	164	172	176	194	258
Hastings (Bexhill-on-Sea)....	64	..	87	117	..	144	..	147	..	..	..	..	..
Canterbury	55	..	98	124	125	147	144	154	177	..	..	..	278
Sittingbourne (Lynsted)......	39	..	..	123	..	146	151	..	..	..	..	..	..
Rochester	40	54	107	120	129	140	150	..	..	..	..	..	..
Ewhurst (Coneyhurst)	43	59	..	..	..	..	..	..	..	..	..	..	..
Godalming	..	..	95	118	..	128	139	..	..	..	..	..	..
Cranleigh (Winterfold)	56	..	113	109	..	138	141	153	156	..	193	..	273
Cobham	37	..	..	..	..	..	..	..	..	..	..	..	..
Weybridge (Addlestone)	..	..	..	..	..	..	..	..	175	..	198	..	..
East Molesey	..	67	127	121	129	132	142	..	171	..	206	205	..
Salisbury (Farley)	36	65	84	114	123	134	135	138	166	170	187	189	270
Salisbury ,, ...	31	46	66	112	116	132	135	157	170	182	185	202	..
Salisbury ,, ...	33	48	59	107	..	136	133	149	166	..	..	..	..
Salisbury (Denton)	23	65	81	116	120	136	143	..	..	..	..	..	..
Devizes (Potterne)	..	..	86	118	122	134	143	..	..	..	..	..	..
Marlborough	39	46	62	118	120	133	152	157	169	179	197	222	278
Reading (Whitchurch)	46	..	88	116	..	..	..	..	..	..	..	..	..
Henley on Thames	..	..	..	121	..	134	144	145	171	169	190	200	..
Henley-on-Thames	45	..	120	116	126	134	144	..	..	..	..	..	..
London (Hampstead and Highgate)	..	..	..	126	132	132	141	157	165	185	194	182	..
D.													
Oxford	..	..	95	122	122	131	148	150	..	..	..	..	..
Burford (Great Barrington) ..	39	96	..	117	..	148	148	154	172	175	209	(236)	..
Cheltenham	..	73	98	115	123	132	135	158	168	179	200	196	269
Tewkesbury (Beckford)	38	54	93	114	121	133	137	152	164	176	201	189	262
St. Albans	40	..	..	..	127	143	147	..	170	178	..	..	..
St. Albans	..	..	87	..	..	151	148	155	173	173	191	223	..
Berkhamsted	48	91	..	124	128	150	153	..	167	198	..	202	302
Harpenden	40	87	89	124	123	145	146	161	171	..	..	..	..
Ross	46	59	..	..	..	..	..	..	..	..	..	..	..
Evesham	55	..	102	117	..	..	..	..	..	..	..	..	..
Northampton	47	82	110	117	127	143	149	..	175	180	..	..	..
Churchstoke	45	54	96	120	119	153	157	161	173	195	191	199	..
Thurcaston	43	82	103	124	129	145	147	163	172	169	192	..	..
Melton Mowbray (Rotherby)..	..	80	..	134	(152)	153	148	161	170	..	205	205	243

TABLE I.—Date (Day of Year) of First Flowering of Plants, 1891—*Continued.*

District and Station.	Hazel.	Coltsfoot.	Wood Anemone.	Blackthorn.	Garlic Hedge Mustard.	Horse Chestnut.	Hawthorn.	White Ox Eye.	Dog Rose.	Black Knapweed.	Harebell.	Greater Bind-weed.	Ivy.
D.													
Uppingham	..	94	98	..	..	151	150	..	..	..	..	..	..
Walsall	45	64	87	115	131	151	156	167	182	195	195	197	..
Burton-on-Trent	..	53	89	122	138	..	150	..	171	..	..	..	301
Burton-on-Trent	..	..	106	..	..	149	..	..	..	..	..	..	..
Stoke-on-Trent (Tean)	58	64	108	127	..	129	128	140	(143)	..	..	..	..
Beeston	..	..	..	120	..	149	150	177	179	185	178	..	..
Worksop (Hodsock)	32	59	106	116	125	138	151	168	175	191	190	187	271
Bakewell	(127)	..	..	132	..	159	161	173	186	..	..	(242)	..
Macclesfield	55	96	124	136	..	154	154	157	166	184	186	192	278
Grantham (Belton)	38	69	96	121	132	147	148	158	164	171	200	..	..
Harrogate	57	81	102	122	128	157	159	171	179	196	200	207	312
E.													
Hertford	32	46	81	109	113	137	137	157	172	172	185	204	277
Hitchin	43	60	89	118	118	143	139	..	..	..	..	..	..
Braintree	..	..	..	121	126	129	152	162	169	177	201	..	258
Colchester (Lexden)	(98)	..	106	117	..	145	..	..	..	..	..	..	262
Saffron Walden	45	46	100	..	..	..	..	..	..	..	..	..	..
Ipswich (Sproughton)	..	..	..	..	..	..	..	156	173	203	..	230	291
Wymondham (Tacolneston)	42	72	100	123	121	131	148	..	..	..	..	..	..
Wryde	57	61	..	120	..	147	..	..	..	..	..	..	..
F.													
Parkgate (Heswall)	..	53	..	..	..	..	..	..	..	..	..	..	..
Rochdale	..	88	126	..	..	..	..	..	..	..	..	..	..
Caton (Claughton)	52	81	103	127	..	..	..	..	..	..	..	..	..
Settle	47	49	101	126	147	164	162	163	172	194	180	..	299
Settle (Giggleswick)	46	50	100	125	..	..	158	163	..	..	..	..	..
Ambleside	42	67	..	118	155	..	..	..	..	..	..	..	..
Egremont	52	71	96	..	117	143	144	141	168	191	184	192	288
Orry's Dale	56	..	120	128	..	125	138	..	159	..	185	188	283
Ramsey	..	..	102	103	..	..	139	..	..	..	..	..	..
G.													
Edgeworthstown	..	..	..	130	..	147	..	..	..	..	..	..	..
Loughbrickland	..	..	106	112	..	152	151	..	..	..	..	..	..
Saintfield	..	..	..	114	..	147	154	..	..	222	..	..	274
Antrim	..	..	..	104	110	146	151	..	..	..	..	226	301
H.													
Dalry (Dalshangan)	(106)	86	..	..	..	..	..	..	..	..	..	..	..
Penpont (Auchenhessnane)	76	103	116	131	..	153	166	..	180	206	206	..	..
Tynron	46	100	106	128	..	161	163	174	175	..	193	..	..
Thornhill	52	101	118	126	158	..	161	177	177	197	200	211	..
Jardington	..	..	113	129	..	154	156	..	..	..	193	..	..
Helensburgh	46	97	113	113	..	141	152	166	176	215	..	210	..
1.													
Doddington	..	..	103	124	..	142	152	..	178	..	..	..	..
Driffield	41	95	..	125	..	168	160	..	182	207	..	228	..
Thirsk	37	45	84	123	124	167	145	165	168	175	182	175	272
Darlington (East Layton)	25	116	..	132	129	..	..	..	..	..	..	..	..
Durham	..	57	105	132	..	169	167	182	182	..	190	..	338
Hexham (Bingfield)	(96)	59	149	142	..	..	..	..	..	208	..	..	..
K.													
Garve (Inverbroom)	..	80	114	..	..	..	..	..	..	..	..	..	..

The dates in brackets have not been taken into consideration when calculating the means given in Table II.

Explanation of the dates in the Tables.

1– 31	are in January.	182–212	are in July.
32– 59	„ February.	213–243	„ August.
60– 90	„ March.	244–273	„ September.
91–120	„ April.	274–304	„ October.
121–151	„ May.	305–334	„ November.
152–181	„ June.	335–365	„ December.

TABLE II.—MEAN DATES (DAY OF YEAR) FOR THE FIRST FLOWERING OF PLANTS IN 1891, AND THEIR VARIATIONS FROM THE AVERAGE.

Plants.	A. Eng. S.W.			B. Ireland, S.			C. Eng. S.			D. Eng. Mid.		
	1891.	Approximate Average.	Variation from Average.	1891.	Approximate Average.	Variation from Average.	1891.	Approximate Average.	Variation from Average.	1891.	Approximate Average.	Variation from Average.
Hazel	41	23	+18	35	21	+14	42	31	+11	45	35	+10
Coltsfoot	60	44	+16	55	42	+13	62	52	+10	74	56	+18
Wood Anemone	87	58	+29	64	56	+ 8	92	66	+26	99	70	+29
Blackthorn	110	91	+19	66	91	—25	117	91	+26	122	93	+29
Garlic Hedge Mustard	116	111	+ 5	104	111	— 7	123	111	+12	127	113	+14
Horse Chestnut	133	126	+ 7	126	126	0	136	126	+10	146	128	+18
Hawthorn	145	131	+14	131	131	0	142	131	+11	149	133	+16
White Ox Eye	153	139	+14	143	139	+ 4	149	139	+10	160	141	+19
Dog Rose	165	156	+ 9	164	160	+ 4	168	155	+13	173	158	+15
Black Knapweed	186	175	+11	192	179	+13	175	174	+ 1	183	177	+ 6
Harebell	195	189	6	190	193	— 3	189	188	+ 1	195	191	+ 4
Greater Bindweed	195	195	Av.	199	199	Av.	196	194	+ 2	200	197	+ 3
Ivy	290	263	+27	260	266	— 6	275	270	+ 5	280	274	+ 6
Means for the 13 Plants	144	131	+13	133	132	+ 1	144	133	+11	150	136	+14

Plants.	E. Eng. E.			F. Eng. N.W.			G. Ireland, N.			H. Scotland, W.		
	1891.	Approximate Average.	Variation from Average.	1891.	Approximate Average.	Variation from Average.	1891.	Approximate Average.	Variation from Average.	1891.	Approximate Average.	Variation from Average.
Hazel	44	36	+ 8	49	32	+17	..	29	..	55	33	+22
Coltsfoot	57	57	Av.	66	53	+13	..	50	..	97	54	+43
Wood Anemone	95	71	+24	107	67	+40	106	64	+42	113	68	+45
Blackthorn	118	95	+23	121	97	+24	115	97	+18	125	99	+26
Garlic Hedge Mustard	120	115	+ 5	140	117	+23	110	117	— 7	158	119	+39
Horse Chestnut	139	130	+ 9	144	132	+12	148	132	+16	152	134	+18
Hawthorn	144	135	+ 9	149	137	+12	152	137	+15	160	139	+21
White Ox Eye	158	143	+15	156	145	+11	..	145	..	172	147	+25
Dog Rose	171	157	+14	166	161	+ 5	..	164	..	177	164	+13
Black Knapweed	184	176	+ 8	193	180	+13	222	183	+39	206	183	+23
Harebell	193	190	+ 3	183	194	—11	..	197	..	198	197	+ 1
Greater Bindweed	217	196	+21	190	200	—10	226	203	+23	210	203	+ 7
Ivy	272	273	— 1	290	271	+19	288	271	+17	..	273	..
Means for the 13 Plants	147	136	+11	150	137	+13	171	138	+33	152	139	+23

+ indicates the number of days later than the average date.
— „ „ „ earlier „ „
Av. „ average date.

fine, added to which apples, pears, plums and cherries came for once into full flower at the same time. So satisfactorily had the shoots of the trees become ripened during the previous Autumn, and so late was the flowering season, that the prospect of a good fruit year appeared, at one time, everywhere most promising. Unhappily, at Whitsuntide, there occurred a very

TABLE II.—MEAN DATES (DAY OF YEAR) FOR THE FIRST FLOWERING OF PLANTS IN 1891, AND THEIR VARIATIONS FROM THE AVERAGE—*Continued.*

Plants.	I. Eng. N.E.			J. Scotland, E.			K. Scotland, N.			British Isles.		
	1891.	Approximate Average.	Variation from Average.	1891.	Approximate Average.	Variation from Average.	1891.	Approximate Average.	Variation from Average.	1891.	Approximate Average.	Variation from Average.
Hazel	34	37	— 3	..	38	..	..	37	..	43	31	+12
Coltsfoot	74	58	+16	..	59	..	80	58	+22	69	53	+16
Wood Anemone	110	72	+38	..	73	..	114	72	+42	99	66	+33
Blackthorn	130	102	+28	..	103	..	..	110	..	114	95	+19
Garlic Hedge Mustard	127	122	+ 5	..	123	..	..	130	..	125	115	+10
Horse Chestnut	162	137	+25	..	138	..	..	145	..	143	130	+13
Hawthorn	156	142	+14	..	143	..	..	150	..	148	135	+13
White Ox Eye	174	150	+24	..	151	..	..	158	..	158	143	+15
Dog Rose	178	163	+15	..	166	..	..	173	..	170	160	+10
Black Knapweed	197	182	+15	..	185	..	..	192	..	193	178	+15
Harebell	186	196	—10	..	199	..	..	206	..	191	192	— 1
Greater Bindweed	202	202	Av.	..	205	..	..	212	..	204	199	+ 5
Ivy	305	274	+31	..	277	..	..	276	..	283	270	+13
Means for the 13 Plants	157	141	+16	..	143	..	97	65	+32	149	136	+13

+ indicates the number of days later than the average date.
— " " " earlier " "
Av. " average date.

severe frost, in many districts preceded by snow, which destroyed a great part of the fruit blossom, and to a certain extent frustrated these glowing prospects. Very few places appear to have entirely escaped this frost. In the North of England, however, and more particularly in Yorkshire, where it was most keenly felt, the young leaves of the beech were completely killed, while potatoes and strawberries also suffered severely. The Coltsfoot proved late in showing flower throughout the whole country, but the departures from the mean are very irregular. During April the flowering of plants was more backward than at any other period of the year, the Wood Anemone and Blackthorn being as much as from three weeks to a month late in nearly all districts. In May the differences were not so great, the Garlic Hedge Mustard, Horsechestnut and Hawthorn coming into blossom in most places from a week to a fortnight later than the average.

Observers' Notes.

MARCH.—*Marazion* (A.). The frosts of the past winter killed many plants of Brocoli. *Liskeard* (A.). The great blizzard of March 10th, 11th and 12th left snow on the ground for several weeks, and checked vegetation and the appearance of insects. *Bodmin, Cornwall* (A.). 9th and 10th. Large numbers of sheep and lambs were buried by the snow and many died, and in the colder districts near the moors the losses of sheep, cattle and colts were heavy.—R. S. Olver, in *Bell's Weekly Messenger*. *Plympton, Devon* (A.). 9th and 10th. Very great damage to orchards, and a great number of sheep have died during the snowstorm.—W. P. Vosper, in *Bell's Weekly Messenger*. *Babbacombe* (A.). The weight of snow and the tremendous gale of the 9th and 10th threw down and broke a large number of trees and shrubs. *Tavistock, Devon* (A.). Winter

TABLE III.—DATE (DAY OF YEAR) OF MIGRATION OF BIRDS, 1891.

District.	Stations.	Song.	Migration.				
		Song Thrush First heard.	Swallow First seen.	Cuckoo First heard.	Nightingale First heard.	Flycatcher First seen.	Swallow Last seen.
A.	Penzance (Marazion)	..	105	114	..	..	..
,,	Liskeard	25	100	118	..	..	..
,,	Torquay (Babbacombe)	..	114	111	..	..	324
,,	Bideford (Westward Ho)	..	96	123	..	136	307
,,	Weston-super-Mare (Sydcot)	38	111	110	..	..	..
,,	Bristol	..	122	116	..	..	..
,,	Bristol (Clifton)	..	117	114	126	..	..
,,	Bristol (Clifton)	..	123	110	111	..	..
,,	Cardiff (Castleton)	..	102	114	..	..	276
,,	St. David's	49	101	105	..	..	255
B.	Killarney	28	111	..	..	..	..
,,	Wicklow	34	97	109	..	..	303
C.	Charmouth (Whitchurch Canonicorum)	37	108	115	115	125	..
,,	Wincanton (Buckhorn Weston)	..	106	108	..	124	288
,,	Lymington (Pennington)	36	106	111	116	134	318
,,	Winchfield (Strathfield Turgiss)	..	101	104	109	140	..
,,	Hastings (Bexhill-on-Sea)	29	107	110	121	..	325
,,	Canterbury	..	109	118	115	..	275
,,	Sittingbourne (Lynsted)	..	117	108	109	..	..
,,	Rochester	..	108	119	115	133	..
,,	Ewhurst (Coneyhurst)	46	..	..	..	..	..
,,	Godalming	..	112	108	114	122	..
,,	Cranleigh (Winterfold)	20	110	108	113	120	277
,,	East Molesey	..	117	123	127	(164)	..
,,	Salisbury	..	111	111	..	..	..
,,	Salisbury	47	107	..	..	..	314
,,	Salisbury (Denton)	35	110	107	113	124	..
,,	Devizes (Potterne)	..	97	115	..	137	..
,,	Marlborough	34	103	111	106	146	309
,,	Lambourne	..	118	124	..	..	..
,,	Reading (Whitchurch)	28	..	111	120	..	..
,,	Henley-on-Thames	..	92	107	122	125	310
,,	Henley-on-Thames	35	..	118	119	..	..
,,	London (Hampstead and Highgate)	..	118	124	118	132	..
D.	Oxford	..	110	115	116	..	305
,,	Burford (Great Barrington)	41	104	109	..	145	326
,,	Cheltenham	..	109	113	..	113	292
,,	Tewkesbury (Beckford)	32	109	108	117	121	294
,,	St. Albans	..	115	116	..	..	..
,,	St. Albans	..	109	110	109	..	288
,,	Berkhamsted	31	100	112	118	..	276
,,	Harpenden	40	108	109	111	..	..
,,	Ross	29	111	112	..	151	..
,,	Evesham	..	112	111	..	..	..
,,	Northampton	..	106	115	113	..	294
,,	Churchstoke	44	113	117	..	..	..
,,	Thurcaston	..	117	117	..	..	..
,,	Melton Mowbray (Rotherby)	(61)	105	115	..	110	289
,,	Uppingham	35	106	108	129	143	..
,,	Walsall	34	112	114	..	..	..
,,	Burton-on-Trent	..	107	115	..	..	..
,,	Stoke-on-Trent (Tean)	36	108	116	..	130	288
,,	Beeston	..	109	118	..	124	284
,,	Worksop (Hodsock)	33	109	114	120	136	299
,,	Bakewell	..	116	126	..	132	279
,,	Macclesfield	49	116	125	..	..	276

TABLE III.—Date (Day of Year) of Migration of Birds, 1891.—*Continued.*

District.	Stations.	Song.	Migration.				
		Song Thrush First heard.	Swallow First seen.	Cuckoo First heard.	Nightingale First heard.	Flycatcher First seen.	Swallow Last seen.
D.	Grantham (Belton)	28	108	117	120	146	290
,,	Harrogate	37	108	114	..	137	291
,,	Huddersfield	..	..	..	..	..	299
E.	Hitchin	..	107	103	101	..	..
,,	Braintree	..	..	109	124	..	..
,,	Colchester (Lexden)	42	113	105	122	..	291
,,	Saffron Walden	27	..	..	..	..	..
,,	Ipswich (Sproughton)	..	..	..	..	..	318
,,	Wymondham (Tacolneston)	..	111	114	..	..	..
,,	Wryde	57	111	118	..	121	..
F.	Chester	..	95	116	..	..	286
,,	Parkgate (Heswall)	28	..	..	..	..	..
,,	Rochdale	53	120	..	..	..	..
,,	Caton (Claughton)	41	117	114	..	..	..
,,	Settle (Giggleswick)	34	114	119	..	..	..
,,	Ambleside	53	113	110	..	..	..
,,	Egremont	..	117	109	..	149	258
,,	Douglas	55	126	..	..	..	..
,,	Orry's Dale	..	110	118	..	..	..
,,	Ramsey	..	107	119	..	..	..
G.	Edgeworthstown	32	109	114	..	..	..
,,	Loughbrickland	..	104	117	..	..	..
,,	Saintfield	..	110	117	..	..	280
,,	Antrim	..	101	116	..	144	..
H.	Dalry (Dalshangan)	..	116	114	..	..	274
,,	Penpont (Auchenhessnane)	37	117	116	..	145	..
,,	Tynron	34	116	116	..	..	..
,,	Thornhill	..	113	122	..	..	283
,,	Jardington	..	120	116	..	..	..
,,	Helensburgh	32	113	116	..	..	..
I.	Ulceby (Great Cotes)	..	102	118	..	..	..
,,	Doddington	..	122	123	..	..	..
,,	Driffield	46	118	119	..	..	292
,,	Thirsk	28	112	123	..	139	278
,,	Darlington (East Layton)	54	118	..	..	..	..
,,	Durham	33	116	117	..	(191)	303
,,	Hexham (Bingfield)	43	121	118	..	118	..
K.	Garve (Inverbroom)	43	..	123	..	..	..
	Mean Dates for the British Isles in 1891	38 Feb. 7th	110 April 20th	115 April 25th	117 April 27th	136 May 6th	291 Oct. 18th

The dates in brackets have not been taken into consideration when calculating the means for the British Isles.

Oats all destroyed, also a large proportion of turnips and swedes. Wheat looking very thin and the plant weak.—R. Bickle, in *Bell's Weekly Messenger*. *Sydcot* (**A.**). The ploughed land was never in better condition owing to the long continued frost and drought. *Clifton* (**A.**). The abundance of the early spring Lepidoptera was very marked after the severe winter; tending to show the harmlessness of intense cold on their pupæ, which same cold played such havoc with their natural enemies, the insectivorous birds. *Monmouth* (**A.**). 9th and 10th. The snowstorm caused very serious losses among the ewes and lambs.—R. Stratton, in *Bell's Weekly Messenger*. *St. David's* (**A.**). 23rd. Wheatear first seen. *Wicklow* (**B.**). A nasturtium has lived out all the winter in a window-

TABLE IV.—DATE (DAY OF YEAR) OF FIRST APPEARANCE OF INSECTS, 1891.

District.	Stations.	Honey Bee.	Wasp.	Small White Butterfly.	Orange Tip Butterfly.	Meadow Brown Butterfly.
A.	Penzance (Marazion)	..	..	62	..	..
,,	Liskeard	98	125	87	133	107
,,	Torquay (Babbacombe)	..	43	90	133	..
,,	Tiverton	57	..	117	..	..
,,	Bideford (Westward Ho)	47	..	56	118	173
,,	Weston-super-Mare (Sydcot)	25	(212)	..	114	173
,,	Bristol	(227)	(227)	(151)	..	..
,,	Bristol (Clifton)	..	..	124	..	..
,,	Bristol (Clifton)	95	95	125	..	171
,,	Cardiff (Penarth)	96	107	107	123	169
,,	Cardiff	55	54	57	..	..
,,	St. David's	55	..	114	..	..
B.	Killarney	65	89	98	103	172
,,	Wicklow	55	75	88	125	133
C.	Charmouth (Whitchurch Canonicorum)	43	126	106	125	125
,,	Wincanton (Buckhorn Weston)	45	161	107	118	152
,,	Lymington (Pennington)	54	101	101	133	175
,,	Winchfield (Strathfield Turgiss)	46	61	111	136	..
,,	Hastings (Bexhill-on-Sea)	49	142	110	..	..
,,	Canterbury	80	50	111	..	..
,,	Sittingbourne (Lynsted)	33	..	..	..	..
,,	Rochester	..	129	129	..	..
,,	Ewhurst (Coneyhurst)	56	..	..	..	..
,,	Godalming	..	120	134	128	..
,,	Cranleigh (Winterfold)	47	87	..	..	..
,,	Cobham	41	..	..	..	..
,,	East Molesey	81	127	113	160	..
,,	Salisbury	..	..	111	..	..
,,	Salisbury	58	..	..	..	..
,,	Salisbury (Denton)	46	..	105	..	..
,,	Devizes (Potterne)	..	..	116	..	..
,,	Marlborough	..	..	102	127	171
,,	Lambourne	..	135	..	..	..
,,	Reading (Whitchurch)	..	58	..	..	..
,,	Henley-on-Thames	..	111	102	126	..
,,	Henley-on-Thames	..	..	(35)	..	..
,,	London (Hampstead and Highgate)	..	..	125	132	178
D.	Oxford	105	..	107	..	..
,,	Burford (Great Barrington)	43	94	..	..	..
,,	Cheltenham	..	107	107	..	..
,,	Tewkesbury (Beckford)	46	125	116	132	178
,,	St. Albans	..	109	..	..	..
,,	St. Albans	47	..	..	..	..
,,	Berkhamsted	49	99	100	165	..
,,	Harpenden	58	75	116	..	105
,,	Ross	47	..	107	..	..
,,	Evesham	55	..	118	..	..
,,	Northampton	95	..	95	..	..
,,	Churchstoke	94	131	126	132	..
,,	Thurcaston	..	126	126	161	..
,,	Melton Mowbray (Rotherby)	56	106	113	155	173
,,	Uppingham	..	41	..	..	..
,,	Walsall	110	..	128	..	..
,,	Burton-on-Trent	83	..	107	..	..
,,	Stoke-on-Trent (Tean)	59	..	126	140	..
,,	Beeston	58	119	113	..	..
,,	Worksop (Hodsock)	27	105	120	162	..

TABLE IV.—DATE (DAY OF YEAR) OF FIRST APPEARANCE OF INSECTS, 1891—*Continued.*

District.	Stations.	Honey Bee.	Wasp.	Small White. Butterfly.	Orange Tip Butterfly.	Meadow Brown Butterfly.
D.	Bakewell	..	..	125	..	..
"	Macclesfield	..	54	..	..	..
"	Grantham (Belton)	26	60	107	161	..
"	Harrogate	109	149	116	151	..
E.	Hitchin	..	47	..	..	..
"	Braintree	..	84	..	..	..
"	Colchester (Lexden)	..	46	..	..	..
"	Saffron Walden	43	46	..	..	..
"	Ipswich (Sproughton)	..	..	..	163	..
"	Wymondham (Tacolneston)	43	..	..	..	..
"	Wryde	..	84	126	..	..
F.	Chester	..	39	..	..	..
"	Parkgate (Heswall)	43	58	..	..	..
"	Caton (Claughton)	50	..	..	..	..
"	Egremont	88	92	110	137	195
"	Douglas	55	..	107	..	..
"	Orry's Dale	39	121	112	..	..
"	Ramsey	..	..	107	..	..
G.	Edgeworthstown	32	151	72	..	..
"	Loughbrickland	..	..	110	131	..
"	Saintfield	..	..	108	129	..
"	Antrim	..	167	111	129	..
H.	Dalry (Dalshangan)	41	..	..	..	..
"	Penpont (Auchenhessnane)	..	145	..	..	..
"	Tynron	98	..	144	..	..
"	Thornhill	81	129	..	..	..
"	Jardington	..	127	108	..	190
"	Helensburgh	..	116	127	..	(228)
I.	Driffield	59	..	..	..	..
"	Thirsk	31	60	87	150	190
"	Darlington (East Layton)	43	126	132	..	..
"	Durham	100	130	132	170	..
"	Hexham (Bingfield)	49	114	..	(204)	..
K.	Garve (Inverbroom)	57	..	..	..	..
	Mean dates for the British Isles in 1891	56 Feb. 25th	101 April 11th	110 April 20th	139 May 18th	171 June 20th

The dates in brackets have not been taken into consideration when calculating the means for the British Isles.

box facing North. *Buckhorn Weston* (C.). 2nd. The meadows are as dried up and barren as in December. *Pennington* (C.). 26th. Peach and nectarine in blossom—26 days later than in 1890. *Basingfield, Hants* (C.). 5th. I am far within the mark when I say that nine-tenths of the thrushes, blackbirds, hedge-sparrows, tits and wrens perished during the past winter. The song of a thrush or blackbird is here now a marvel to be noted, last year they swarmed at this time. The larks and robins did better than other small birds.—J. Salter, *Quarterly Record of Royal Botanic Society*. *Lynsted* (C.). The keep for cattle unusually short owing to destruction of root-crops. *Cranleigh* (C.). The following shrubs were most injured by the frosts of the winter—Laurel (rotundifolia), Laurustinus, Euonymus and gorse-garden Brocoli suffered severely, and strange to say the leaves of the strawberry were all killed to the ground level. *Denton* (C.). The winter frosts have killed a myrtle which has been in the ground for over 20 years. Thrushes are not nearly so numerous as usual. *Whitchurch* (C.).

TABLE V.—ESTIMATED YIELD OF FARM CROPS IN 1891.

Description of Crop.	England. A. SW.	England. C. S.	England. D. Mid.	England. E. E.	England. F. NW.	England. I. NE.
Wheat	12%O.A.	8%O.Av.	8%O.Av.	7%O.Av.	10%O.A.	9%O.A
Barley	5%O.Av.	Av.	Av.	Av.	6%O.Av.	Av.
Oats	3%O.Av.	3%O.Av.	2%O.Av.	4%U.Av.	4%U.Av.	5%U.A
Corn Harvest began, average Date	231 (Aug. 19)	226 (Aug. 14)	236 (Aug. 24)	229 (Aug. 17)	235 (Aug. 23)	242 (Aug. 30
Beans	U. Av.	U. Av.	U. Av.	U. Av.	Av.	U. Av.
Peas	U. Av.	O. Av.	U. Av.	U. Av.	Av.	Av.
Potatoes	O. Av.	O. Av.	Av.	Av.	Av.	O. Av.
Turnips	Av.	Av.	U. Av.	U. Av.	Av.	U. Av.
Mangolds	O. Av.	Av.	U. Av.	U. Av.	U. Av.	Av.
Hay	U. Av.	Much U. Av.	Much U. Av.	U. Av.	Much U. Av.	Much U. Av.

Description of Crop.	Scotland. H. W.	Scotland. J. E.	Scotland. K. N.	Ireland. B. and G. S & N.	British Isles.
Wheat	10%O.A.	1%O.Av.	11%O.A.	O. Av.	O. Av.
Barley	Av.	Av.	9%O.Av.	O. Av.	Av.
Oats	Av.	Av.	Av.	O. Av.	O. Av.
Corn Harvest began, average Date	243 (Aug. 31)	247 (Sep. 4)	257 (Sep. 14)	232 (Aug. 20)	238 (Aug. 26)
Beans	O. Av.	U. Av.	O. Av.	Av.	U. Av.
Peas	O. Av.	Av.	..	..	Av.
Potatoes	O. Av.	O. Av.	Av.	O. Av.	O. Av.
Turnips	O. Av.	U. Av.	U. Av.	Av.	U. Av.
Mangolds	U. Av.	Av.	Av.	O. Av.	Av.
Hay	Much U. Av.	U. Av.	U. Av.	U. Av.	Much U. Av.

Symbols:—O. = Over. U. = Under. Av. = Average.

The variations from the average relating to Wheat, Barley and Oats have been obtained from the *Agricultural Produce Statistics* issued by the Board of Agriculture, but those for the other crops from Returns which appeared in the *Agricultural Gazette*.

In spite of the prolonged frost shrubs have suffered but little. I attribute the little damage to the steady hold of the frost from December 8th to January 23rd, and there being little or no sun. All Brocoli and Cauliflowers destroyed. *Berkhamsted* (D.). When pruning Hybrid Perpetual Roses they were found to be uninjured by frost. 1st. First frog-spawn. *Churchstoke* (D.). 3rd. Frog-spawn first seen. *Walsall* (D.). 26th. Crocuses ready to open at end of February, have only now expanded their petals. *Beeston* (D.). 18th. Pied Wagtails first seen. *Hodsock* (D.). Only such delicate shrubs as Escallonia and Bay suffered at all from the winter frosts. *Harrogate* (D.). Privet denuded of its leaves by frost. Common laurel in many places killed to the ground. Aucubas have also suffered severely. *Wryde* (E.). Land in splendid order for spring sowing. *Tynron* (H.). 8th. Snow a foot deep. The wood pigeons afterwards became so tame that they entered the cottage gardens and ate the plants of green colewort. *Helensburgh* (H.). 1st. Shoots on Roses two inches long. 30th. Heard a lark for the first time. *Thirsk* (I.). Primroses which were out in the middle of February have been destroyed by the recent frosts. *Durham* (I.). 20th. Rooks busy building. *Inverbroom* (K.). Roses and Veronicas were in many places killed by frost.

APRIL.—*Sydcot* (A.). 4th. Cowslip first in flower. *Buckhorn Weston* (C.). 7th. Until the last two days the country has looked as desolate as if it

TABLE VI.—ESTIMATED YIELD OF FRUIT CROPS IN 1891.

Description of Crop.	England.					
	A. SW.	C. S.	D. Mid.	E. E.	F. NW.	I. NE.
Apples	U. Av.	U. Av.	U. Av.	Av.	U. Av.	U. Av.
Pears	Av.	Av.	U. Av.	Av.	U. Av.	U. Av.
Plums	O. Av.	O. Av.	O. Av.	Av.	U. Av.	U. Av.
Raspberries	O. Av.	O. Av.	O. Av.	O. Av.	O. Av.	U. Av.
Currants	O. Av.	O. Av.	O. Av.	Av.	U. Av.	U. Av.
Gooseberries	O. Av.	O. Av.	O. Av.	Av.	U. Av.	U. Av.
Strawberries	O. Av.	O. Av.	O. Av.	O. Av.	O. Av.	O. Av.

Description of Crop.	Scotland.			Ireland.	British Isles.
	H. W.	J. E.	K. N.	B. and G. S & N.	
Apples		U. Av.		U. Av.	U. Av.
Pears		U. Av.		U. Av.	U. Av.
Plums		U. Av.		U. Av.	Av.
Raspberries		O. Av.		Av.	O. Av.
Currants		U. Av.		Av.	Av.
Gooseberries		Av.		Av.	Av.
Strawberries		Av.		Av.	O. Av.

Symbols:—O. = Over. U. = Under. Av. = Average.

This Table has been compiled from Returns which appeared in the *Gardeners' Chronicle* and the *Garden*.

were December—no daisies even in bloom. *Pennington* (C.). Trees and all vegetation very backward. Very great scarcity of food for cattle and sheep owing to the grass growing so slowly, and the roots having rotted. Birds late in nesting. No flowers for Easter. 18th. Wryneck first seen and heard. 21st. Chiff-chaff and White-throat first heard. Wild Gooseberry in flower—57 days later than in 1890. *Strathfield Turgiss* (C.). Nightingales more numerous than usual. Cuckoos rather scarce. Swallows very scarce and Martins up to May 31st. Butterflies of all kinds exceedingly scarce. *Whitchurch* (C.). 6th. Sand-martin first seen. 30th. Wild cherry in flower. *Henley-on-Thames* (C.). The Nightingale and Cuckoo rather late in making their appearance in this district. *Cheltenham* (D.). 5th. Chiff-chaff first heard. 26th. Almond only now fully out. *St. Albans* (D.). Nightingales are unusually abundant with us this year. They are still in song (June 16th). *Northampton* (D.). Have frequently found Hawthorn in flower before the date on which the Blackthorn blossomed this year. *Churchstoke* (D.). 23rd. House-martin first seen. *Thurcaston* (D.). Vegetables very scarce, all but Brussels sprouts have been killed by frost. Euonymus killed outright. *Beeston* (D.). 13th. Willow-wren first seen. 15th. Oats which were sown on March 6th only just appearing above ground. *Harrogate* (D.). 26th. At Harlow Hill, 600 feet above sea level, male and female flowers of Hazel still immature. *Tacolneston* (E.). 30th. A few beeches, horse chestnuts and sycamores are out here and there, but on a general and distant view the country appears as brown and leafless as in mid-winter, so far as the trees and hedges are concerned. *Helensburgh* (H.). 8th. Gooseberry first in flower. 19th. Saw a small common tortoiseshell butterfly. *Ulceby, Lincoln* (I.). Raw, damp and sunless, with strong North-easterly winds and occasional showers of cold rain and hail between 1st and 10th; also cold from 10th to 20th. All this abnormal low temperature delayed the arrival of the ordinary spring visitors. Wheatears were not seen before the 10th at Spurn. 27th. Wind backed to South-west, and the next morning Cuckoos were to be seen all over the country. —J. Cordeaux, in *Zoologist*. *Durham* (I.). 16th. Sand-martin first seen. 28th. Willow-wren first seen. *Bingfield* (I.). Very dry, pastures quite brown.

TABLE VII.

Approximate Variations from the Average in Mean Temperature, Rainfall, and Sunshine. 1890–91.

Months.	Eng. SW.	Ire. S.	Eng. S.	Eng. Mid.	Eng. E.	Eng. NW.	Ire. N.	Scot. W.	Eng. N.E.	Scot. E.	Scot. N.
***Winter* 1890–91.**											
Temperature.											
	°	°	°	°	°	°	°	°	°	°	°
December ..	−7·0	−3·8	−9·0	−8·8	−9·2	−6·8	−3·2	−2·4	−4·6	−1·6	−1·2
January	−4·0	−2·5	−4·8	−3·8	−4·8	−2·5	−2·0	−1·0	−3·0	−1·3	−1·3
February .	+0·5	+1·8	−0·8	+0·5	−0·3	+2·5	+2·8	+2·8	+1·0	+3·8	+4·5
Winter ...	−3·5	−1·5	−4·9	−4·0	−4·8	−2·3	−0·8	−0·2	−2·2	−0·3	+0·7
Rain.											
	Ins.	Ins.	Ins.	Ins.	Ins.	Ins.	Ins.	Ins.	Ins.	Ins.	Ins.
December	−1·8	−0·6	−0·9	−2·4	−2·2	−2·8	−1·5	−2·7	−1·7	−1·8	−3·1
January	−0·5	−1·5	+0·1	−0·4	0·0	−1·0	−1·2	−1·4	−0·9	−1·2	0·0
February	−3·1	−3·0	−2·1	−2·0	−1·6	−2·2	−2·3	−3·4	−1·6	−1·8	+·03
Winter	−5·4	−5·1	−2·9	−4·8	−3·8	−6·0	−5·0	−7·5	−4·2	−4·8	−2·8
Sunshine.											
	hrs.	hrs.	hrs.	hrs.	hrs.	hrs.	hrs.	hrs.	hrs.	hrs.	hrs.
December	−22	−12	− 7	−29	−22	−13	+ 1	−24	−21	−34	+5
January	+20	+21	+21	+22	+18	+16	+18	+14	+11	+ 2	−1
February	+57	+12	+52	+45	+38	+42	+12	+ 5	+35	+23	+2
Winter	+55	+21	+66	+38	+34	+45	+31	− 5	+25	−13	+6
***Spring* 1891.**											
Temperature.											
	°	°	°	°	°	°	°	°	°	°	°
March	−2·5	−2·8	−2·3	−2·0	−0·8	−2·0	−2·5	−2·5	−1·8	−2·5	−3·8
April	−1·6	−1·6	−2·6	−3·0	−2·8	−2·8	−2·6	−2·8	−2·8	−3·0	−2·8
May	−2·3	−3·3	−2·3	−2·5	−2·8	−2·5	−3·0	−2·0	−3·0	−2·8	−2·3
Spring ...	−2·1	−2·6	−2·4	−2·5	−2·1	−2·4	−2·7	−2·4	−2·5	−2·8	−3·0
Rain.											
	Ins.	Ins.	Ins.	Ins.	Ins.	Ins.	Ins.	Ins.	Ins.	Ins.	Ins.
March	−0·4	−1·4	+0·8	−0·4	−0·2	−0·9	−0·1	+0·1	+0·5	+0·5	+1·0
April	−0·6	−0·4	−1·2	−0·1	−0·8	−0·3	−0·1	−1·2	− 0·5	−0·5	−1·6
May	+0·4	+0·6	+0·7	+0·6	+0·7	−0·2	+0·2	−0·9	+0·3	−0·1	−0·1
Spring	−0·6	−1·2	+0·3	+0·1	−0·3	−1·4	0·0	−2·0	+0·3	−0·1	−0·7
Sunshine.											
	hrs.	hrs.	hrs.	hrs.	hrs.	hrs.	hrs.	hrs.	hrs.	hrs.	hrs.
March	−20	+17	−24	−18	− 7	− 2	+23	+20	+ 4	+ 2	+ 7
April	−11	−15	− 5	−17	−38	−20	−10	+10	− 1	+10	+19
May	− 3	−11	− 7	−18	−32	−34	− 7	− 7	−23	− 8	+ 7
Spring	−34	− 9	−36	−53	−77	− 56	+ 6	+23	−20	+ 4	+33

+ indicates above the average, — below it.

TABLE VII.

Variations from the Average—*Continued.*

Summer 1891.

Temperature.

Months.	Eng. SW.	Ire. S.	Eng. S.	Eng. Mid.	Eng. E.	Eng. NW.	Ire. N.	Scot. W.	Eng. NE.	Scot. E.	Scot. N.
	°	°	°	°	°	°	°	°	°	°	°
June	+1·0	+1·5	+0·5	+0·8	0·0	+1·0	+2·0	+2·5	−0·8	−0·3	+1·0
July	−1·2	−0·8	−1·4	−1·4	−1·4	−0·8	−0·2	−0·2	−0·2	+0·8	+0·2
August	−2·3	−1·8	−2·0	−1·8	−1·8	−1·3	−0·8	−0·5	−1·8	−0·5	−0·5
Summer ..	−0·8	−0·4	−1·0	−0·8	−1·1	−0·4	+0·3	+0·6	−0·9	0·0	+0·2
Rain.											
	Ins.	Ins.	Ins.	Ins.	Ins.	Ins.	Ins.	Ins.	Ins.	Ins.	Ins.
June	−0·1	+0·4	−0·4	+0·2	−0·4	+0·3	−1·1	−1·6	−1·1	−1·6	−1·1
July	+0·1	−0·6	0·0	−0·6	+0·6	−0·2	−0·7	−2·3	+0·2	+0·1	+1·1
August	+2·9	+2·3	+2·4	+1·4	+1·6	+2·8	+2·2	+1·3	+1·4	+1·4	+1·0
Summer ..	+2·9	+2·1	+2·0	+1·0	+1·8	+2·9	+0·4	−2·6	+0·5	−0·1	+1·0
Sunshine.											
	hrs.	hrs.	hrs.	hrs.	hrs.	hrs.	hrs.	hrs.	hrs.	hrs.	hrs.
June	−14	+ 7	+27	+ 1	− 24	+ 1	+ 9	+12	+13	− 7	+56
July	+ 3	−18	+ 2	−18	− 48	−19	+ 7	+ 2	−18	−29	−51
August	−37	−37	−30	−35	− 32	−46	−27	−25	−44	−34	−15
Summer ..	−48	−48	− 1	−52	−104	−64	−11	−11	−49	−70	−10

Autumn 1891.

Temperature.

Months.	Eng. SW.	Ire. S.	Eng. S.	Eng. Mid.	Eng. E.	Eng. NW.	Ire. N.	Scot. W.	Eng. NE.	Scot. E.	Scot. N.
	°	°	°	°	°	°	°	°	°	°	°
September ..	+0·6	+0·8	+1·4	+1·4	+1·8	+2·2	+1·6	+1·2	+1·6	+1·4	+1·4
October......	0·0	−1·3	−2·3	+0·5	+1·8	+0·5	−1·3	+0·3	+0·5	0·0	+1·0
November....	−0·8	−2·5	0·0	−0·5	−0·3	−0·8	−1·5	−0·5	−0·3	−0·5	−0·3
Autumn ..	−0·1	+1·0	+1·2	+0·5	+1·1	+0·6	−0·4	+0·3	+0·6	+0·3	+0·4
Rain.											
	Ins.	Ins.	Ins.	Ins.	Ins.	Ins.	Ins.	Ins.	Ins.	Ins.	Ins.
September ..	−0·3	−0·2	−0·9	−1·1	−1·2	+0·9	0·0	+2·9	−0·6	+1·4	+2·2
October......	+3·7	+2·5	+3·9	+2·6	+1·5	+0·3	+1·0	+2·2	0·0	+0·1	−0·2
November....	−0·2	−0·2	+0·2	+0·1	−0·5	+0·4	−0·7	−0·2	−0·2	−0·1	−0·9
Autumn ..	+3·2	+2·1	+3·2	+1·6	−0·2	+1·6	+0·3	+4·9	−0·8	+1·4	+1·1
Sunshine.											
	hrs.	hrs.	hrs.	hrs.	hrs.	hrs.	hrs.	hrs.	hrs.	hrs.	hrs.
September....	− 6	+22	+16	+20	−67	−10	+26	−11	+12	− 4	−28
October......	+18	+38	+ 9	+ 9	+14	+22	+46	+27	+ 4	+19	+11
November....	− 3	− 3	+ 1	−13	−20	−20	− 7	−11	−10	− 9	− 8
Autumn....	+ 9	+57	+26	+16	−73	− 8	+65	+ 5	+ 6	+ 6	−25

The above Table has been compiled from the variations from the mean given in the *Weekly Weather Reports* issued by the Meteorological Office.

MAY.—*Wells* (A.). Owing to the frosts of the 16th and 18th gooseberries and pears are lying on the ground by hundreds. *Clifton* (A.). The small white butterfly did not become actually common until the 11th of May—an unusually late date. *Penarth* (A.). Insects have been scarce until nearly the end of May. Since then (June 10th) they have been abundant, and more particularly moths. *W[illegible]* (B.). Foliage very backward and much injured by the cold and storms of 23rd and 24th. 31st. Lime trees not fully in leaf, and no leaves showing upon the ash and only coming out on the oak. The Hawthorn has very little flower upon it this year. *Buckhorn Weston* (C.). 15th-17th. Heavy hail-storms, which damaged the young leaves a good deal. 17th. A severe frost which cut off even more. Potatoes were quite killed. *Pennington* (C.). 17th. Walnuts and other fruit trees, also strawberries and potatoes, injured by frost. *Canterbury* (C.). The blossom on the fruit trees was remarkably abundant. The plum, pear, cherry and early flowering apples were all to be seen in blossom at the same time. *East Molesey* (C.). Horse-chestnut in Bushey Park not fully out until the 23rd. Hawthorn only fully out on the 30th. *Henley-on-Thames* (C.). In the warm spell, May 9th-14th, wasps came out in large numbers, but on the return of cold on the 15th there were none to be seen. The wells in the Chalk are very low indeed. The nesting of rooks and other birds took place about the usual date. *Great Barrington* (D.). 20th. Swift first seen. Blossom on apple and crab trees very abundant. *Berkhamsted* (D.). Eight per cent. of my Tea roses have been killed by frost. *Birch, Hereford* (D.). Many Tea roses both dwarf and standards have been killed outright by the frosts of the past winter and spring. Of the dwarfs, several hundred plants were cut down to the ground level. Height above sea 550 feet.—Rev. F. R. Burnside. *Beeston* (D.). 4th. Landrail first heard. 12th. Turtle Dove first heard. 17th. Potatoes blackened. *B[illegible]* (D.). 3rd. A few green leaves on sycamores and birches, but beech and elm look as black as in winter. *Macclesfield* (D.). 19th. Sharp frost which destroyed a great deal of fruit blossom and many potatoes and other tender plants. *Belton* (D.). 19th. Early apple and plum blossom damaged by frost. Asparagus received a severe check, and for ten days did not grow at all. *Harrogate* (D.). The foliage of the beech, which is about half grown, is in many instances shrivelled as if it had been scorched by fire. 11th. Fieldfares still here in large flocks. 16th. Nightingale heard at Thornton-le-Moor, in the N. Riding of Yorkshire. This is mentioned because it is, I believe, the only well authenticated instance of this bird being heard in song so far North. 17th and 18th. The frosts of these two nights, coming when all foliage was wet with melted snow, did great damage to vegetation. Swallows and Martins perished in many of the streams during the heavy fall of snow. *Tacolneston* (E.). 18th. Walnut leaves killed by frost and snow. *Wryde* (E.). 19th. The peas in some places have been killed down to the ground, also the young mangolds. *Claughton* (F.). 17th. Heavy and frequent snow and hail-showers and very sharp frost at night, which cut down potatoes, and did a great deal of damage to gooseberries, &c. *Settle* (F.). Leaves of the beech completely shrivelled and brown since the frost of the 16th. *Egremont* (F.). 17th. This frost did great damage to vegetation. I observe that all potatoes which face the east have been entirely spoilt, while those facing the west have escaped injury. Again on the east side of trees the leaves are all black and withered and have fallen off; but on the west side they remained uninjured. *Antrim* (G.). Nearly all the early planted potatoes have been cut down by frost. 17th. There was a heavy fall of snow which not only bore down flowering plants, but laid beds of rhubarb level with the ground, and in many cases severed the stems from the roots. *Tynron* (H.). 10th. Landrail first heard. *Driffield* (I.). 18th. 10° of frost in screen, and 20° on grass. The ash (just opening) and beech leaves (fully out) were completely blackened and destroyed. The larches, sycamores, maples, horse and Spanish chestnuts were considerably damaged. The greater part of the fruit buds open and unopened of the strawberry, plum, pear, cherry and apple are dead in the centre, and only a very few of the late blossoms have escaped injury. 27th. Landrail first heard. *Stareley, Yorks, W. Riding* (I.). Writing a month after the event (June 17th), the damage caused by the frost and snow in May has become apparent. It is sad to mark the havoc that has been wrought among the fruit and garden crops, and to see the blighted foliage—brown as in autumn, of the beech. A portion of the foliage of the horse-chestnut and the larch appears as if scorched by a sudden blast. The walnut trees, standing up among the summer foliage of the sycamore and hornbeam, still as bare and gaunt as when held in the grip of winter, lend a weird look to the landscape. In the hedgerow the privet and bramble have suffered, and the flower buds of the Rowan-tree, laburnum and sycamore have fallen unopened.—Rev. E. P. Knubley, in *Naturalist. Thirsk* (I.). 18th. The foliage of the beech and horse-chestnut which was just opening much injured by frost. *Boston Spa, Lincoln* (I.). I have been a grower of ferns for 30 years, and never knew our out-of-door native species suffer as much as they did in the frost at the end of May this year.—J. Emmet, in *Naturalist. Durham* (I.). 13th. Landrail first heard. 15th. Swift first seen. 19th. Recent frosts have done much damage to fruit blossoms. *Bingfield* (I.). 17th. Potatoes blackened and cherry blossom damaged. *Inverbroom* (K.). 2nd. Wheatear first seen.

The Summer.

June was, if anything, rather a warm, dry and sunny month in nearly all districts, while July and August on the other hand proved cold, wet and sunless. Taking the three months together, the mean temperature was about 1° below the average in England, about the average warmth in Ireland, and slightly above it in Scotland. But as was the case in the spring, there was a marked deficiency of bright sunshine in nearly all parts of the British Isles. Towards the end of June haymaking began in the earliest districts, but, owing to the frequent rains of the two following months, a small crop was in most places harvested with great difficulty, and in inferior condition. The summer fruits were fairly abundant, with the exception of black currants, but all were deficient in flavour. In some localities trees and shrubs suffered much owing to the dryness of the subsoil. During June insects were tolerably numerous, but after this comparatively few were to be seen. Butterflies were almost everywhere very scarce. Caterpillars affecting fruit trees proved far less destructive than in recent years. In June the Dog-rose was almost everywhere about a fortnight late in coming into blossom. During July, the nearest approach to the normal dates of flowering seem to have been reached in nearly all the districts, the departures from the mean in many localities varying only from a few days to about a week late.

Observers' Notes.

JUNE.—*Babbacombe* (A.). 22nd. Haymaking began. *Penarth* (A.). Insects plentiful during this month, and also in the spring, but not nearly so numerous afterwards. *Pennington* (C.). 27th. Field-rose in flower. Bees backward in swarming. *Strathfield Turgiss* (C.). Everything backward. Dog-rose extraordinarily fine. *Orford* (D.). Bloom on horse-chestnut unusually abundant. *Great Barrington* (D.). 1st. Peacock butterfly seen. 3rd. First swarm of bees. *Cheltenham* (D.). Wild flowers bloomed in great profusion. *Berkhamsted* (D.). 16th. *Rosa Hibernica* in flower—later than in any of the previous five years. *Harrogate* (D.). 1st. Night jar first heard. The cuckoo and landrail not nearly as numerous as usual. *Lexden* (E.). Nightingale singing as late as the 26th. *Driffield* (I.). 28th. Beech trees made a second growth of leaves.

JULY.—*Marazion* (A.). Butterflies have been very scarce this summer. *Babbacombe* (A.). 16th. Haymaking generally finished. *Wicklow* (B.). Almost a plague of snails in the gardens. During the last three weeks of this month we were obliged to water our garden frequently, or many of the shrubs would have suffered. Here there has been quite a plague of woodlice. *Whitchurch Canonicorum* (C.). We have noticed a great quantity of double wild flowers this year, principally buttercups, cuckoo flower, tormentil, daffodil and lesser celandine, also pale shades and white in many flowers of usually decided colour. *Pennington* (C.). Scarcely any corn cut by end of month. *Strathfield Turgiss* (C.). Here it might be said that no butterflies at all had been seen this summer. *Addlestone* (C.). 5th. Wild strawberries ripe. *Great Barrington* (D.). Turnip fly very numerous during latter part of June and early in July. *Cheltenham* (D.). Absence of sun and the quantity of rain have spoilt the fruit crop, which is sour, watery and flavourless. *Beeston* (D.). 4th. Hay first cut, quite a fortnight later than usual. *Hodsock* (D.). 3rd. Black currants are an entire failure from spring frosts. 18th. First corn cut. *Belton* (D.). 8th. Violent hailstorm—flowers and leaves torn to shreds and much fruit knocked off. *Harrogate* (D.). 12th. Cuckoo last heard. *Sproughton* (E.). Swallows have been more numerous than usual this year. *Chester* (F.). Female wasps unusually abundant early in the season, but owing to the excessive wet few were to be seen at the end of July. A late season and insects generally scarce. *Claughton* (F.). Hay was well got in early in July. *Driffield* (I.). The severe frosts at Whitsuntide destroyed fully a fortnight's crop of strawberries. First strawberries gathered July 1st, or nine days later than the average of the previous nine years, and twenty-two days later than in the previous year. Hay crop spoilt by drought and now by wet.

August.—*Babbacombe* (A.). 15th. Oats first cut. *Sydcot* (A.). 24th. Autumn crocus in flower. *Pennington* (C.). 13th. Wheat and spring oats first cut. 17th. Last night jar heard. 31st. Last swift seen. *Strathfield Turgiss* (C.). August has been the coldest and wettest on record at this station for more than 30 years. Wasps very scarce. *Henley on-Thames* (C.). 29th. Saw two cuckoos flying across the river. *Cheltenham* (D.). 8th. I noticed much hay still out. *Beckford* (D.). At least four bushels to the acre of wheat have been blown out by the high winds. Barley stained by wet. *Macclesfield* (D.). At many farms on the hills the hay crop has been almost ruined. There have been but few caterpillars and aphides during the summer. Small fruits did not ripen well. *Harrogate* (D.). Lime flowering sparingly. 30th. First ripe blackberries.

The Autumn.

The cold and wet of August was continued into September, but after the first week came ten days of beautifully fine and hot summerlike weather, which was greatly welcomed by the farmers, and enabled them to get in a large area of corn in good condition. After this, however, there was a return to frequent rains and high winds, which lasted until nearly the close of the following month. So that even as late as the end of October harvest was not over in some of the northern counties of England. The autumn proved on the whole moderately warm, and as it was also excessively wet, the trees retained their foliage to a much later period than usual. The autumn tints were as a rule poor, and lasted but a short time, and in many cases the leaves became shrivelled by cold winds instead of gradually changing colour. Owing to the saturated condition of the soil, all seasonable farming operations were greatly in arrear, and on some heavy lands the sowing of autumn wheat could not be proceeded with at all. As is usually the case in wet seasons, the root crops continued to make steady progress. Notwithstanding the heavy rains there appears to have been a singular absence of potato disease in all parts of the country. The tubers of the early varieties, however, came small, owing to the injury done to the haulm by the May frosts. The ivy flowered in most of the districts during October, and taking the British Isles as a whole, was more than a fortnight later than the average in opening its petals.

Observers' Notes.

SEPTEMBER.—*Babbacombe* (A.). 29th. Harvest finished. *Pennington* (C.). 12th. Harvest finished. Fruit lacking flavour. Bees swarmed late and made but little honey. *Oxford* (D.). 9th. Swift last seen. *Cheltenham* (D.). All fruits are insipid and watery. *Hodsock* (D.). 24th. Harvest finished. *Macclesfield* (D.). 1st. Oats in many places are still quite green and badly laid with the rain and wind. *Harrogate* (D.). 2nd. Oats first cut. 8th. Swifts last seen. 19th. Autumn crocus in flower. *Durham* (I.). Second blooms on wild flowers were common.

OCTOBER.—*Wicklow* (B.). The foliage of trees remained perfectly green until the storm of the 5th. *Berkhamsted* (D.). 31st. Dahlias killed by frost. *Rotherby* (D.). 31st. Dahlias killed. *Hodsock* (D.). Autumn tints not good this year. Trees only changed colour late in the month. *Harrogate* (D.). 21st. Fieldfares and redwings arriving in large numbers. 28th. Beech, lime, horse-chestnut and elm defoliated. *Sproughton* (E.). Most swallows left on the 25th. *Helensburgh* (H.). Foliage of trees shrivelled by cold high winds. *Thirsk* (I.). 19th. The leaves of trees have as yet hardly changed colour, and very few have been shed.

NOVEMBER.—*Babbacombe* (A.). 11th. Most trees defoliated. 19th. Field Elm and Hawthorn defoliated. 28th. Oaks defoliated. *Wicklow* (B.). 22nd. Dahlias killed. *Pennington* (C.). 8th. Dahlias killed by frost. *Canterbury* (C.). Many elms, oaks, ashes and maples held their leaves till the 25th. *Salisbury* (C.). The swallow tribe reappeared here in considerable numbers. *Northampton* (D.). House-martins seen up to 19th. *Rotherby* (D.). 20th. Trees nearly stripped of their leaves. *Beeston* (D.). The leaves remained on the trees till late this year. *Lexden* (E.). 19th. Several martins seen. *Tacolneston* (E.). 7th. Thirty-seven different wild flowers were gathered by the roadside. 24th. Many oaks and elms still in full leaf although brown. *Claughton* (F.). 12th. Nearly all the leaves blown off the trees. *Ulceby* (I.). 8th. I saw two swallows on Kilnsea Warren on their passage from North to South, and in both separate cases with snow bunting, a curious combination of spring and winter visitors. 13th. A swallow was seen at Grainsby.—J. Cordeaux, in *Naturalist.*

The Year 1891.

In most of the English districts the winter of 1890-91 proved very destructive to the root crops on the farms and to green vegetables and half-hardy shrubs in the gardens. Birds also suffered severely through the prolonged frost. In Scotland and Ireland, however, there was scarcely any severe weather until March. The flowering of wild plants was considerably retarded by the cold spring, but during the summer the departures from the average were not so great. The harvest was late and its ingathering much interfered with by stormy weather. The fruit crops proved fairly abundant, but were mostly lacking in flavour owing to the sunless character of the summer.

A few words of explanation as to how the approximate averages given in Table II., and also in the diagrams (Plate VI.), were arrived at, may be of interest. In the first place it became necessary to ascertain for each of the plants on the list in what order it came, as a rule, into flower in the eleven Districts into which the British Isles are divided. For this purpose all the available observations relating to these plants which had been sent to the Society during the last eight years were tabulated. The mean results showed a very close approximation between the order in which the plants flowered in the different

Districts, and the order which these Districts take up when arranged according to their mean annual temperatures. Therefore, no readjustment of Districts was considered necessary, and they remain as in the two previous Reports, arranged according to their relative mean temperatures.

The next step proved a far more difficult one, and that was to find out, if possible, what number of days should be considered as equivalent to an increase or decrease of 1° in mean temperature. The eight years' observations above referred to were again most carefully examined and re-examined, also those given in the Floral Calendar of the *Natural History Journal*, as well as Mr. W. F. Miller's Croydon records. The only point, however, which came out in any way clearly was that during the summer there was, as a rule, less difference between the dates of flowering for the warmer and for the colder Districts than in the spring months. As regards the question of how many days should be taken as representing a degree of mean temperature, the evidence was most conflicting. Moreover, further difficulty arises from the fact that the relative temperatures of the Districts are different in different parts of the year, *e.g.* on the average of the year. For instance, the North of Scotland is rather warmer than the East of Scotland during the winter half of the year, but more than 2° colder during the summer half.

It was ultimately decided to allow four days for plants flowering during the winter and spring, and three days for those coming into blossom in the summer and autumn, for each degree of difference in mean temperatures, as being the closest approximations at present obtainable. The corrections having been determined, it only remained necessary to secure standard dates for any one District for each of the thirteen selected plants, and then to apply these corrections in order to obtain average dates for all the other Districts. Such standard dates were found ready to hand in the Rev. T. A. Preston's *Results of 20 years' observations at Marlborough.*

The average date of flowering of any plant on the list in any District was now easily ascertained. For instance, taking the Hazel, the Marlborough dates being, as a rule, among the earliest in the country, the standard date 32 (February 1st) is given to District **C.** (South of England), and from this starting point the means for the other Districts are calculated. For example, District **B.** (Ireland South) during the first quarter of the year is 2°·4 warmer than District **C.** Consequently the average date of first flowering (reckoning 4 days to 1°) comes out as 22 (January 2nd). On the other hand District **D.** (the Midlands) being 1° colder than District **C.** the average date is taken to be 36 (February 5th).

As regards the mean dates for 1891 (Table II.), it may be pointed out that had the mean value for each District been derived from an equal number of observations, the departures from the average dates would have come out much more consistent than they do. In the present Report unfortunately some of the Districts are very inadequately represented.

DISCUSSION.

THE PRESIDENT (Dr. Theodore Williams) said that the Society was greatly indebted to Mr. Mawley for the report he had placed before them. Phenological observations, although not strictly belonging to meteorological work, were very useful, and afforded valuable collateral evidence of the weather as recorded by the various meteorological instruments. Mr. Mawley had taken up the labours of Mr. Preston and directed them to a useful end.

Mr. SYMONS said that he was pleased with the diagram of mean dates of flowering which Mr. Mawley had prepared. It was the first step in an important direction in phenological work, and the averages given were without question very valuable. There was no doubt that the energy of the individual observers was an important consideration in comparing the observations. The returns from Marlborough College, specially alluded to by Mr. Mawley, formed a case in point, as the boys studying there were encouraged to scour the country round in search of first specimens of flowering plants, and so dates of observation of first flowering were promptly recorded.

Mr. SOUTHALL expressed the high appreciation with which he regarded these reports, and said that the observations he had himself made of the dates of flowering, &c. of plants in his own garden (which he had now carried on for twenty years) fully concurred with Mr. Mawley's results. He thought that the very late average date of the ingathering of the harvest had hardly been sufficiently brought out in the report.

THE HON. ROLLO RUSSELL inquired whether the colours of the leaves on the trees in autumn were in any way connected with the degree of dryness of the atmosphere. He had never seen, even in a dry English season, such brilliancy of colour, especially in birches and in ferns, as was to be witnessed in Perthshire.

Mr. TRIPP asked whether Mr. Mawley was able to say if the date of flowering was at all influenced by elevation above sea-level, as he was under the impression that such was the case; and, if so, had any allowance for height above sea-level been made in preparing the curves of average dates shown on the diagram.

Mr. MAWLEY, in reply, said that he had been agreeably surprised, when drawing the mean curves of the dates of flowering for the different districts, to find that in the first year of the new system of observation they came out on the whole so well. He did not know how to account for the fact of the autumn tints being, as a rule, more pronounced in Scotland than in England, unless it were for the reason Mr. Russell had stated. The tints were generally finest when the temperature gradually declined as the autumn advanced, for then the ripening of the shoots of the trees and also of their leaves proceeded simultaneously. The curves of mean dates were based upon all the observations sent in from the districts into which the country had been divided, no allowance being made for differences in elevation. No doubt the height above sea-level had much influence upon the dates of first flowering, but he did not consider the number of strictly accurate observations as yet sufficient to allow of corrections for elevation being introduced.

The Untenability of the Atmospheric Hypothesis of Epidemics.

By the Hon. F. A. ROLLO RUSSELL, M.A., F.R.Met.Soc.

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The ancient doctrine which attributed plague and pestilence to some malignant constitution or influence of the atmosphere has, within the last 120 years, but especially within the present century, been driven from point to point and from refuge to refuge, until by the issue of the Local Government Board Report on the recent epidemic of Influenza, its last remnants of plausibility have yielded to the strong demonstration of connected facts. The result arrived at is of very high importance to mankind, and appears to me to deserve full recognition by this Society, for it seems to complete the evidence leading to the conclusion—that no kind of epidemic or plague is conveyed by the general atmosphere, but that all of them are caused by human conditions and communications capable of control.

It will not be necessary to recount how in the case of almost every great epidemic disease in past times the atmosphere has been erroneously charged with the pernicious quality or malignant influence which has spread death and disease among the nations. The Plague, Cholera, Yellow Fever, Small Pox and even Rabies or Hydrophobia, have all been supposed in former times, and one of them quite recently, to be spread or caused by morbific atmospheric conditions.

Consumption, or tuberculosis, is now traced to human, and not to atmospheric conditions; indeed, the free air of sea, plain and mountain, seems never to contain the germs in a potent condition. Even colds of a certain kind and of a severe type may, with much reason, be ascribed to impurities in soil, houses and clothing, the organisms concerned being sparsely scattered and commonly harmless in the general atmosphere, but more concentrated and potent in houses and towns, so that most colds are caught by direct infection. On the deck of a ship, or on a mountain top, colds are seldom caught, and people who are isolated in the country are also generally free from colds, except in the neighbourhood of marshes, wet valleys or estuaries. The severe colds which attack the people of St. Kilda after the landing of a stranger are apparently due to the conveyance of a certain organic dust from populous places, from which the island is free. The circumstances are described by Mr. Macdonald in the *Report of the Local Government Board on the Epidemic of Influenza in 1890.*

Epizootics, cattle plague for instance, and pleuropneumonia, which had been attributed to the atmosphere and an "epidemic constitution" connected, perhaps, with the planets or more occult causes, were shown to be really due to contagion and conveyance of infectious matter through short distances of impure air.

Some of the diseases above mentioned are apparently capable of conveyance through a moderate distance of outside air, without altogether losing their infective power. Thus small pox, when concentrated in a hospital, has increased above the normal the number of cases of small pox within a radius of half-a-mile.

With other zymotic diseases the proper ventilation of hospitals almost annihilates their infective power.

While, therefore, we must recognise the frequent conveyance of epidemic disease from one case to another through a short distance of air, we are enabled to exclude the totally different proposition, that epidemics are ever caused by a general impurity or peculiar condition of the atmosphere.

By far the strongest case for atmospheric diffusion of disease poison was afforded by influenza, and in this pestilence the appearance has been so delusive, that over a large part of the continent of Europe and of America, and to a considerable extent in England, the atmospheric hypothesis is still held.

Last century medical opinion was largely in favour of the theory of contagion; but in the epidemics of the first half of the present century a mass of rather inaccurate observation helped to shift the responsibility back upon the atmosphere, and the careful, almost conclusive, observations of Dr. Haygarth and others were discountenanced.

At first sight there is something in the manner of invasion of influenza which seems to suggest a general cause, such as might be found in a contamination of the atmosphere or large portions of it, with living organic dust. But examination of the geographical distribution of the disease, of its course through a country, a town or a village, is sufficient to dispel this illusion, and to lead to the conviction that in influenza we have simply an example of a highly infectious malady of short incubation period and long striking distance through confined air.

The study of the manner of propagation of influenza has so much bearing on many other serious pestilential and epidemic diseases, that I propose to submit the following evidence, which you will, I think, admit is more than sufficient for the particular purpose of proof against the unfruitful doctrine of atmospheric contamination and diffusion.

The rate of progress of influenza is largely proportional to the possible rate of communications. Thus it extends rapidly from Moscow to St. Petersburg, from St. Petersburg to Berlin, Vienna, Paris, London and Madrid, or from any one of these capitals to any other, slowly from one small village to another, if these are far apart and not connected, except by communication from one small place to another in the intervening country. Rapidly in present times compared with past: thus in 1832 it took eight months to cross Germany; and the epidemic of 1782 in England had begun in Canton and India in the autumn of 1780, in Tobolsk some time in 1781, in Moscow in December 1781, in St. Petersburg in January 1782, in London in May, and in most parts of England in June, in France in June, in Italy in July, and in Portugal and Spain in August and September. In the autumn of 1830 and earlier in the same year influenza was prevalent in China, and in 1831 it appeared in several of the capitals of Europe, reaching London in May.

The pandemic of 1847-8 attacked Russia in February and March 1847, Turkey in August, France in September, Denmark in October, Germany in October, Italy in December, London in November, the greater part of England and Wales early in 1848, the North of Scotland in December 1847, and the Sandwich Islands in January 1848.

In 1889-90 the rate at which the epidemic spread over Europe and America was, on an average, fully twice that which prevailed before the introduction of railways. It should be remembered that the increase of rate would not be in proportion to the increase of travel-speed; for an important factor in the time of propagation of influenza is the distribution and increase up to a degree of wide prevalence in large towns, which takes much more time than the actual transference from place to place, except in countries where travelling is still slow. Moreover, influenza is frequently conveyed from port to port in sailing ships, of which the rate of travel is the same as before the age of steam. In 1782 influenza is recorded to have been brought in a little over 48 hours from the Thames to Shields in a sailing ship.

The most instructive instances of outbreaks of influenza, especially with regard to dates of first appearance, are afforded by islands having much, little, or very rare communication with infected continents.

The following information is mainly derived from the Report by Dr. Parsons on the epidemics of 1889 and 1890:—

Bardsey Island, off the Welsh coast, was free from influenza until January 1st, although cases had existed in Pwllheli, on the mainland, since the third week in December. On January 1st, the islanders visited Pwllheli to pay their rents, and had ample opportunity for contracting infection. Within a few days after their return almost all the inhabitants of the island (182) suffered from influenza.[1]

At *Guernsey*, January 10th seems to have been the date of the first attack.

At *Alderney*, January 14th; the first two persons attacked were Custom House Officers taking charge of the parcels brought by steamer. Influenza had occurred both at Guernsey and Cherbourg before it appeared at Alderney.

The *Scilly Isles* were affected about the middle of February. There is much communication with the mainland at this season, owing to the flower trade.

At *Trinidad* no influenza of an epidemic character had shown itself up to June 18th, 1890.

In *Iceland* influenza became epidemic in June or July. Previous epidemics are said always to have occurred in the summer, when communications with Europe were frequent.

At *Tobago* cases began to occur at the end of January, 1890. The epidemic appeared to begin at Scarboro', the port of entry, and to be more prevalent there than in any other part of the island.

At *Antigua* a mild epidemic began in January, 1890.

At *St. Kitts* and *Nevis*, it began on February 9th, 1890, and was definitely epidemic from the second week in February.

The *Bahamas*, *Grenada*, and *St. Lucia* are reported to have escaped.

[1] Mr. Hugh Rees, Medical Officer of Health for Carnarvonshire.

At *St. Vincent*, the first case was noticed on January 22nd, 1890. It appeared to spread by infection, and horses and dogs suffered from catarrhal affections.

At *Barbadoes* the date of first occurrence was given by a committee of medical men as April 15th, 1890, and the disease became epidemic early in May. At the Glendairy prison on the island, the first case occurred on May 19th. The first three cases occurred in convicts who had been in prison respectively 5 months, 4 months, and 1¼ month, but they had all three been working in one of the corridors where prisoners when first brought in are stripped and examined, and might have come in contact with the clothing which such men were wearing before admission. In the female prison the first case occurred in a woman who had been in prison 11 days, and no source of infection was known.

In *Bermuda* there appears to have been very little influenza, except in Ireland Island. On March 5th, 1890, the Swedish corvette *Saga*, with a crew of 12 officers and 196 men, arrived at St. George's, Bermuda, having on board upwards of 70 men ill with influenza. On February 27th, the *Saga* had left Havana. The following day the sickness broke out and soon attacked a large number. She was put in quarantine till March 12th, and on March 18th, being granted pratique, she proceeded to H.M. dockyard at Ireland Island, and on March 20th came into the Camber.

The first case of influenza in *Ireland Island* occurred on board H.M.S. *Bellerophon* on March 27th; this ship had come into the Camber on March 22nd, and made fast just ahead of the *Saga*. 160 cases followed on board the *Bellerophon*. The disease then became epidemic on several other ships further off from the *Saga* and finally, when it had ceased on board the ships, became epidemic on the island.

At the *Falkland Islands* there was no influenza; there was an epidemic of whooping-cough, imported from Punta Arenas, South America, whither it had been imported by a French emigrant ship from Europe.

At the *Canary Islands* there seems to have been no definite influenza, but feverish colds prevailed.

At the *Cape Verd Islands* an outbreak occurred on board H.M.S. *Australia* between January 7th and 25th.

At the *Azores* influenza seems to have broken out in the late spring of 1890.

At *St. Helena* there appear to have been no cases up to August 1st, 1890, but later in the month three cases were reported.

At *Axim*, on the *Gold Coast*, which may be considered as best isolated on the land side, the first case was observed in the beginning of May, and one of the first cases was a Customs Officer. From him it spread in a striking manner to the other officials.

In the *Shiré Highlands of Africa*, the epidemic appears to have been severe during the summer of 1890.

At *Mauritius* the epidemic began at Port Louis, the chief town, in August 1890, and spread thence to other districts.

In *Rodriguez* the influenza began in June, the two first cases being on June 22nd. On June 12th, H.M.S. *Garnet* had called, leaving the same day. Fifty men on board this ship had been subject to influenza between March 16th and April 9th. The *Maggie Low* had arrived on June 17th, but there is no statement respecting the presence or absence of influenza on board this ship. The dates indicate the probability of importation by one of these two vessels.

At the *Seychelles* there does not appear to have been any influenza.

At *Réunion* cases occurred on September 25th, 1890, in the following way: A lady had visited a house at Mauritius where influenza prevailed, and left on September 23rd, with preliminary symptoms. She reached a country house in Réunion on September 25th. Two days later the family and servants at this house were attacked.

At *Shoah*, in *Abyssinia*, influenza broke out in November 1890, among certain Italian officials.

In *Ceylon* the first cases occurred about February 7th, 1890, among some pilot boatmen employed in the Harbour of Colombo, after the arrival on January 30th of the troop ship *Himalaya*, with 19 cases on board, there having been 140 cases on the voyage from Plymouth. An early case also occurred in a post-office clerk engaged in sorting the mails. Places invaded late by the epidemic (summer 1890) are in the centre of the island and away from railway communication.

In *Penang, Straits Settlements*, the disease first occurred in the native bazaar, where coolies were employed in opening cases of "piece goods."

In *Singapore*, in the third week of February, the disease attacked the wharf coolies employed about the ships. The largest number of cases occurred among the coal coolies, who live in an overcrowded building; a very small proportion of cases occurred in large well ventilated houses in the country.

At *Borneo* the first case occurred on March 4th, 1890.

At *Hongkong*, cases of influenza occurred in January and February. An English steamer and an American steamer arrived in January, having cases on board. One steamer from England had landed 5 cases at Bombay in December, and came on to Hongkong *via* Singapore.

In *Japan* the epidemic began in February 1890.

In *New Zealand* influenza was reported on March 17th, 1890.

In *Victoria, Australia*, the influenza began early in March 1890.

In *New South Wales* in March and April, 1890, at various places, the course of the epidemic indicated transmission along the lines of railway and communication. In no case was the rate of extension greater than the rate at which a man could easily travel.

In *British New Guinea* no epidemic had occurred up to June 19th, 1890.

At places in *Queensland*, the dates of the first observed cases varied from the middle of April to July 7th.

In *West Australia* influenza appears to have prevailed in May and June.

Dr. Whittell, President of the Central Board of Health of *South Australia*, inclined to the belief that the contagion was carried from America to New Zealand and thence to the Australian colonies, to Sydney and Melbourne first, thence to South Australia, and thence to West Australia.

In *Tasmania*, the influenza first occurred in March, 1890, and soon became epidemic.

In *Fiji* there was no influenza in 1890.

At *Honolulu* influenza was prevalent in the middle of January 1890.

A certain amount of useful information is afforded by ships which had been free from influenza during the voyage, but were attacked soon after touching at infected ports. Thus, the *Malabar* troop ship from India arrived at Cadiz on January 19th, and 19 cases occurred on the 20th; the *Melita* arrived at Malta from Port Said on December 26th, and the disease began on board on December 31st; it was then prevalent at Malta; the *Monarch* had cases 10 days after arrival at Gibraltar on January 2nd; the *Northumberland* 9 days after arrival at Gibraltar; the *Orlando* had cases at Melbourne on March 21st, 6 days after arrival; the disease had then suddenly appeared on shore; the first case on board the *Serapis* was that of an officer who had visited friends suffering from the disease at Malta on December 26th.

The surgeon of the *Grantully Castle* (of the Castle Line from the Cape) was severely attacked two days after his arrival in London in February.

Messrs. Ismay, Imrie and Co. reported that no case occurred on board any of their vessels when more than four days from port.

The following classes of men were absolutely free from influenza during the epidemic period, except in those rare cases in which communication was held with an infected place:—Deep-sea fishermen, lighthouse keepers and their families, crews of ships at sea during long voyages.

Thus 20 smacks, each with a crew of six men, sailed for a fishing ground in the North Sea between November 26th and December 14th, and returned between January 29th and February 7th; there was no case of influenza.

The experience of other fishing boats, altogether carrying some thousands of men, is similar, the only cases occurring where communication happened to have taken place with the shore.

In a Journal called *Toilers of the Deep* for March 20th, 1890, it is stated: "The influenza has attacked several of our men; but, oddly enough, the doctors have observed none at sea, though carefully on the watch for it."

However, an instructive case occurred later on. On March 10th a boat with a crew of 10 men at the tail of the Dogger was boarded by two men from a fish carrier who had lately had influenza. On March 14th one of the boat's crew, and subsequently seven others, were attacked on board the fishing boat. The Secretary of the Great Grimsby Smack Owners' Association reported on March 14th, 1890, that the only suspicious case he could hear of on board the vessels of that port was that of a man who had spent the fortnight previous to sailing at Nottingham, and who was attacked a few days after sailing.

No authentic cases seem to have been noted of influenza having broken out on board a ship, when the port of embarkation, the crew and passengers, and the places whence these came, were known, or could be presumed to be free from infection. The number of sailors and passengers on board ships during the early months of the first epidemic in Europe must have been many thousand, but there is apparently no instance of an original attack at sea.

Dr. Parsons has shown that the often-quoted cases of the *Goliah* in 1782 and the *Stag* in 1888 rather prove the subtlety of the infection and the inaccuracy of the narratives than the conveyance of the contagion across a tract of sea. Other instances on which the hypothesis has leant will be found on inspection to be inconclusive and valueless.

Dr. Gregory, in his *Life of Sir Robert Christison*, seems to refer to the outbreak on board Lord Howe's fleet in 1782:—"The whole fleet was in excellent health and spirits when a cutter arrived from the Admiralty, and the signal was given for an officer from each ship. The officer was accordingly sent with a boat's crew from every vessel, and returned with orders, carrying with them also the influenza. In the lieutenant's ship, from whom Dr. Gregory received the account, he was one of two who alone escaped it; the other ships fared scarcely better."

Here we have the true account of infection: less fully informed people would speak of a mysterious outbreak on board ships at sea, long after leaving port, without communication with the shore.

Among lighthouse and lightship men, 415 in all, seven cases occurred, and each of these was accounted for by recent communications from the shore.

Three lightkeepers at *Bardsey Island* suffered after the people at the island had been on shore to pay their rents, as related above. A lightkeeper from the *Eddystone* Lighthouse landed at Plymouth on January 11th, and was taken ill on the 18th. If the cause of influenza had been diffused in the atmosphere, some hundreds of fishermen, and perhaps 50 or 100 lighthousemen would have been affected; but the fact that none of those who were isolated during the whole period of the epidemic caught it, and that only a few of the deep-sea fishermen and lighthousemen, the very persons who had been to infected places or near infected persons accidentally while at sea, were attacked, amounts to as good a proof as can be desired that the disease is infectious and not atmospheric. Moreover, from such cases as these, the time of exposure and attack, and the period of incubation is learnt with precision, and is shown to vary usually from a little less than two to five days.

It appears that to highly susceptible persons, who in relation to this malady are a rather large proportion of the population, a short and slight exposure to infected air or things is sufficient to start the disorder in their systems. This being the case, it is not surprising that soon after its first introduction to the chief centres of population it is distributed over nearly every part of the country. There are scarcely any villages so remote or inaccessible as not to be in daily, or at least weekly, communication with the chief towns, and there is no division of the United Kingdom which is out of touch, as it were, with the chief towns and ports of foreign countries. And in every small place the majority of the inhabitants have frequent opportunities of contracting infection in numbers at a time from a single case. This applies to scattered farms and villages. I remember being at the lighthouse at Cape Wrath more than 20 years ago, and the keeper telling me that he and his family drove to the nearest village, a distance of 14 miles, every Sunday; and I remember also that bread was distributed along great distances of road in the north of Scotland from certain centres, as far, I think, as 30 or 40 miles. Considering the small size of the particle, which, according to the researches of Messrs. Pfeiffer, Canon, Kitasato, and Koch, is concerned in the production of the disease, the large numbers given off from a single case, the short incubation period, and common susceptibility, the rapid spread of influenza is not out of agreement with the known qualities of many other epidemics and infections. I have calculated that the number of microbes of the stated size on a square inch of surface, closely packed, might be 12,500,000,000, or about equal to ten times the number of inhabitants of the globe. In a cubic inch, closely packed, the number would be 3,125,000,000,000,000, or 2,500,000 times the number of inhabitants of the globe.

Next to fishermen, sailors, and the inhabitants of remote islands, persons living much in the open air, and not gathering within doors in close places, were attacked in small proportion. Engine drivers, cabmen, omnibus drivers, and in most places out-door labourers, were less attacked than porters, clerks, and messengers. In a former epidemic an instance was given of the complete escape of 200 women who spent much of their time standing in sea-water near the wharves, raking up coal from the sea-bottom. This is unluckily an occupation which not even the prospect of immunity would induce many people to follow.

A large proportion of persons living in conditions of strict seclusion were not attacked. In the prisons of Bodmin, Kendal, Norwich, Portsmouth, and Ipswich, containing 420 persons, there was no case of influenza, although it prevailed outside in the neighbourhood. In many other prisons cases occurred, communications with the outside through warders and fresh prisoners being numerous.

An account has been published of the extension of the disease into the interior of Africa, by which it appeared that the arrival of two natives from a distant place, where influenza was prevalent, immediately set up influenza among the other inmates of the large room in which they lived.

Similar but less striking experience was very common in the recent and in former epidemics. It does not seem certain whether infection is more commonly carried in the person of intermediaries or in goods to which light and air have not had access.

An officer returned from Paris on December 8th, 1889, to Brest with some goods, which he unpacked himself. Three days later he was attacked, and on December 14th, before he was well, he went on board the ship *Bretagne.* On the 16th a case occurred on board the ship, and in a short time 244 out of 850 on board were taken ill.

The first case of influenza at Llanfyllin was that of a person who unpacked a few days before parcels of cloth from a large establishment in London, in which many of the *employés* had suffered from influenza. In Suffolk there was a history of introduction; at Lowestoft from Antwerp; at Bury St. Edmunds and Eye from France; at Stowmarket from London; in Cornwall, to Newquay, from Denmark; to Truro by German and Russian letters.

With respect to meteorological conditions, it is difficult to bring the propagation of influenza into necessary relations with any particular state of the air as regards temperature, moisture, rainfall, or wind, for it has occurred in all climates and in opposite conditions.

According to the Rev. W. Clement Ley, "the epidemic swept over the continent of Europe, following a south-westward course, under conditions which were in the main anticyclonic. It attacked the United States and Canada in atmospheric conditions as much the reverse of the former as if they had been intentionally planned as a contrast." And in India, according to Surgeon-Major Ellis, "the history of the epidemic all tends to show the influence of human intercourse on the spread of the disease." It seems to have been very closely connected with the movement of European troops. Meteorological conditions seemed to have little effect, for the disease occurred in the heat and dryness of Kampti, the warmth and moisture of Bombay, and the cool and temperate climate of Simla.

There is no definite or known atmospheric quality or movement on which the hypothesis of atmospheric conveyance can rest, and when closely approached it is found to be vague, unsubstantial and uncorroborated. Neither lower nor upper currents have ever taken a year to cross Europe from east to west, or adjusted their progress to the varying rate of human intercourse.

Like other maladies of high infective capacity, influenza has spread most easily, other things being equal, in cold calm weather, when ventilation in houses and railway cars is at a minimum, and when perhaps the breathing organs are most open to attack. But large and rapid communications seem to be of much more importance than mere climatic conditions. Across frozen and snow covered countries and tropical regions it is conveyed at a speed corresponding, not with the movements of the atmosphere, but with the movements of population and merchandise.

Its indifference to conditions of soil and air, apart from human habits depending on these, seems to eliminate all considerations of outside natural surroundings, and to leave only personal infectiveness, with all which this implies of subtle transmission, to account for its propagation.

If the courses of other plagues which have the same manner of attack from person to person, but a less vulnerable and extensive field on which to operate simultaneously, and which are so common among us as to be known as endemic, were more frequently and fully tracked from their local cultivation ground to their distant ramifications, the possibility of ultimate national or international control would be better recognised.

THE ORIGIN OF INFLUENZA EPIDEMICS.

By H. HARRIES, F.R.Met.Soc., Mem. German Met.Soc.

[Abstract.]

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The author begins by calling attention to the almost universal distribution of Influenza during the past two years, and to the very great illness and mortality caused by it, adding that its recent world-wide distribution has been quite accordant with Dr. Cullen's remark in 1785 that "The disease has always been particularly remarkable in this, that it has been the most widely spreading epidemic known."

Up to the present time there is no agreement among medical men as to the cause of the recent epidemic. The first theory was that it arose from the decomposition of the bodies of victims of the great inundation in China, and that the dust resultant therefrom had been carried by surface winds—but the normal course of the winds is just the reverse of that in which the Influenza spread. The suggestion by Sir A. Mitchell and Dr. Buchan that germs might be sucked up by cyclones and then transported by upper currents is noticed, and also Prof. Hildebrandsson's inquiries, which led him to conclude that the infective matter was carried about by travellers, and the statement of the Local Government Board that Influenza "is a dangerously infectious disease;" and then in opposition to this view the author quotes a statement that "The three keepers of the Casquets Lighthouse have all been suffering severely from Influenza. It is extraordinary that it should get to such a thoroughly isolated spot, 12 miles from Guernsey, seven from

Alderney, surrounded by the sea and swept by every wind." Other similar instances are quoted.

The author then proceeds to analyse the mortality returns for London in times of fog, and during Influenza, and considers that these have much in common, and he urges that the extra mortality in time of fog is due not to a fall of temperature, nor to fog *per se*, but to the sulphurous acid and other products of combustion accumulated in the atmosphere and remaining there owing to the absence of wind. This suggested to him a possible source for Influenza, viz., sulphur and other volcanic products. He then submits that the recent epidemics may have arisen from the subsidence of the matter ejected from Krakatoa in August 1883, when more than a cubic mile of volcanic products was ejected, some of it to an altitude of 23 miles. The calculations in the Report of the Krakatoa Committee of the Royal Society are quoted in order to show that, though this matter was shot up with great rapidity, it would take some years to fall owing to the extreme lightness and minuteness of the particles, and would chiefly be brought down in winter during the prevalence of anticyclones; and this is exactly when the Influenza was most severe. The late Prof. Ragona, in his paper "Influenza delle condizioni atmosferiche sull' Influenza," stated that Influenza appeared in Italy during an anticyclone, and while extremely fine dust was being deposited. This is no new suggestion; Dr. Darwin, when noting the misty appearance of the air in 1782, suggested that the matter which made the air thick produced the prevalent catarrh. The author incidentally calls attention to the rarity of analyses of atmospheric air, and suggests that systematic analyses might lead to important discoveries. The paper continues as follows:—

"Carefully reviewing the facts connected with the Krakatoa eruption of 1883, the atmospheric phenomena which have continued at intervals down to the present, the Italian dust deposition, and the haze observed in our own country, and combining all with what we know of the circulation of the atmosphere, I believe I have established a case in favour of the dust from volcanic eruptions being considered the principal factor concerned in the propagation of Influenza epidemics, that, as this dust invades the lower levels of the atmosphere, so a peculiar form of sickness assails mankind.

"The particulars relating to previous volcanic outbursts are not so complete as those we possess respecting the event of 1883, and our knowledge of the extent of the ravages of the earlier Influenza epidemics is rather limited, but I have prepared the following table showing the principal eruptions and all the Influenza epidemics of the eighteenth and nineteenth centuries. Eruptions of extraordinary violence are indicated by italics.

TABLE SHOWING THE PRINCIPAL VOLCANIC ERUPTIONS AND ALL THE INFLUENZA EPIDEMICS OF THE EIGHTEENTH AND NINETEENTH CENTURIES.

	Volcanic Eruptions.		*Influenza Epidemics.*
1698	Vesuvius, Carguairazo (Chili)	1699–1700	North Europe
		1702–03	England
1707	*Vesuvius, Santorin, a Japanese Volcano*	1708–12	Europe
1716	Taal (Luzon), Hofs Jökull (Iceland); 1717 Vesuvius, Iceland	1717	"
1721	*Kötlugia* (Iceland)	1725–30	"All the World"
1732	Etna	1732–33	America, Europe
1735	Etna	1737	Both hemispheres
1737	Vesuvius, &c.	1741–44	Europe
1744	*Cotopaxi*	1747–48	America, Europe
1748–52	Sandfells Jökull; 1751 Vesuvius	1752	
1754	Vesuvius, Hecla	1755	England, France
1755–56	*Kötlugia;* 1755 Etna; 1756 Vesuvius	1756–57 1758	America Europe
1759–60	Vesuvius; 1760 Peteroa (Chili)	1761 1762	America, W. Indies "All the World"
1766	*Hecla, Albai (Luzon)*	1767	Europe
1770	Colima	1771–72	America
1772	*Papandayang* (Java), Hecla	1773 1775	" "All the World"
1779	*Vesuvius*, (Captain Cook's ships covered with ashes in North Pacific)	1779–83	Widely spread
1783	*Skaptar Jökull, Asama* (Japan)	1788–90	America
1785	*Vesuvius*	1787–90	Europe, &c.
1790	Vesuvius; 1792–93 Etna	1792–93 1794–95	America British Fleet
1794	*Vesuvius*; 1799 Guatemala; 1803 Cotopaxi; 1805 Vesuvius;		
1807	Merapi (Java); 1808 St. George (Azores); 1809 Etna;		
1811	*Azores*, Vesuvius, Etna; 1812 *St. Vincent*, Vesuvius;		
1813	*Vesuvius*; 1814 *Albai*; 1815 *Tomboro* (Sumbawa);	1797 to 1823	Frequent Visits to different parts of the World
1818	*Goenoing* (Java), Vesuvius, Colima, Hecla;		
1821	*Klutschewskaja-Sopka* (Kamschatka;)		
1821–22	*Eyafialla Jökull*; 1822 *Vesuvius*, *Galung* (Java)		
1826	Tolima (Chili); 1827 Perace (Columbia)	1827	America, Siberia
1830–31	*Etna*;		
1831	*Graham's Island* (Palermo), *Babujan Islands, Pinchincha*	1830–34	
1834	Vesuvius; 1835 *Coseguina, Osorno, Aconcagua*	1836–37	
1841 1843	Mount Regnier	1843	America
1845	*Hecla*; 1846 *Hecla, Amugura* (Fiji)	1847–48	
1850	(February) Vesuvius	1850–51	
1852	Etna; 1855 *Vesuvius*; 1856 Cotopaxi, Japan; 1858 Vesuvius	1855–58	
1862	Vesuvius	1864	Switzerland
1865	Etna; 1866 Santorin; 1867 Iceland, Japan	1867 1867–68	France Peru
1872	*Vesuvius, Merapi* (Java), New Hebrides; 1873 Skaptar Jökull	1874	Cape Breton, England
1883	*Krakatoa, St. Augustin* (Alaska)	1889–92	

NOTE.—The Eruptions of *Awatska* in 1837 and the *Vatna Jökull* in 1875 do not appear to have been succeeded by Influenza Epidemics.

"Most persons will be surprised to find that, after many assurances that the malady is one of the rarest of visitors, Influenza has been amongst us so frequently. Out of the above list, however, the severest epidemics appear to have been those of 1709, 1729, 1732-33, 1742-43, 1758, 1762, 1767, 1775, 1782, 1789-90, 1803, 1822-23, 1830-31, 1837, 1847, 1858, and 1889-92. The most active volcanic period was in the first quarter of the present century, ten eruptions of great violence occurring from 1811 to 1822. Influenza seems to have been wandering about Europe between 1797 and 1823, and in 1819 a Parliamentary inquiry was held, the result being a conflict of opinion on the subject. Between 1750 and 1790 there were a number of the severest type of eruptions, and six widespread Influenza epidemics raged in the period. From 1830 to 1850 was another spell of activity, and three of the worst recorded epidemics occurred in this interval.

"The eruptions which are not classed as of extraordinary violence, were nevertheless in very many cases sufficiently powerful to produce similar phenomena of sky glows and dry fogs over extended regions of the earth, and in other accounts than those catalogued by the Krakatoa Committee the eruptions are often described as tremendous. To enter into details about each epidemic, and the events which preceded it, would occupy a volume of our Journal; I shall, therefore, content myself with presenting the list as it stands, so that those who interest themselves in the matter can easily refer to works which deal fully with the phenomena.

"I would, however, remark that it is necessary to bear in mind that there may be a great difference in the ultimate destination of dust ejected from tropical and that from extra-tropical volcanoes. Near the Equator the atmospheric conditions would favour the rapid distribution of the particles to all parts of the world, whereas a somewhat different arrangement in higher latitudes might tend to keep the dust circulating in one hemisphere only, and possibly within comparatively narrow limits. It does not necessarily follow that because the Krakatoa outburst caused sky glows in New Zealand and in England; that a similarly violent convulsion in Iceland would also produce the same effect in New Zealand.

"Taking a broad view of the materials which I have now placed before the Society, bearing in mind the varying degrees of violence of eruptions; the difference in the volume and in the density of the dust they eject, and the height to which it ascends, and, therefore, the time required for its descent to earth again; the widely-distributive effects of high level atmospheric currents in dispersing quantities of infinitely comminuted particles in every direction and to great distances; and the numerous instances of the unusual haze which seems to accompany catarrhal epidemics, I think we have, if not conclusive, at least very strong, presumptive evidence which points to but one origin for Influenza, and that is volcanic dust. And further, that meteorological conditions—the circulation of the atmosphere in cyclones and anticyclones, upward and downward currents—are essential for spreading the cause of the disease to every quarter of the globe. No other hypothesis can account for the Influenza epidemics of the past two years being as universal as the phenomena which resulted from the Sunda Straits disaster.

"It is highly desirable, therefore, that on all future occasions of volcanic violence observations of a more precise character than have hitherto been thought necessary should be registered. There should be records at places situated as near as possible to active craters from which we could obtain particulars as to the height attained by the ejected materials, the directions in which the clouds of dust are carried, and other things which cannot be seen at great distances. Away from the scenes of disaster a closer investigation of sky glows from their first appearance, spectroscopic and other observations bearing on the character of the material causing the glows, the movements of upper currents, the distribution of pressure as shown by weather charts, the presence of the pale blue mist which has been alluded to, and the changes, if any, in the chemical constitution of the air we breathe, should be undertaken. It is only by so doing that we can hope to obtain direct proofs to decide what is of the very highest importance to the human race. From the scientific standpoint, the question is one which in the first place concerns seismologists. When they anticipate an outbreak of volcanic activity, it is time for meteorologists to be ready for observations of atmospheric events, and when they in their turn can discover signs of the imminent descent of Influenza poison, chemists and the medical profession must be called upon to take up the thread of the approaching change."

DISCUSSION.

Rev. F. W. Stow, in a communication to the Secretary, said :—"At the beginning of January Influenza was very prevalent in the district lying further down the valley (Wensleydale), and from 5 to 10 miles to the east and east-north-east of us. We expected it here, but it did not come. Our doctor told me that he had expected it daily for a fortnight. The wind during this time was generally North-west, blowing off the moors, as also South and South-west winds do. There were 19 observations of wind, West to North inclusive, 3 of North-north-east, 1 of South, 2 of South-west, 4 of calm, up to January 14th, when the wind changed to East, blowing from the infected districts for 5 days. Immediately cases of influenza appeared all over my parish, which covers 40 square miles, and also beyond us, further up Wensleydale to the west, in villages and farms from 3 to 12 miles apart or more. Within a week some 3 or 4 per cent. of the population were seized by it. The cases were mostly not severe, but decided. There have happily been no deaths within my parish.

"Since January 21st the wind has been Westerly.

"Fresh cases have been fewer in number since then, but the epidemic is by no means over (February 11th).

"I am no doctor, and have no theory as to the behaviour of bacilli. I presume that no one doubts that all infection is somehow due to these. I would not venture to doubt that to some extent influenza is communicable from one person to another. I had rather submit the facts, and leave those who understand the natural history of bacteria to explain them.

"But I would just venture to observe that the facts above stated show that it is impossible that the infection could have been conveyed from one person to another so as to invade so large a district *simultaneously*. It must have been in the air, and it looks very much as if it came with the East wind. Both barometer and thermometer were as low before it came as at the time of the outbreak. As far as I can see, the difference in the direction of the wind was the only meteorological condition which differentiated the time of the outbreak from the preceding."

Dr. J. EWART, in a letter to the Secretary, said :—

"The old atmospheric theory of the spread of epidemics has been a very convenient one. The germ theory and more exact methods of research and testing of knowledge, to my mind, explain satisfactorily the origin, germination, development, growth and spread of infectious disorders. The atmosphere and its varying conditions just probably play the same part in retarding or promoting microbic growth and propagation as we know they do in regard to those of the animals and plants."

The PRESIDENT (Dr. Theodore Williams), after expressing the obligations which the Society were under to Mr. Russell and Mr. Harries for their communications, said that both papers were especially interesting because they dealt with different sides of the same question, viz. the origin of influenza epidemics and the means by which they were spread. Mr. Russell had used the material upon which he had based his conclusions in a very able manner, Dr. Parsons's valuable report having, in particular, been skilfully utilised. He (Dr. Williams) was strongly inclined to hold to the idea that contagion was the principal factor in the spread of influenza. There were three considerations which he thought favoured this conclusion. First, influenza did not seem to have any connection with meteorological conditions, and did not appear to be influenced by wind, temperature, or any other of the elements which are included under the term 'weather,' neither were its ravages confined to, or its progress affected by, any particular climate, hot and cold countries, all over the world, suffering alike from the epidemic. Secondly, the spread of the malady clearly followed the principal channels or routes of human intercourse. Thirdly, in places where the population was large, there the disease spread rapidly, while in thinly populated districts the rate of its progress was slow. Another point was, that ports were the first places attacked, the epidemic afterwards appearing in isolated country towns in cases where communications with an infected area had taken place. One peculiarity in connection with the diffusion of influenza was, that when it made its appearance in a house, it frequently happened that nearly the whole of the household fell victims to the malady at once, and were not attacked one by one as was generally the case with other contagious disorders, such as, for instance, scarlet fever. But this perhaps was not so difficult to account for as, at first sight, it appeared to be, for it must be remembered that the incubation period of the germ of this complaint was very short, and further it was quite possible for the individual who had brought the infection into a house to disseminate sufficient microbes to infect three or four, or even more persons. Immunity from infection was principally found among persons who did not mingle in ordinary intercourse. For instance in prisons, it was the warders who were attacked, they having intercourse with the outside world, the prisoners (and particularly those kept in solitary confinement) almost entirely escaping. Similarly in Lunatic Asylums the patients suffered but very slightly, but the majority of the officials became victims to influenza, they having mingled with persons in infected areas outside the institutions with which they were connected. At the Hospital for Consumption at Brompton the epidemic had been severely experienced, but it was the nurses who were first attacked, they, as in the case of the prison and asylum officials, being permitted to visit persons outside the precincts of the institution in which they laboured. At one time, indeed, nearly all the nurses were down with influenza, and the admission of patients to the hospital was suspended for a fortnight in consequence. A considerable number of patients were attacked afterwards, but not in so large a proportion as the nurses were. On the first occasion of its appearance at Brompton, the disease was not regarded as contagious, but in the recent visitation more or less complete isolation of influenza cases was practised, with the result that not nearly so large a number of persons were attacked, nor was the disease of so severe a type as in the first epidemic. Regarding Mr. Harries's theory that the visitations of influenza epidemics were due to the deposition of dust thrown up in volcanic eruptions, he had always understood that in the case of the Krakatoa eruption in August 1883, the dust emitted from the volcano only occupied ten days in encircling the world, and this being the fact, surely the dust shower ought to have become less and less, and the influenza epidemic, if at all connected with it, have commenced much earlier than 1889, and gradually decreased in virulence. Then, too, if influenza was the result of volcanic activity, why should it not extensively prevail in the immediate vicinity of the scene of an eruption, and why should it not be always found in the neighbourhood of volcanoes which were continuously active? For example, the inhabitants of the island of Sicily should be peculiarly liable to influenza epidemics, from the presence of Etna, and those of Naples from that of Vesuvius, but he had never heard that such was the case. If the volcanic dust theory of influenza origin was correct, then no part of the world should be free from the influence of influenza epidemics, but in Dr. Parsons's Report it was shown that the Fiji Islands, which had on previous occasions greatly suffered from epidemics of measles and other complaints, had been exempt from influenza. New Guinea and the Falkland Isles were also free. It was not easy to understand why they should have escaped if the influenza was spread by atmospheric influence.

Dr. LAWSON said that, for the last thirty years, he had paid much attention to the study of epidemics, and he now offered the following remarks on the papers just read. He thought Mr. Harries had missed the point which Dr. Prout had emphasised in connection with his observations on the weight of air in 1832, which was that, after carrying on there (in London) for six weeks, the wind came to East on February 9th, when there was a small though distinct increase of weight, which continued with slight fluctuation for another six weeks while the experiments lasted. Dr. Prout attributed this increase to the diffusion of some matter heavier than air in the lower strata of the atmosphere, and mentioned that the first case of cholera in London occurred immediately after. He (Dr. Lawson) had carried on meteorological observations for ten years to ascertain whether there were any connection between the spread of epidemics and the weather, but he had failed to establish any such relation between them. The expressions "Epidemic Cause," "Epidemic Influence," are merely conventional terms to represent those factors which are engaged in generating and diffusing them, until these factors can be adequately described. Epidemic influence appeared to act in localities where facilities for its development were to be found. Large towns, at a great distance apart, were often similarly affected while isolated country places escaped for some time, and even, occasionally, were entirely exempt. He then entered on the question of how far personal contagion was concerned in the spread of epidemics, and said that unless local conditions could be excluded, communication from man to man could not be established: to illustrate this position he gave the following instance, one of many establishing the same point, he was acquainted with. There was a severe epidemic of yellow fever at Sierra Leone in 1865, and the *Isis*, a receiving ship for the Navy, lying there, had had several fatal cases among those on board in November and December. The *Bristol*, a 50 gun frigate with a crew of 500 men, arrived from England on December 25th, and anchored in the open sea, some few miles from where the *Isis* lay. As it was thought the latter was in an unhealthy position, 116 men and officers from the *Bristol* were sent to her on December 28th and 29th, who removed her to another position; these men returned to the *Bristol* each night without going on shore. Two of them were attacked with yellow fever on December 31st, twenty on January 1st, 1866, and sixteen more up to January 12th, and twenty-one died on board the *Bristol*, and two afterwards at Ascension. Now had those men remained on board the *Isis* it is highly probable the great majority of them would have been attacked within a month, and at least half would have died, and it would have been quoted as a marked case of communication of the disease from man to man; but removal from the *Isis* to the *Bristol* was from the unhealthy locality to a healthy one, and no further spread of the fever took place, no one having been attacked who had not been exposed in the *Isis*. (*Milroy Lectures*, 1888, p. 56.) In none of the numerous appearances of influenza mentioned in Mr. Rollo Russell's paper was any attempt made to separate the local influences at the time, and consequently his conclusions are altogether unreliable. Mr. Harries's theory that the late influenza epidemic was caused by the dust from a volcanic eruption is one which has been frequently advanced, but hitherto the connection between the two phenomena has never been established.

Dr. PARSONS said that Mr. Russell had so thoroughly grasped the facts given in his (the speaker's) Report on the influenza epidemics, that it was unnecessary for him to say anything further concerning the contagion hypothesis. As regarded the volcanic dust theory, he considered that if this idea were correct the epidemic of influenza should have commenced in the immediate vicinity of volcanic action and shortly after the eruption; for much of the dust would soon fall to the ground. Looking down the list of eruptions given by Mr. Harries, it was very noticeable that violent volcanic activity prevailed at least once in every ten years, so that it would not be a very difficult matter to find instances of eruptions which would correspond with the prevalence of influenza epidemics. The rapidity of travel of the epidemic influence had been used as an argument in favour of the theory of atmospheric origin, but it had been clearly shown that the disease did not spread at a faster rate than the movements of human beings from place to place. The case of the outbreak at Aysgarth described by the Rev. F. W. Stow did not appear to be incompatible with diffusion by contagion, as doubtless the farmers attended local markets, and inmates of the various farm-houses were present at the Sunday services in either church or chapel, all of which communication would afford opportunities for the propagation of the disease. Concerning the question of the almost simultaneous attack of whole populaces and households, such occurrences did not appear in the investigation he had made, as it was invariably found that there were a few first cases from which others rapidly spread. In the case of an Industrial School at Southwark, at which the inmates were not allowed out in the streets, influenza did not appear until after it had prevailed for a fortnight among the population around; nor then until the contagion was brought into the school by some of the staff. In Birmingham, too, the inmates of a lunatic asylum were not attacked until a month later than the prisoners confined in the adjoining gaol. Why were they not attacked at the same time? It could hardly be supposed that the volcanic dust descended on one institution and left the other untouched for a time. The incubation period for influenza was very short, sometimes only 24 hours, so that the epidemic spread very rapidly, and at a much greater rate than other infectious disorders, such as small pox, the incubation period of which was twelve days. Taking the incubation period of influenza as two days, and supposing each case to give rise to two others, a very simple calculation showed that at the end of the twelfth day 126 cases would have arisen from the first case, whereas, with small pox, two fresh cases only would have occurred. It was certainly unwise to reason that influenza was not contagious because some persons who were in infected districts escaped, for in the case of other admittedly highly infectious disorders personal susceptibility varied and some persons exposed to contagious influences did not develope the disease. Dr. Barry had shown that during the great epidemic of small pox in Sheffield, in 1887-8, of those persons living in infected households who had not been protected either by vaccination or by a previous attack of small pox, 25 per cent were unaffected by the disease although in such close contact with the contagion. The high rate of mortality from influenza in the agricultural districts did not appear to be due to any greater prevalence of the disorder among people exposed to the open air, but was apparently explained by the fact that a larger proportion of elderly people was to be found in country villages than in towns; influenza being peculiarly fatal to persons of advanced years. He did not pretend to be able to completely explain all the puzzling questions which arose in connection with the recent visitations of influenza, and there still appeared to be some mystery attaching to the development and progress of the epidemics. Influenza was considered to have first appeared in the south-east of England towards the close of 1889, and began to be epidemic in London about January 1st, 1890. In the course of a few weeks it had spread to all parts of the Kingdom, though some remote places in mountainous districts in the north of England, South Wales, and Devonshire, were not attacked until March. This first outbreak seemed to have gradually died out, and influenza was not heard of in an epidemic form until February or March 1891, when it appeared at Hull, whence it spread to the surrounding districts. Early in April a very serious outbreak was experienced at Sheffield and from thence it was believed to have been carried to London by a large number of persons who came to the metropolis for the purpose of giving evidence in connection with a bill before Parliament. Many members of Parliament were early attacked. The epidemic appeared to have commenced in London at about the end of April, and from London as before it spread with great rapidity all over the country. This second epidemic died out during the summer of 1891, although in some localities it could not be said to have entirely disappeared; but in September 1891, influenza again broke out as an epidemic, chiefly in two centres, one in Scotland and the other in the west of England, the Scottish centre spreading southwards, and the infection from the western centre moving in an easterly direction. The third visitation of influenza began in London about December, and soon after Christmas the epidemic extensively prevailed, eventually rapidly spreading over the whole country. In each instance the epidemic, once it had established itself in London, spread rapidly through the country, owing, as the speaker thought, to the frequent communications between all parts of the Metropolis. But besides the contagious nature of the disease, the history given seems to show that some other factor or factors are necessary to account for its epidemic spread at one time and not at another. One of these factors appears to be the aggregation of susceptible persons, with consequent concentration of the poison, but of others the nature is unknown, possibly they may be partly meteorological.

Dr. Althaus said that the mass of evidence which had been accumulated concerning the recent epidemics of influenza had become so complete, that he had no hesitation in subscribing to the theory that the spread of influenza was due to contagion. He narrated an instance of influenza having been brought on board a ship by a first-class passenger, who, while suffering from the complaint, was attended by the ship's doctor and steward, both of whom were subsequently attacked; the infection afterwards spreading over the ship until fully 50 per cent of the crew fell victims to the malady. Interesting instances were also afforded by the caretakers of the Hospices in the Alps, as it had been found that the appearance of influenza among these men, who were placed in such isolated spots, could always be traced to contagion. One hospice, in particular, showed clearly that the outbreak of influenza within the building was due to infection through personal communication with an infected area. On one Sunday a caretaker visited the village below the hospice, returning the same evening. Nine days afterwards one of his companions was attacked by influenza. The doctor was at first considerably puzzled to know how this man had contracted the disease, as supposing the infection to have been brought to the hospice by the caretaker who had visited the village (no other inmate of the institution having had personal communication with the outside world), the influenza should have appeared a week earlier. After some inquiry, however, he found that the suit of clothes worn by the caretaker on the occasion of his visit to the village, were those which he was only accustomed to wear on Sundays. These clothes, in which the infection undoubtedly was, were put away with his companion's, and neither set of garments were worn until the following Sunday, with the result that two days afterwards influenza was developed by the caretaker whose clothes had been in contact with those worn by his fellow caretaker when visiting in the village nine days previously. The staff in charge of the observatory on the summit of the Säntis had all remained in good health because none of them went down the mountain while the epidemic was raging in the districts below. He could not agree that volcanic eruptions produced influenza, for he had been in Sicily when Mount Etna had been in a state of considerable activity, but had not heard of any cases of influenza following the outbreak of the volcanoes. In the Lipari Islands, more particularly in Stromboli, eruptions occurred habitually every five minutes or so, yet influenza appeared to be unknown there.

Dr. W. Bezly Thorne said that he was glad to learn from Dr. Parsons that there was still some mystery surrounding the recent influenza outbreaks. As a medical practitioner he could say that since 1889, there had not been a longer consecutive period than a fortnight during which he had no case of influenza under his care. The variation in the infectiousness of influenza attacks was very puzzling, for now the characteristics of the malady were well known he was perfectly certain that he had treated at least three cases of genuine influenza long before the disease became general in 1889. These patients, too, had themselves recognised their symptoms, and had ventured to inform him that he had mistaken their ailment for some other complaint. The curious point about these cases was that no other person had been infected by them. He could not help thinking that it was possible that some unknown condition of the atmosphere had been at work in epidemic periods assisting in the propagation of the influenza germs.

Dr. T. Gilbert Smith thought that there was something to be said for both the atmospheric hypothesis of the spread of influenza and the theory of its diffusion by contagion. Influenza was, without doubt, a contagious disease, but there appeared to be something more than mere contagion at work to account for the manner in which the epidemic was disseminated. It was well known that the spread of cholera could be traced along the lines of caravan routes, but the propagation of influenza did not appear to have always followed the main channels of human communication. Between Berlin and London, for instance, intercourse was exceedingly frequent, yet although the influenza was raging in Berlin in October 1889, he had only one case of influenza brought under his notice at that time in the eastern district of London where he laboured, and this did not prove to be infectious. If the infection theory was the true explanation of the epidemic character of influenza, then the densely populated localities should have suffered most. Such, however, was not the case, for the inhabitants of the crowded neighbourhood of Whitechapel had not been afflicted in so great a proportion as persons residing in the western end of London, the district in which the last speaker had the privilege of working. Then too, Dublin and Cork, although in frequent and direct communication with London by means of the Irish Mail and other channels of intercourse, enjoyed comparative immunity from the influenza epidemic. There were a good many considerations which led one to hesitate in unreservedly accepting the idea that contagion was wholly responsible for the spread of influenza. It did not follow that because the disease was not evenly distributed over a tract of country that it was therefore not in some measure due to, or influenced by, any atmospheric condition. Atmospheric conditions were by no means evenly distributed, and only the previous evening he had particularly noticed, when traversing the London streets, that, irrespective of any difference in the description of paving, some roads were frozen quite hard, rendering locomotion difficult, while others were damp and soft.

Mr. Symons said that he thought that it was quite possible that some of the dust ejected in the eruption of Krakatoa was still present in the atmosphere. The heavier particles reached the surface of the earth soon after the eruption, and if any were still descending they must be microscopic fragments of pulverised pumice, or minute particles of glass. He certainly could not see why the fall of these exceedingly fine dust particles should produce influenza among the inhabitants of the earth.

Hon. F. A. R. Russell, in reply, said that in the case of the keepers of the Casquets lighthouse, mentioned by Mr. Harries as an instance where influenza broke out without the persons affected having had communication with an infected area, it had been reported that one of the men had a short time previously come from Guernsey, where the epidemic was very severe at the time. He thought there was great difficulty in accepting the view that the dust emitted in the eruption of Krakatoa was able to affect us now, as when the dust reached the region of cloud, rain, and wind, it would soon be brought to the ground, and during the last few years there had been no sign of any unusual constituent of the atmosphere. If volcanic dust could affect humanity in the way suggested by Mr. Harries, then an exceedingly serious epidemic should have been experienced after the great volcanic eruptions in 1783, when Europe was for weeks covered with a dense haze in the lower air. The remarks of Dr. Althaus afforded very interesting evidence of the effect of immediate infection in spreading influenza to remote places. With reference to what Dr. Lawson had said concerning yellow fever in relation to contagion, the material concerned in that malady was capable of thriving in outside soil such as might be found in mud and bilge water, and would be copiously emitted from these media. Influenza did not increase at so great a rate when a strong wind was blowing as when the air was calm; this was probably due to the fact that more air passed through our rooms and ventilation generally speaking was greatly improved in windy weather. Considering the extreme minuteness of the organism, it seems possible that in the organically contaminated air of close places, and in the deposits of vapour on the walls, where the air is impure, it may find a pabulum capable of supporting it for a short time. The rapid spread of influenza from place to place is best explained by a high infectivity of the organism, and its first effective incidence not always on those who have been most exposed to it, but on those who are most highly susceptible.

Mr. HARRIES, in reply, said that the fact that Fiji had not been attacked was not an argument against his theory but against that of infection, for Fiji, being one of the principal ports of call for trans-Pacific traders, ought to have been infected both from Australia and from America. Then again Hull and the northern towns were attacked towards the end of February and beginning of March 1891, yet in spite of almost hourly intercourse with southern towns London was not affected until late in April, a fact which lends itself neither to the wholly infectious theory, nor to the view that the rate at which the disease spreads is proportional to the facilities for intercommunication, the principal towns suffering first. Mr. Russell has adopted these ideas *en bloc*, but the facts do not justify such a sweeping conclusion, according to which the epidemic of 1889 ought to have travelled from St. Petersburg to Vienna, thence to Paris, and across the Channel to Dover and London within a few days. Instead of this we find the epidemic at Brest and at a little out-of-the-way village some miles from Grantham before the three capitals mentioned were affected; it appears simultaneously on the Carnarvonshire coast and in the United States a week or more before London felt it; and influenza prevailed in Honolulu by the time it was beginning to appear in the Channel Islands, and positively a month before Scilly was reached, although the islands at the mouth of the Channel were in constant communication with English and French infected ports. Barbadoes is the 'London' of the West Indies, it is the point for which all ships make with passengers, merchandise, and mails, to be distributed thence by local ships amongst the islands of the Leeward group. But influenza reached Antigua and St. Vincent three months before a case had occurred at Barbadoes, the trade of the island with infected Europe and the infected local islands not having been interrupted in the meantime. Bombay was visited in December, and as was to be expected a convenient ship arrived from England about the same time, but the fact is completely ignored that that vessel must have left our shores before there was the slightest suspicion of the malady having appeared in this country, and possibly before even St. Petersburg was attacked at the close of November. What Mr. Russell's extracts show, and clearly too, is that the epidemic selected its own routes and rates of propagation, neither of which corresponded with the theory of infection pure and simple. The epidemic appeared in Northern Europe in November 1889, its general spread being southwards towards the tropics, reaching Barbadoes in April 1890 and the Gold Coast in May. Similarly New Zealand and Tasmania first felt it in the Southern Hemisphere in March 1890, the disease spreading northwards to the tropics, to New Guinea in June, to St. Helena and Mauritius in August, and Réunion in September. These facts unquestionably point to some other cause than mere infection, and the theory which he (Mr. Harries) now advanced explained this winter season distribution in both hemispheres. Mr. Russell spoke of tracking other plagues from their local cultivation ground, but his paper did not contain a syllable which suggested that he had discovered the local cultivation ground of influenza. As to the objection made by the President and Drs. Parsons and Althaus that influenza is not always present in the vicinity of active volcanoes, he (Mr. Harries) thought that were it otherwise then his theory of diffusion by atmospheric circulation would at once fail. The grosser materials from the craters descend in the neighbourhood within a few minutes or a few hours, and would have no injurious effect on health, while the lighter dust ascending to greater elevations would be quickly wafted away, possibly to undergo important chemical changes during its period of suspension, but it would be in the last degree improbable that it would descend again near the crater which ejected it. Vesuvius and Etna throw out dust (other than in great eruptions) sufficiently high to be scattered in small quantities to most parts of Europe, and according to his (Mr. Harries's) theory odd cases of true influenza should be consequently of comparatively frequent occurrence, taking Europe as a whole, more frequent perhaps than even the medical profession is aware of, but of course epidemics like those of 1889-92 would require great eruptions to supply the necessary pabulum to affect the whole world. With reference to Mr. Symons's doubt about Krakatoa dust being the cause of any illness, it would suffice to remind him of the thousands of Londoners who succumb every winter because of a little extra burnt coal dust in the atmosphere.

NOTE ON A LIGHTNING DISCHARGE AT THORNBURY, GLOUCESTERSHIRE, JULY 22nd, 1891.

By ERNEST H. COOK, D.Sc. (Lond.)

[Received December 16th, 1891.—Read February 17th, 1892.]

On July 22nd, 1891, the district of Thornbury, in Gloucestershire, was visited by three severe thunderstorms. The first of these occurred at about 6 a.m., the second at 2.30 p.m., and the third at 4 p.m. Each storm came from the west and proceeded to the east. The velocity was moderately high, and it was a peculiarity that, as far as the district in question is concerned, only one vivid flash was observed in each storm. During the progress of the second storm the tree represented in the photographs shown to the meeting was struck. Before reaching the tree the storm passed over an almost perfectly flat low-lying district between Chepstow and Thornbury.

The tree was a young oak about 50 feet high, and in full and vigorous growth. It measured 5 feet 9 inches in girth at the base, and 5 feet 3 inches at a height of 6 feet from the ground. The lowest branch left at a height of 7 feet. The sister tree, still standing, is at a distance of 16 yards, and a smaller tree is at a diagonal distance of 13 yards, the hedges between meeting at right angles. Twenty-five yards behind, but to the south, is a plantation containing many individual members of greater height. A small ditch containing water runs at the base of the tree in question and its sister tree, and forms the boundary of two fields; its course lying due north and south.

A very intelligent young farmer who saw the occurrence states that he saw the tree fall *before* he saw the lightning. This did not appear to come from the clouds, but straight over the tree, and looked like a ball of fire and not a flash. The noise of the thunder was tremendous, and heavy rain immediately followed. He was at work in a rick barton at a distance of about 60 yards, with a knife in his right hand, and experienced a violent tingling sensation in his right arm which lasted for about two hours after the shock. The branches were torn off the tree at the places where they left the trunk. The trunk was entirely stripped of its bark, which was scattered in small pieces in all directions around to considerable distances, and at the same time was split longitudinally in innumerable places. These splits are more or less parallel and run from the outside to the central pith. They are of all degrees of size, from an opening of 6 inches to a hair split. Although the trunk was completely stripped of bark, the branches were not touched.

The discharge illustrates what may be called the vagaries of lightning, for, although separated by a distance of only a few yards from a similar tree of the same height, this second tree is quite uninjured. Neither can we regard the discharge as taking the most prominent object on the landscape, for at a short distance (25 yards) to the south-west is the wood containing numerous trees of very much greater height. The explanation of this, however, is probably to be found in the circumstance of the ditch at the base of the tree. There is no water at the base of the taller trees, and, therefore, they were not selected as the conducting channel.

The entire removal of the bark from the main trunk, and its splitting, while the branches, except being torn off, are apparently uninjured, indicates that little resistance was experienced to the passage of the electricity until the junctions of the branches and trunk were reached, but that at these points the insufficient conducting power of the trunk caused an enormous opposition which could only be overcome by the tearing away of the branches, the splitting of the trunk, and the removal of the bark. The dried-up cells of the outer layer of this bark were deficient in conducting power, but the young moist cells of the inner layer contained the necessary fluid, hence the selection of this path by the electricity, and the entire removal of the bark. The splitting indicates the passage of the electricity through the wood from this layer to the central pith, which with its cells full of fluid affords an extra conducting passage to the water at the base.

The appearance of the flash, as described, seems to indicate that the discharge was what is known as "globular." The falling of the tree, before the flash was observed, is an interesting feature. I have carefully questioned the observer, and can find no reason whatever to doubt the correctness of the statement.

Attention is directed to the lateral shock felt at a distance of 60 yards as a point of some interest.

PROCEEDINGS AT THE MEETINGS OF THE SOCIETY.

JANUARY 27th, 1892.

Ordinary Meeting.

DR. W. MARCET, F.R.S., Vice-President, in the Chair.

The following resolutions were proposed by the CHAIRMAN and agreed to:—

1. "That this Meeting desires to record its profound sorrow for the great loss which Her Most Gracious Majesty the Queen and the Nation have sustained in the death of H.R.H. The Duke of Clarence and Avondale, and to express its fervent hope that the knowledge of the universal sympathy felt by her subjects may tend to soften the sorrow which has fallen on Her Majesty."

2. "That this Meeting desires to record its profound sorrow at the great and sudden blow which has fallen on Their Royal Highnesses the Prince and Princess of Wales in the death of H.R.H. The Duke of Clarence and Avondale, and its hope that the knowledge of the universal grief and sympathy which have been felt and expressed in all parts of the world may in some degree tend to alleviate their affliction."

3. "That copies of the above resolutions be sent to Her Majesty and Their Royal Highnesses respectively."

NATHAN RAW, M.D., B.S., The Infirmary, Bolton, was balloted for and duly elected a Fellow of the Society.

JANUARY 27th, 1892.

Annual General Meeting.

DR. W. MARCET, F.R.S., Vice-President, in the Chair.

Mr. W. M. BEAUFORT and Mr. H. HARRIES were appointed Scrutineers of the Ballot for Officers and Council.

Mr. SCOTT read the Report of the Council and the Balance Sheet for the past year (p. 68).

It was proposed by the CHAIRMAN, seconded by Mr. SCOTT, and resolved:—"That the Report of the Council be received and adopted, and printed in the *Quarterly Journal.*"

It was proposed by Dr. WILLIAMS, seconded by Mr. MAWLEY, and resolved:—"That the best thanks of the Royal Meteorological Society be communicated to the President and Council of the Institution of Civil Engineers for having granted the Society free permission to hold its Meetings in the rooms of the Institution."

It was proposed by Mr. R. W. P. BIRCH, seconded by Mr. M. JACKSON, and resolved:—"That the thanks of the Society be given to the Officers and other Members of the Council for their services during the past year."

It was proposed by Mr. B. WOODD SMITH, seconded by Mr. F. B. EDMONDS, and resolved:—"That the thanks of the Society be given to the Standing Committees and to the Auditors, and that the Committees be requested to continue their duties till the next Council Meeting."

Owing to the absence through illness of the President, Mr. BALDWIN LATHAM, his Address on "Evaporation and Condensation" was read by Mr. Symons (p. 53).

It was proposed by Mr. EATON, seconded by Mr. INWARDS, and resolved:—"That the thanks of the Society be given to the President for his services during the past year, and for his Address, and that he be requested to allow it to be printed in the *Quarterly Journal*."

The Scrutineers declared the following gentlemen to be the Officers and Council for the ensuing year.

President.

CHARLES THEODORE WILLIAMS, M.A., M.D., F.R.C.P.

Vice-Presidents.

ARTHUR BREWIN.
WILLIAM HENRY DINES, B.A.
BALDWIN LATHAM, M.Inst.C.E., F.G.S.
HENRY SOUTHALL.

Treasurer.

HENRY PERIGAL, F.R.A.S., F.R.M.S.

Trustees.

HON. FRANCIS ALBERT ROLLO RUSSELL, M.A.
STEPHEN WILLIAM SILVER, F.R.G.S.

Secretaries.

GEORGE JAMES SYMONS, F.R.S.
JOHN WILLIAM TRIPE, M.D., M.R.C.P.Ed.

Foreign Secretary.

ROBERT HENRY SCOTT, M.A., F.R.S.

Council.

FRANCIS CAMPBELL BAYARD, LL.M.
ALEXANDER RICHARDSON BINNIE, M.Inst.C.E., F.G.S.
GEORGE CHATTERTON, M.A., M.Inst.C E.
ARTHUR WILLIAM CLAYDEN, M.A., F.G.S.
WILLIAM ELLIS, F.R.A.S.
CHARLES HARDING.
RICHARD INWARDS, F.R.A.S.
ADMIRAL JOHN PEARSE MACLEAR, F.R.G.S.
WILLIAM MARCET, M.D., F.R.S., F.C.S.
HENRY JOHN MARTEN, M.Inst.C.E.
EDWARD MAWLEY, F.R.H.S.
WILLIAM BLOMEFIELD TRIPP, M.Inst.C.E.

FEBRUARY 17th, 1892.

Ordinary Meeting.

Dr. C. THEODORE WILLIAMS, President, in the Chair.

CAPT. DAVID S. CROMARTY, 3 Pendennis Street, Anfield, Liverpool;
ROBERT GODFREY, Assoc.M.Inst.C.E., King's Heath, Birmingham;
CHARLES SHAPLEY, 11 Strand, Torquay;

EDWARD JAMES SMITH, Park Royd, Halifax ;
EDMUND KIRBY SPIEGELHALTER, Norton, Malton, Yorks ;
REV. HERBERT STEWART, Nidderdale, Exmouth ; and
REV. WALTER E. STEWART, M.A., Elcott House, Hurworth, Darlington,
were balloted for and duly elected Fellows of the Society.

The following letter was read :—

"Marlborough House.

"Sir Francis Knollys is desired to convey to the Council and Fellows of the Royal Meteorological Society, the sincere thanks of the Prince and Princess of Wales for the sympathy they have expressed on the occasion of their Royal Highnesses' bereavement.

"5th February, 1892."

The following Papers were read :—

"REPORT ON THE PHENOLOGICAL OBSERVATIONS FOR 1891." BY EDWARD MAWLEY, F.R.Met.Soc. (p. 99.)

"THE UNTENABILITY OF AN ATMOSPHERIC HYPOTHESIS OF EPIDEMICS." BY THE HON. F. A. ROLLO RUSSELL, M.A., F.R.Met.Soc. (p. 124.)

"THE ORIGIN OF INFLUENZA EPIDEMICS." BY HENRY HARRIES, F.R.Met.Soc. (p. 132.)

"NOTE ON A LIGHTNING DISCHARGE AT THORNBURY, GLOUCESTERSHIRE, JULY 22ND, 1891." BY ERNEST H. COOK, D.Sc. (p. 143.)

CORRESPONDENCE AND NOTES.

REMARKABLE METEOROLOGICAL PHENOMENON OBSERVED AT MANICALAND, EAST AFRICA, DECEMBER 9th, 1891. By LORD DEERHURST.

ON the evening of December 9th, 1891, I was rowing down the Pungwe river, Manicaland, Portuguese East Africa, with two friends, Mr. Bobbert of Mpanda, and Mr. Armytage of America, when at 6 p.m. or thereabouts, just before sunset, the moon having risen, and being almost directly overhead, we saw what, I thought, might prove of interest, as none of us had ever seen the like before.

From the east we noticed a light blue streak in the sky very little darker than the blue of the heavens ; it was narrow at first, but gradually became broader and extended, getting darker as it did so (it got darker from the east, the densest part being in the east horizon), eventually passing between us and the moon, and being lost in the west at the point where the sun was going down. This streak seemed quite transparent, and deepened, when fully up, from a very light blue in the west to almost indigo in the east.

It passed, seemingly, between us and the clouds, and you could distinctly see them through it, also the moon. In fact it was as if one were looking through coloured spectacles or a veil at the heavens above.

The clouds in the sky were few, in the west they were white, and in the east there were some of the most beautiful grey ones that I have ever seen. The sunset was extremely fine.

After sunset the streak, which was about double the breadth of a rainbow, disappeared as it had come, and as it did so, left in the sky what looked like an aurora borealis, but of a heliotrope colour, and as night came on this disappeared and the sky was covered with white clouds, small undulating ones, which became thicker.

This may or may not prove of interest, but we were much struck with it.

Our position on the map was about 20 miles north-west of Beira, which is about lat. 19° S., long. 35° E.

THUNDERSTORM AND FOG, APRIL 17TH AND 18TH, 1892, AT MALPAS, CHESHIRE. By REV. C. WOLLEY DOD.

ON the evening of April 17th (Easter Sunday) between 9.45 and 10.15 several peals of thunder were heard eight or ten miles to the west in the direction of Ruabon and Wrexham. The wind for the last three days had been very variable, differing at different elevations. On the 17th it seemed nearly uniform and decided from North-north-west. This morning, 18th, there was snow from low clouds till noon. Then the clouds lifted, and a remarkable low drifting fog, reaching to 4 feet above the ground, advanced in a well defined line at about 4 miles an hour from south-west, leaving half-an-hour later in the opposite direction in an equally well defined line. This lower south-west current rapidly veered, and now (at 1.30 p.m.) the upper clouds are again north-west, the lower clouds being from west.

SUNSHINE IN THE BRITISH ISLES DURING THE TEN YEARS 1881-1890.

THE Meteorological Council have recently issued a work *Ten Years Sunshine in the British Isles*, 1881-1890, giving the results for each month of the working of the Campbell-Stokes Sunshine Recorder at some 46 stations. The tables give the total sunshine recorded, and also the percentage of the possible amount for each month. The tables would have increased in value if the yearly amounts had also been given.

The general results of the discussion appear to be :—

1. That the sea coast receives more sunshine than the inland parts of the country. This is natural, as the sea coasts are low, as a rule, and clouds form inland where the ground rises to hills.

2. Large manufacturing cities, like London and Glasgow, cannot fairly be compared even with stations in their immediate neighbourhood, particularly in winter. This is evidently due to smoke, which possibly affects to a certain extent all town records.

3. The south and west coast stations, and especially the Channel Islands, are particularly favoured in almost all months of the year. Jersey is the only station recording in any month, on the mean of the 10 years, an average of even one half of its possible duration of sunshine ; 52 per cent. was registered there in May, and 55 per cent. in August. The highest figure for any other station was only 48 per cent.

4. The east coast of Great Britain, as represented by Aberdeen, Geldeston, and Hillington, is comparatively sunny. In the case of Aberdeen, this is evidently due to the position of the observatory with the high Braemar mountains on its western side.

5. In the summer and early autumn the north-west of Ireland, and of Scotland with the Orkneys, receive very little sunshine.

6. In the late autumn Ireland generally receives more sunshine than most of England.

During the period under investigation, the month in which most sunshine was recorded over the United Kingdom was May 1882. In that month at least 50 per cent. of possible duration was registered at 33 stations, being 25 in England and Wales, 5 in Ireland, 1 in Scotland, 1 in the Isle of Man, and 1 in Jersey. The mean of all these stations gave 55 per cent. ; the highest figure was 61, and this was reached at Southbourne and Geldeston.

June 1887, Her Majesty's "Jubilee" month, was nearly equal to that just described ; 50 per cent. was registered at 24 stations, being 17 in England, 5 in Ireland, 1 in the Isle of Man, and 1 in Jersey. The mean of all these stations was 56 per cent. The highest figure was 68 (Falmouth), and this was followed closely by Plymouth with 65.

The months of July and August 1887 were also very cloudless, at least southern and eastern England. For these districts, therefore, the summer 1887 was exceptionally sunny, but no station in Ireland or over England north of latitude 52° (except Aspley Guise, Cambridge, Geldeston and Hillington) registered 50 per cent. after June. In July 17 stations surpassed 50 per cent.

the average of these was 56, and the highest record 60 per cent. at Southampton and Jersey. In August 14 stations exceeded 50 per cent., being the same stations as were cited for July with the exceptions of Greenwich, Glynde, and Cambridge, which fell short of 50. The average of the 14 stations was 58. The highest record was, as in July, at Jersey, and was 68. Falmouth was only 1 per cent. less, 67.

Silver Thaw at Ben Nevis Observatory.

Mr. R. C. Mossman has discussed the phenomenon of silver thaw, or rain falling when the air is below the freezing point and congealing when it falls, which is somewhat of common occurrence at Ben Nevis Observatory. He says that "a prolonged fall of silver thaw occasioned considerable inconvenience to the observers. Outside objects became covered with several inches of solid uncrystalised ice, through which their original outline could be but faintly distinguished. The chimneys of the observatory became choked with ice, and as the ladder leading to them was in these circumstances impassable, the whole being frozen into a solid mass, the observers had to endure the discomforts of back draughts until a thaw came, when the ladder could be cleared without destroying the woodwork. The rain froze on the observers' coats, gloves, and even on their faces, and thus, the taking of outside observations was very disagreeable. By far the most serious effect of a fall of rain with a temperature below 32° was the choking up of the Stevenson Thermometer Screen. The log book of the observatory teemed with such entries as "Louvres of Stevenson Screen badly choked with ice," &c. ; under these circumstances a fresh box was put out, the other being brought in to be thawed.

In the six years 1885-90, 198 cases of silver thaw were observed, lasting, on an average, 4½ hours each. In December, January, and February, the average duration of each case was 6 hours, whereas during the other months of the year it did not continue more than 3 hours. Silver thaw was almost wholly confined to the winter months, nearly all the cases occurring from November to March.

With the view of ascertaining under what weather conditions silver thaw took place, an examination was made of the daily weather charts for the 190 days on which the cases were observed, with the result that on 137 days the distribution of pressure was cyclonic and on 61 anticyclonic. The mean duration of the cyclonic cases was 8·2 hours, and the anticyclonic 7·6 hours. In anticyclonic conditions there was a cyclone central off the north-west coast of Norway, while the centre of the anticyclone was over the south of England and Ireland, but it was rarely central so far south as France. In cyclonic cases Ben Nevis was distinctly within the area of low pressure, the centre of which was off the north-west coast of Norway, while the anticyclone was more to the south over the Iberian Peninsula. The lowest temperature at which this phenomenon took place was 18°. It was of rare occurrence below 27°, fully 90% of the cases occurred between 28° and 31°·9, hence the greater number of cases occurred just before thaw.

The winds were almost wholly confined to the western half of the compass, the mean velocity under cyclonic conditions being 21 miles per hour, and under non-cyclonic 17 miles per hour. An examination of storm charts for the day of silver thaw, as observed on Ben Nevis, disclosed a somewhat remarkable fact that 73% of the cyclonic and 63% of the anticyclonic cases of silver thaw at Ben Nevis were followed or preceded by gales at several stations on the north and north-west of Scotland.

RECENT PUBLICATIONS.

American Meteorological Journal. A Monthly Review of Meteorology and Medical Climatology. January 1892. Vol. VIII. No. 9. 8vo.

Contains among other information :—The verification of Weather Forecasts : by Prof. H. A. Hazen (4 pp.).—The mountain meteorological stations of the United States : by A. L. Rotch (10 pp.). The author gives a description of the following observatories: Mount Washington, New Hampshire, 6,280 feet abo the sea: Blue Hill, ten miles south of Boston, Mass., 640 feet; Pike's Pe Colorado. 14.134 feet; and Mount Whitney, California, 11,600 feet.—Durat and intensity of rainfall at Rochester, N.Y., and vicinity: by E. Kuichli (13 pp.).

ANNUAIRE DE LA SOCIÉTÉ MÉTÉOROLOGIQUE DE FRANCE. 1891. Octob November. 4to.

The principal paper is:—Étude sur les relations du gradient et de la force vent appliqué à la prévision du temps: par G. Guilbert (17 pp.). The excess wind over the average being followed as a consequence by an excess of press is a most remarkable phenomena. The scientific explanation of this might, author believes, serve as a foundation for new theories, but his incapacity in s complicated matters will not allow him to attack the question, so he merely p forward an hypothesis. This hypothesis would be to observe in the case of e excess of wind the resultant of a contest between two opposite forces, t cyclones and the anticyclones, both subject to movements often contrary direction. It is then evident that the simultaneous and comparative study a examination of isobaric charts, and of cloud movements, would be most adva tageous. and would certainly yield splendid results. The combination of t two methods is indispensable for forecasts embracing every meteorological ph nomenon.

JOURNAL OF THE SCOTTISH METEOROLOGICAL SOCIETY. Third Series. No VIII. 8vo. 1892.

This contains several papers relating to the meteorology of Ben Nevis, viz 1. Silver Thaw: by R. C. Mossman (see p. 149.).—2. Preliminary Notes on observations of Dust-particles: by A. Rankin (8 pp.). The greatest amount of dust occurs in the spring months, when Easterly and South-easterly winds are most prevalent both at sea level, and also on Ben Nevis.—3. The influence of high winds on the barometer: by Dr. Buchan (5 pp.).—4. Certain relations of pressure and temperature at the Ben Nevis Observatories: by Dr. Buchan (3 pp.). The object of this investigation was to ascertain the differences of atmospheric pressure, reduced to sea-level, which accompany differences of temperature, as observed at the observatories on the top of Ben Nevis and at Fort William. The author finds that when the higher observatory has the higher temperature, and when the differences of temperature at the two observatories are small, then the reduced pressure at the top of the mountain is the greater of the two; but when the differences of temperature are very large, then the reduced pressure at the top is the less of the two.—Contribution to the meteorology of Central Africa: by Dr. Buchan (4 pp.). This gives the results of observations made at Fwambo, 40 miles south-east of Lake Tanganyika, from November 1887 to January 1888, and at Kavala Island, on Lake Tanganyika, from June 1889 to May 1890, by the Rev. R. S. Wright.—Influenza and Weather of London in 1891: by Sir A. Mitchell and Dr. Buchan (6 pp.).

METEOROLOGISCHE ZEITSCHRIFT. Redigirt von Dr. J. HANN und Dr. G. HELLMANN. January to March 1892. 8vo.

The principal articles are:—Alexis v. Tillo: Die Vertheilung des Luftdruckes im Gebiete des Russischen Reiches und des Asiatischen Kontinentes auf Grund der Beobachtungen von 1836-85 (11 pp.). This is a summary by Dr. Köppen of General von Tillo's great work which appeared last autumn. It is unfortunately inaccessible to most English readers, being in Russian with a very short abstract in French. The book appears as Vol. XXI. of the Memoirs (Sapiski) of the Russian Geographical Society. It treats of the pressure for the half century 1836-85, and deals with the records by lustra. The text is accompanied by an atlas of 69 maps, which, at least, are internationally intelligible. Meteorologists will be very grateful to Dr. Köppen for the pains he has taken to inform them of the contents of this great work.—Stadtnebel und ihre Wirkungen: von W. J. Russell (9 pp.). This is a translation of Dr. Russell's Fog Paper which appeared in *Nature*, November 1891.—Die Wärmestrahlung der atmosphärischen Luft: von Dr. W. Trabert (6 pp.). This is an attempt to ascertain the amount of heat conveyed to, and lost by, the atmosphere by radiation, irrespective, of course, of insolation.—Die Veränderlichkeit der Temperatur in Oesterreich: von Dr. J. Hann (27 pp.). This is an abbreviated edition of Dr. Hann's great paper on Temperature Variability.—Ein neues Instrument zur Bestimmung von Dampfspannungen bei niedrigen Temperaturen: von K. Sonden (8 pp.). This is an apparatus which is intended for physical experiments, not for meteorological observations. It was first constructed to test the humidity of the air contained in the pores of building materials, but it serves very well to test the determinations of humidity made by any hygrometers below the freezing point.

THE RAINFALL OF JAMAICA. Thirteen Maps showing the Average Rainfall in each Month and during the Year. With explanatory text. By MAXWELL HALL, M.A., Jamaica Government Meteorologist. (Special Publications of the Institute of Jamaica. No. I.). Foolscap folio. 1891.

These maps are based upon rainfall registers kept at 153 stations in Jamaica, from about 1870 to the end of 1889. The north-eastern and northern divisions of the island have winter rains in November, December and January, and the north-eastern and west central divisions have summer rains, while the southern division is dry, having rains for the most part only during the May and October seasons. The yearly rainfall varies from thirty to thirty-five inches in a few places to over one hundred inches in the north-eastern division.

REPORT OF THE BRITISH ASSOCIATION FOR THE ADVANCEMENT OF SCIENCE. 1891. Cardiff Meeting. 8vo. 943 pp. 1892.

This contains several papers on meteorological subjects, among which may be mentioned the following:—Report of the Committee on Meteorological Photography (10 pp.).—Report of the Committee on the Meteorological Observations on Ben Nevis (7 pp.).—Report of the Committee on the Seasonable Variations in the temperatures of lakes, rivers, and estuaries (58 pp.).

SYMONS'S MONTHLY METEOROLOGICAL MAGAZINE. February-April 1892. Vol. XXVII. Nos. 313-315. 8vo.

The principal articles are:—Town Fogs (9 pp.). This is a comparison of the fog records at Brixton and Westminster and Camden Square, which shows that there are nearly three times as many fogs at the former places as at Camden Square. This article led to some correspondence on the subject from Mr. F. J. Brodie, Mr. J. W. Scott, Mr. A. Brewin, and Rev. J. Slatter.—The severe frost of February 1892 (5 pp.). On the morning of the 17th the greatest cold was near the centre of England, the temperature at Loughborough falling to—0°·5; and on the 19th it was even colder in the north of England and the south of Scotland, the lowest temperatures being—2°·0 at Newton Reigny, Penrith, and —6°·2 at Norton, Malton.

WING POSITION OF THE PHENOLOGICAL STATIONS, 1891.

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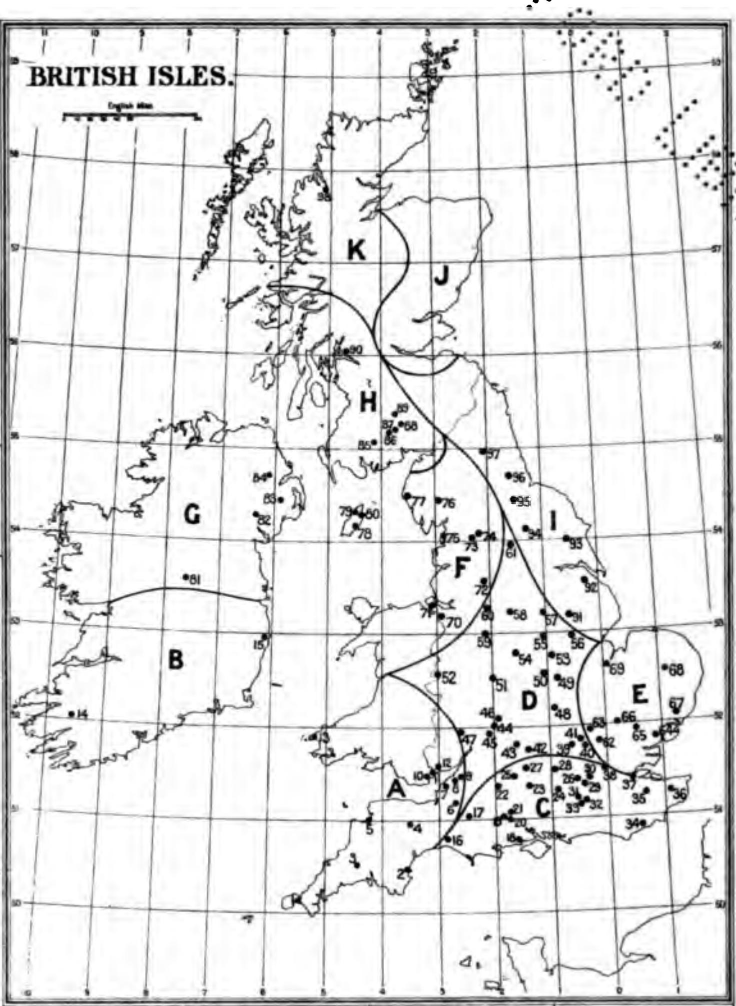

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F.

70. *Chester*
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73. *Settle*
74. *Giggleswick*
75. *Claughton*

F. Continued

76. *Ambleside*
77. *Egremont*
78. *Douglas*
79. *Orry's Dale*
80. *Ramsey*

G.

81. *Edgeworthstown*
82. *Loughbrickland*
83. *Saintfield*
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H. Continued

88. *Thornhill*
89. *Jardington*
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91. *Doddington*
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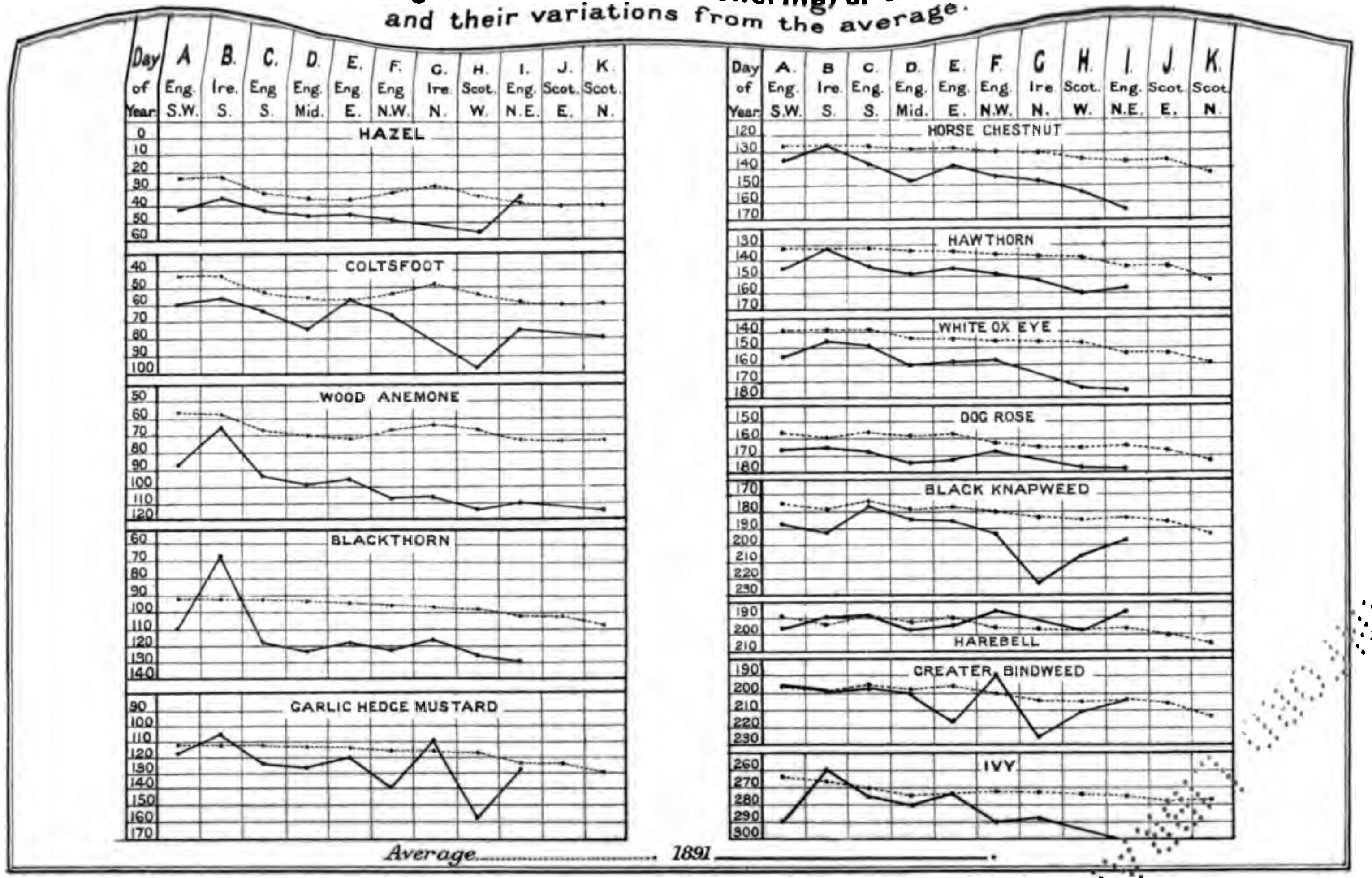


QUARTERLY JOURNAL

OF THE

ROYAL METEOROLOGICAL SOCIETY.

VOL. XVIII. JULY 1892. No. 83.

THE VALUE OF METEOROLOGICAL INSTRUMENTS IN THE SELECTION OF HEALTH RESORTS.

An Address delivered to the Royal Meteorological Society, March 16th, 1892.

By C. THEODORE WILLIAMS, M.A., M.D., F.R.C.P.,
PRESIDENT.

...OLOGY is undoubtedly the basis of all sound climatology; and the ...f a patient observation of temperature, of moisture, of air pressure, ...ind, for a series of years, are the best foundation for the claim of a ...ofessing to be a sanitarium; but we must bear in mind that we ...only to record scientific observations on the meteorological elements, ...w conclusions from them, and to apply these to the practical needs ...s.

...Address is to introduce an Exhibition of Instruments relating to ...r, I propose to say a few words on the great importance of these, ...t out what help we may fairly expect from them in such studies.

Thermometers, maximum and minimum.—The thermometer is the great foundation of climate selection and classification, though its results are greatly modified by other meteorological conditions, such as air currents and moisture. The mean winter temperature of a health resort is important, but what is most important is the temperature of the air during the hours when it is requisite that the invalid should take exercise, the night temperatures being of less consequence, as the patient can be rendered independent of these by good housing and artificial warmth. The great object to be kept in view for all forms of disease likely to be benefited by climatic treatment being that the climate should admit of outdoor exercise, active or passive, during the hours of daylight. An additional requisite would be, though this cannot always be insisted on, the possibility of sitting or reclining out of doors for prolonged periods.

The next point of information which the thermometer furnishes is whether the climate is one of more or less equability, or one of great extremes, due to radiation. Both these conditions have their medical uses, but are not suited to the same cases. The first class generally owe their equability to the addition of some influence tempering the sun's rays, derived either from the neighbourhood of the sea, or from a large amount of moisture present in the atmosphere, or from both of these influences. Moisture tempers extremes in two ways, firstly by diminishing the power of the direct sun rays, and secondly by forming a vaporous covering to the earth, and in this way obstructing terrestrial radiation and reflecting the heat back to the earth again.

As an example of this compare the thermometry of Madeira, the type of a warm equable climate, where the mean daily range does not exceed 11°, with that of Cairo, a desert climate marked by great radiation, where the difference between day and night temperatures is about double that of Madeira; and this contrast is still more marked in the desert itself, in the neighbourhood of Luxor, where Dr. Marcet has recorded a fall of 17° or 18° after sunset. Madeira owes its equability to the combination of low latitude with its ocean environment, and its comparatively small size causes this marine influence to be felt throughout the island. Cairo is a dry inland climate, where there is practically no marine influence to check the fall of temperature from radiation, though the Nile, which absorbs heat in the daytime and gives it out at night, exercises in its immediate neighbourhood some slight influence in arresting the fall of temperature. In the desert in the winter the maximum may be 83°, and the minimum may be 38° in the same 24 hours.

In the Exhibition there are two minimum thermometers, an earth thermometer by Mr. Symons, a recording thermometer or thermograph by MM. Richard, and an ingenious pneumatic thermometer for recording temperatures at a distance, a Stevenson screen with the usual instruments, and Mr. Wallis's cage for exposing meteorological instruments under a thatch shelter in stations in Tropical Africa; for the Dark Continent's climatology, as well as its geography, is to be conquered.

We have several patterns of the Solar Radiation Thermometer exhibited, two being recording ones, and it may be well if meteorologists turned their attention to inventing a more accurate instrument, as Mr. Whipple informs me that the readings of the present one are not always trustworthy, and yet we have great need of information on the subject of solar radiation.

The Sunshine Recorder is our best method of accomplishing this at present, and it certainly gives some indications of the hours that an invalid may select for exercise. When he looks through the charts of the Campbell-Stokes excellent instrument he can see how far he has availed himself of his sunshine opportunities, and how far he has neglected the golden moments. It is a great pity that this valuable instrument is as yet so little utilised at health resorts.

The Whipple-Casella Sunshine Recorder is furnished with divided latitude and declination circles to be set for any locality and any day of the year.

In the Exhibition we have three patterns of Jordan's Sunshine Recorder, by which the sun's rays are printed on cyanotype paper. McLeod's Photographic Sunshine Recorder is something of the same type, and so is Sir Henry Roscoe's Chemical Photometer, in which the definite effect of daylight on prepared paper is calculated to seconds.

There are also specimens of Herschel's and Hodgkinson's Actinometers, where time is considered one of the elements for ascertaining the absolute heating effect of the sun's rays, as they are made to fall for one minute on the bulb of a thermometer filled with blue fluid, and the rate of expansion noted.

In Pouillet's Direct Pyrheliometer the sun's rays fall on a cylinder of steel of known capacity, filled with a certain quantity of mercury, in which a thermometer is introduced, and the calculation is made on the number of degrees the sun's heat raises the mercury in five minutes.

Southall's Helio-Pyrometer is a modification of the surroundings of the black bulb solar radiation thermometer.

What degrees of heat and cold are beneficial to the human system is one thing, and what degrees it is capable of sustaining without destruction is another. It has been shown that inhabitants of temperate climates can bear great extremes of temperature, both hot and cold, provided the atmosphere be still and dry. Arctic travellers have withstood an astonishing amount of cold with impunity. Captain Parry noted the thermometer as low as $-55°$ F., or 87° below freezing point.. Sir John Franklin observed $-58°$, or 90° below the freezing point, and Sir George Back $-70°$, or 120° below. In all these cases the atmosphere was perfectly still, or life would probably have been impossible. Sir John Richardson[1] states that in his last Arctic Expedition, he was accustomed to go from his sitting room at a temperature of 50° to his magnetic observatory at a short distance from it, without feeling it necessary even to put on a great coat, though the temperature of the external air was $-50°$, a difference between the two atmospheres of 100°. Sir John Richardson attributed the absence of chilling influence to the dryness and stillness of the air.

[1] *Carpenter's Human Physiology*, 5th edition, p. 411.

In North America, it is not uncommon during the winter for mercury to freeze, but life is carried on most actively all the same. At Davos and in the Engadine the thermometer falls in winter nights as low as $-11°$ and $-13°$, yet it is the custom for invalids to sleep with open windows and apparently without harm.

If the exposure to great cold be of long duration, the circulation and heat generating powers are lowered, unless largely sustained by warm clothing and abundant food, and in time these aids fail, and the superficial blood-vessels become contracted and no longer admit of the passage of blood corpuscles, and thus all physiological and chemical changes become arrested. The extremities are starved, and death of the fingers and toes takes place through frost bite and gangrene. The general symptoms take the form of great lassitude and langour, with a strong tendency to slumber, but if the individual yields to this inclination and sinks into a sleep it often proves his last one. Death generally occurs by coma. In other cases a low delirium sets in with incoherence and thickness of speech, and the symptoms are often mistaken for those of intoxication, to the great detriment of the unhappy sufferer.

In cold climates a large amount of carbo-hydrates, in form of oil, fat, butter, and blubber, are necessarily consumed to maintain the temperature of the human body, but such is the wonderful power of equilibrium of the thermic process that in the most frigid climes, except when death takes place from cold, the standard of human body heat is maintained equally as in temperate climates. And for the same reason the influence of great heat, apart from sunshine, on the human body, does not show itself in material rise of temperature, provided perspiration be free and abundant. Messrs. Blagden and Fordyce[1] bore a temperature of 280° F. in an oven, with only a rise of 2¼°, as long as the air was dry and the skin perspiring, but when the air became moist, and evaporation was by any cause obstructed, their body heat rose 8°. The effect of excessive solar heat has been shown in the form of *insolatio* or sunstroke, but that of heat in the shade on the human body, according to Rattray,[2] is to cause a slight increase in the body temperature, amounting in the tropics to from 2° F. to 1°·2 F., the maximum being reached in the afternoon. He also found that in persons passing from a cold to a hot climate, there was a reduction in the respiration rate from 16·5 per minute in England to 12·74 in the tropics, accompanied by a slight spirometric increase but not enough to compensate for the diminished number of respirations. Less carbon in the form of carbonic acid and water is exhaled from the lungs in hot climates, and the late Professor Parkes[3] showed that those organs after death are found to be lighter in Europeans in India, than is the case in Europeans in Europe, probably in consequence of this diminished use of the lungs.

The power of digestion is lessened and the desire for animal food diminished,

[1] *Philosophical Transactions*, 1775.
[2] *Proc. Royal Soc.* 1869-72.
[3] *Practical Hygiene*, 4th edition, p. 402.

vegetables and fruit being more acceptable and better suited to the requirements of dwellers in the tropics. The liver is frequently the seat of morbid processes, being first congested, and then undergoing indurative changes, or on the other hand becoming the seat of inflammation and abscess. The skin is stimulated to largely increased action, and there is often an increase of excretion, amounting to 24 per cent; other secretions are diminished.

The nervous system is depressed, especially if humidity be combined with great heat.

However, if the body temperature be kept down by abundant perspiration and the hot season be not of too long duration, great heat is borne well, although a lengthened residence in such regions exercises a depressing influence on Europeans, and by impairing the great functions of digestion, respiration and blood manufacture, prevents the formation of healthy tissue. The tint of skin and the white of the eye in Europeans long resident in the tropics and their lack of energy all prove this.

We cannot doubt that the direct rays of the sun are of the greatest importance to invalids, and in all but distinctly hot climates should be utilised to the full. We see the pallid cachectic tint of invalidism converted into the brown and reddish hue of good health under the sun's influence, and we can hardly doubt but that the beneficial changes which we note in the vegetable kingdom may to some extent take place in the animal kingdom, and that circulation, cell formation, growth of nerve and muscle, are all largely promoted by these rays. Thus we see chilly invalids of great sensitiveness can endure to sit out surrounded by snow and ice in high altitude stations, such as St. Moritz and Davos, where the sun's direct rays shining through an attenuated atmosphere, free from mist, are even more powerful than in low level stations situated further south where the atmosphere is at ordinary pressure. But at these high stations, when the sun sets, or becomes hidden by cloud or snow mist, all is changed and arctic temperatures prevail.

Rain Gauge.—And now we come to instruments for measuring atmospheric moisture, and take first the *Rain Gauge*, which is valuable as indicating the tendency of the climate towards a large or small rainfall. The monthly, weekly and daily records of Mr. Symons tell us how that fall is distributed throughout the year, and this may enable invalids to avoid the months generally found to be rainy at each health station.

But what we require of the rain gauge is that it should tell us at what hour in the 24 hours the rain falls, whether by day or by night, whether it consist of heavy showers with intervals of dryness and sunshine enabling invalids to take exercise, or whether it be continuous fine rain or Scotch mist rendering all going out hazardous to the delicate. Even the beautiful recording instruments of Mr. Binnie and Mr. Tomes exhibited to-day do not give us all this information, but they go a long way towards it. Mr. Scott's paper on the diurnal range of rainfall at seven observatories in connection with the Meteorological Office shows that as regards quantity of rainfall there was little regularity in the fall except at one (Valencia), where there was a decided minimum at 8 p.m., but as regards frequency at Valencia the time that precipitation was most likely to occur was the early morning, and the driest period of the day was about noon. At Kew, however, an inland station, these conditions were exactly reversed, the frequency being greater in the afternoon than during the night hours and early morning. At the other stations, except Armagh, the maximum was marked in the early morning.

Dr. Hann in his investigations of a number of European stations found the afternoon maximum was between 2 and 4 p.m., and that there was a night maximum between midnight and 4 p.m., and at some places three maxima were discernible. It is evident therefore our information is not yet complete about the hours of rainfall, but so far as it goes it points to the forenoon as the best time for invalid exercise.

Mr. Binnie's rain gauge is exhibited as well as Tomes' and Wild's, and also the pattern used by the late Dr. Livingstone in Africa.

Hygrometers.—The results of the *Dry and Wet Bulb* and other hygrometers now in use, are of great, and I may say of growing, importance, for whatever the statistics of treatment by climate may tell us, they teach more and more that dryness is one of the first considerations in the selection of a health resort, and that, what is so unfavourable to the growth of vegetation, is the condition most favourable for recovery from such diseases as rheumatism, bronchitis, asthma and consumption. Some of the most successful climates in the world are those where the difference between the dry and wet bulb is large. In the South of France, where during the mistral it sometimes rises to 15°, a difference of 10° is well borne; in Egypt the difference is often nearly 20°.

What tries an invalid, particularly a consumptive one, is the rapid change from great dryness to moisture, as occurs during a thunderstorm. A patient of mine was trekking in the Kalahari Desert in the Cape Colony, and enjoying the dryness of the climate, the hygrometer showing a difference of 25° between the bulbs. Heavy rain fell and saturation was reached, when my patient was immediately attacked with severe hœmoptysis.

The advantage of great dryness is that it enables patients to sit out, even on the ground, for hours together. However, though dryness of climate is essential for most invalids, there are cases where moisture is so advisable that in their rooms it is necessary to supply it by evaporating water over a lamp of some kind, or by using a steam kettle. This is generally where the bronchial and pulmonary mucous membrane is irritable and the secretion scanty.

The Exhibition contains a number of hygrometers. We have several patterns of de Saussure's Hair Hygrometer, in which the moisture of the air is measured by its influence on a human hair, and which is much used in cold climates where the dry and wet bulb hygrometer fails. Klinkerfues' is a modification of de Saussure's. There is Kater's, where the hair is replaced by a twisted filament of the Indian grass; also the well known one of Daniell, a two bulbed hygrometer, where the dew point is determined by condensing the moisture through the evaporation of ether; Jones's where the same principle is involved; Dines's admirable instruments; and Regnault's and Alluard's beautiful patterns. We have, too, Negretti and Zambra's recording hygrometer, with Mr. Bayard's modification; Nicolle's aqueous meter; and an aspirated psychrometer lent by Dr. Assmann of Berlin; and a self-recording wet and dry bulb thermograph by MM. Richard, who may be fitly termed the recording angel of the 19th century.

A homely adaptation of the principles of hygrometry is the oat-beard hygrometer, or "pocket damp detector," which is used for the detection of damp sheets, damp clothes, etc., a boon to travellers in regions where rooms are unwarmed and beds are unaired!

The Barometer.—The ordinary fluctuations of the barometer, of which two examples are shown, as noted at sea level, though they may occasionally tell on the invalid's sensations, do not materially affect his condition, but the influence of diminished and increased barometric pressure is of the utmost importance. This latter is far too lengthy a subject to be treated adequately at present, so I propose to make it the subject for a future address.

Anemometers.—The direction of the wind is highly important to invalids, but its force, as measured by the various forms of anemometer, of which that of Mr. Dines is a most ingenious and serviceable example, is less important though a glance at the anemometer from indoors may indicate that the day is too gusty for exercise even if the weathercock point in the right direction. An ingenious electrical wind indicator is shown by Mr. G. W. Higham.

Many health resorts owe their reputation almost solely to their shelter from cold winds; for instance, the advantage in climate which Hyères and Mentone enjoy over Marseilles is chiefly due to their being more sheltered from the Mistral, or North-west wind, the scourge of the lower valley of the Rhone from Valence to Avignon.

The Exhibition contains an unusually rich collection of diagrams and photographs, which speak for themselves, and depict various meteorological phenomena and their effect on the works of man, as well shown in Mr. Curtis's pictures of the effects of the Lawrence Tornado and of the Blizzard in New York.

After, however, we have studied the meteorology of a locality with the greatest preciseness and exactitude, after we have brought every possible instrument to bear on our knowledge of its climate for a long series of years, and have accumulated and tabulated thousands of observations, after we have arrived at definite conclusions as to the temperature, hygrometry, and barometric and wind pressure, we find there are climatic peculiarities which we have not yet fathomed; and when we come to the relation of climate to man, this is even more striking. No meteorological instrument has as yet been able to inform us why this climate is exciting and that sedative; why a patient loses his appetite here and regains it there; why an asthmatic sufferer breathes freely in one place and lives in misery in another, not apparently differing from the first in meteorological conditions. All this shows us that we have not yet conquered the powers of the air and harnessed them to our chariot wheels, and that if we are to be successful in our campaign we must enlist more workers, and especially the services of other sciences, such as chemistry and physics, to assist in our investigations. A more complete analysis of the air of health resorts at various seasons of the year, and, as Mr. Harries pertinently suggested at our last meeting, during the periods of epidemics, is much wanted; and I would add to it careful observations with the spectroscope, which has already yielded so large a harvest to inquirers in other fields bordering our own. Spectroscopic observations would neither be toilsome nor difficult; a very short preliminary study might qualify a whole army of observers in this line. Bacteriological inquiries are the fashion just now, too much to the exclusion of others, and excellent though these may be, they should not take the place of chemical investigation, but should rather be combined with them,—especially as research demonstrates more and more that the evil done by our unseen foes the bacteria lies as much in their chemical products as in their direct action on the tissues.

I propose now to treat of groups of climates: and of the various classes of health resorts I have selected the Riviera for my present topic, first, because its features are well defined; second, because it presents great contrasts to our own climate; third, it is a region very accessible to invalids; and fourth, because I have enjoyed during the last 30 years great opportunities of studying it. The Riviera may be described as the north coast-line of the Mediterranean from Toulon to La Spezzia, though some restrict the term to the portion from Nice to Spezia, which, considering that the mountains between Toulon and Nice are all more or less spurs of the Maritime Alps, is hardly warranted. The climatic features of this coast-line depend on three factors:—

1st. The Southerly Latitude, as this tract of country lies between 43°·7′ and 44° North Latitude.

2nd. The protection from cold winds by mountain ranges.

3rd. The warming and equalising influence of the Mediterranean Sea.

The first factor shows itself in the warmth of sunshine during the winter months, which enables invalids on fine days to sit in the open air for hours together. With regard to the second element, *i.e.* protection from cold winds, the Maritime Alps form a good rampart to the north of this region, and consist of a series of mountain chains which run first southwards from the Savoy Alps to the Mediterranean, and then trending to the north-east along the coast, eventually join the Apennines. To the west various spurs extend towards Toulon, forming the Basses Alpes, the Esterels and the Maures, and thus furnishing a more or less unbroken shelter. Between Nice and Genoa the strip of country is backed by a triple chain of mountains of considerable height, and where these approach the shore, they leave a mere ledge intervening between them and the sea, hence the term Cornice Road.

The health resorts to the west of Nice owe their protection to lower ranges, which do not in all cases approach so closely to the sea, and consequently the shelter to the north-west is not always so complete, though quite sufficient for most purposes.

Districts like *La Petite Afrique*, situated between Villefranche and Monaco and facing full south, and backed by the mountain wall of Mont Vinaigrier, are undoubtedly completely sheltered, and gain additional heat from the reflection of the sun's rays from the cliffs above, but owing to the position of those cliffs these places lose the sun's rays earlier and receive them later than less protected health resorts.

It is probable that this variation in the amount of shelter balances to some extent the differences in latitude between the various localities, for otherwise we should expect that the most southerly would be the warmer, but on the Riviera, as the most northerly health resorts happen to be best protected, the differences in temperature are small. The third factor of the climate is the Mediterranean sea, of which the principal characteristics are:—

1. That it has scarcely any tide, a rise and fall of two feet having been noted in some of the greatest indentations as in the Adriatic. On the Riviera there is scarcely any, so that its influence may be said to be always equally potent and not to vary with hour and season.

2. It is a remarkably salt sea, containing more saline matter than either the British Channel or the Atlantic. The *Porcupine* soundings[1] demonstrated clearly that the Mediterranean water has a greater density than the Atlantic and that it contains more chlorine, and moreover that the enormous evaporation, which takes place from the surface of this sea, is probably the cause of this extra salinity, as more enters from the Atlantic than flows out into it.

Traces of this saline matter have been detected by Gilbert d'Harcourt in the air 400 metres inland, and at an elevation of 229 feet, and De Coppet detected it by spectrum analysis 1,000 or 1,200 metres inland. The blue colour of the Mediterranean, I may mention by the way, is attributed by

[1] *Proc. Roy. Soc.* 1870–71.

Professor Tyndall and the late Dr. Carpenter to the particles held in suspension derived from the Rhone and other great rivers which pour their muddy floods into it. Dr. Carpenter assigns the blue colour of the Lake of Geneva to particles in suspension derived from the Upper Rhone, and that of the Mediterranean to the deposits brought down by the Lower Rhone.

3. It is a warm sea, warmer than the Atlantic in the same latitude by several degrees: this has been long known, but the important soundings of the *Porcupine* Expedition demonstrated two salient facts, the one that the surface temperature depends largely on the sun's influence, and the other that there is a uniformity of temperature for all soundings below 100 fathoms, in fact, whatever the temperature was at 100 fathoms that was the temperature of the whole mass of water beneath, down to the greatest depth explored, which in this case was 1,743 fathoms; that temperature being 54°. This, as is well known, is a great contrast to the slow and continuous reduction of temperature encountered in the successive strata of the Atlantic, and is doubtless due to the absence of Arctic currents. The presence of this warm sea has a remarkable influence in neutralising the effects of radiation on its shores, and this has been well demonstrated by Dr. Marcet[1] at Cannes, who found that the mean temperature of the sea was, during the winter months (November to March), 5·8° to 8·6° higher than the mean temperature of the air, and that the minimum experienced close to the sea was higher than that of stations inland. The temperature of the Mediterranean in winter seldom falls below 52° and often rises to 64°, and consequently it is possible to bathe all the winter with due care; indeed, this is frequently done by Britons, though rarely by other people.

The warming influence is best evidenced by its effect on vegetation, for we see the hills sloping to its warm levels richly clad with trees and shrubs, which often attain their greatest luxuriance on the shore itself, where palms and other exotics flourish.

In treating of the meteorology of the Riviera, I shall confine my remarks to the meteorology of the winter and spring seasons, as these are what concern the British invalid. In the summer and early autumn, though many of these health resorts are quite endurable in climate, and are used as bathing places for the French and Italians, they are too hot to be selected as residences for our invalid fellow countrymen and women. By the winter season I mean the six months from November 1st to April 30th, which is very nearly the full period of invalid sojourning.

The mean temperature of the region varies from 50°·8 to 51°·5. It is nearly 8° to 10° higher than that of Greenwich for the similar period. The minimum runs from 42° to 46°·5, being lowest in December.

This represents the mean minima of thermometers, kept in Stevenson screens, but when exposed on the earth, or on grass, the thermometer was found to sink occasionally to 41°.

The fall of the temperature at sunset is very marked, especially in

[1] *Quarterly Journal*, Vol. III. p. 473.

December and January, when the fall may amount to 2°·5 in 12 minutes, and to 10° or 11° in 4 hours. The grass at a distance from the sea may be seen in early morning covered with hoar frost, and I have beheld snow lying on the ground for a few hours, though this is rare. In 1879 I saw the ground white with snow and rose leaves imbedded in ice while roses and heliotropes were in full bloom in the gardens at Cannes.

The mean maximum varies from 56°·7 to 59°·6. The sunshine heat, as registered by the black bulb thermometer *in vacuo*, is great, and the mean monthly maximum ranges from 91° in December to 120° in April.

The relative humidity varies from 61 to 74 per cent. The annual rainfall, records of which have been collected by Mr. Symons in an interesting article in the *Quarterly Journal* for 1890, is about 31 inches, distributed over 65 days. The rainy months are September, October and November, when on an average more than a third, and nearly half of the total amount falls: during the winter months the fall is about 20 inches, distributed over 30 to 40 days. The rain comes down in heavy showers, as much as 4½ inches having been known to fall in 9½ hours, and the intervening periods are generally dry and fine.

The rainfall apparently increases as we proceed eastward on the Riviera, the lowest average being that of Hyères, the highest that of Genoa, and this may be accounted for by the greater proximity of high mountain ranges as we travel towards the east.

The winds are one of the chief features of the Mediterranean climate, and a great contrast between the Riviera climate and our own lies in the fact, that on the Riviera it is the Westerly winds that are the dry, and the Easterly and Southerly the moist ones. The most important wind is the North-west wind, or *Mistral, or Maestral*, derived from *Magister* a master, a dry wind which appears first in the valley of the Rhone, east of the Cevennes mountains, and in the neighbourhood of Avignon; it is at times a perfect scourge, and blows with great violence, having been known to upset carts and carriages and even heavy diligences and to uproot large trees in its course. Taking a north-west direction it sweeps over the passes in the various protecting ranges and reaches the Mediterranean, whose blue waters it lashes into foam for a considerable distance from the shore. It is a dry wind, parching up the country and causing the barren appearance of the mountains near Marseilles, and it drives before it clouds of dust. Its dryness is proved by its causing a difference between the dry and wet bulbs of from 10° to 15° during its prevalence. Its appearance is the signal for fine weather, which generally continues for several days after it has blown. Owing to its desiccating influence it produces the impression of great cold, and is much objected to by invalids and by medical men. It prevails chiefly in March, and appears to originate in the descent of an upper current to supply the place of the mass of heated air ascending from the Rhone valley and the Western Mediterranean basin.

The other dreaded wind is the North-east or *Bise*, or *Bora* or *Greco*, which is a cold blast coming from some portion of the Maritime Alps, and generally accompanied by rain, or occasionally by sleet, hail, or even snow. This wind rarely prevails for more than about eight days in the year, and few of the health resorts are exposed to it. The Southerly and Easterly winds, which are most common, are harmless, except being gusty winds bringing rain; but there is one exception, the Scirocco or South-east wind, which in late spring is hot and relaxing, though in the winter it is chiefly objectionable as a rain bringer, but this sometimes too has its advantages, as the curse of the Riviera are the clouds of dust to be encountered in riding, driving or walking. Summing up the winter climate of the Riviera as a whole, it is a clear bright dry climate with a good deal of wind, with fog and mist practically unknown, with a winter temperature at least 8° to 10° higher than that of England, but subject to a fall from nocturnal radiation sufficient occasionally, but rarely, to cause frost. Compared with England, there are about half the number of rainy days and four or five times the number of bright ones, with plenty of cheerful and interesting surroundings to enliven and charm. It is winter, but cheerful bright winter, of a character to brace and invigorate instead of imprisoning and depressing.

Those who complain of the cold weather and winds of the Riviera, should remember that both these have their beneficial uses, and probably exercise an aseptic and bracing influence, in what would otherwise be too protected and calm an atmosphere. The cold nights are especially beneficial as promoting sleep, which, especially at the seaboard, is often difficult to secure in warm winters.

The Address concluded with a lime light demonstration of 23 views of the various healths resorts of the Western Riviera, exhibiting their position with respect to sunshine and shelter.

ANEMOMETER COMPARISONS.

By W. H. DINES, B.A., F.R.Met.Soc.

(Communicated by the Meteorological Council.)

(Plate VII.)

[Received March 10th.—Read April 20th, 1892.]

At a meeting of the Wind Force Committee of the Royal Meteorological Society, held in May 1890, it was decided that it would be desirable to obtain a direct comparison of the various anemometers in common use, so that some opinion might be formed as to which type of instrument was the most suitable for general purposes, and also for special conditions of situation and exposure. The work, of which I now give an account, has been carried on by means of a grant kindly made for the purpose by the Meteorological Council.

It was suggested that the objects of the inquiry would be best obtained by getting automatic and simultaneous records from all the instruments which it was considered desirable to try, upon the same sheet of paper, and recording apparatus has accordingly been made for the purpose.

The manner in which a record is obtained by moving a sheet of paper by clockwork, and allowing an anemometer or other instrument to move a small siphon pen across the paper, is too well known to need description.

In the present case, the paper used was 36 inches wide, to allow room for several anemometers to record side by side, and was moved at a much greater rate than is commonly employed, in order that the rapid variations in wind velocity, which are known to occur, might be easily seen on the sheets, and their action upon the various types of instrument noted. The time scale could be altered at pleasure from 1 to 3 inches per minute by means of a small governor attached to the clockwork.

Difficulty of comparing Pressure and Velocity.

There is an inherent difficulty in comparing the pressure and velocity of the natural wind, which never seems to remain uniform for more than a few seconds at a time. To make this difficulty plain, it will be best to consider an imaginary case. Suppose the wind to blow during half a certain time with a velocity of 10 miles per hour, and during the other half with a velocity of 20 miles per hour, the changes occurring in any manner whatever. The mean velocity recorded by a correct velocity instrument would be 15 miles per hour. Suppose the pressure for 10 miles per hour to be x, it is well known that the pressure for 20 miles per hour would be $4x$, hence the mean pressure will be $\frac{5}{2}x$. But the pressure corresponding to 15 miles per hour will be $(\frac{3}{2})^2x$, *i e.* $2{\cdot}25x$, which is 10 per cent. less than the above value. How these two amounts will differ in actual practice it is impossible to say, but it seems quite possible that the difference may sometimes be more than 20 per cent. To avoid this difficulty, the ordinate of the pressure curves has been made to correspond to the square root of the pressure, and therefore to the velocity, in a manner subsequently described.

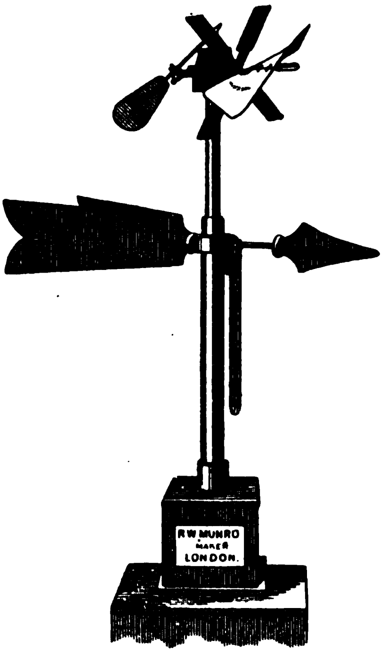
Instruments compared.

The instruments which have been compared are the following:—

1. Kew Pattern Robinson Anemometer.
2. Self-Adjusting Helicoid Anemometer.
3. Air Meter.
4. A Foot Circular Pressure Plate.
5. A Special Modification of Tube Anemometer.

Of these, the Kew pattern Robinson Anemometer is too well known to need description.

The self-adjusting Helicoid Anemometer is described in the *Quarterly Journal of the Royal Meteorological Society*, Vol. XIII. p. 218, 1887. (Fig. 1.)



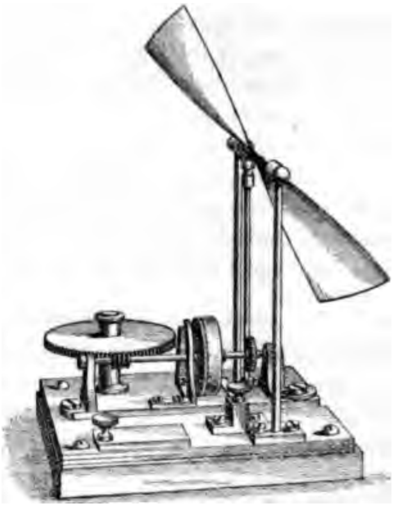


Fig. 2.—Air Meter.

Fig. 1.—Self-adjusting Helicoid Anemometer.

The Air Meter consists of a single blade of thin aluminium of special shape, with a train of wheels and dial to record its revolutions. (Fig. 2.)

PRESSURE PLATE.

The arrangement of the Pressure Plate is shown typically in Fig. 3.

The pressure of the wind is transmitted by means of a flexible cord passing over a small pulley, the lower end of the cord being fastened to a suitably shaped block floating in a tank of water, the block being so adjusted and counterpoised by the weight *W*, that when the tension of the flexible cord is zero the edge of the block is just flush with the surface of the water. It

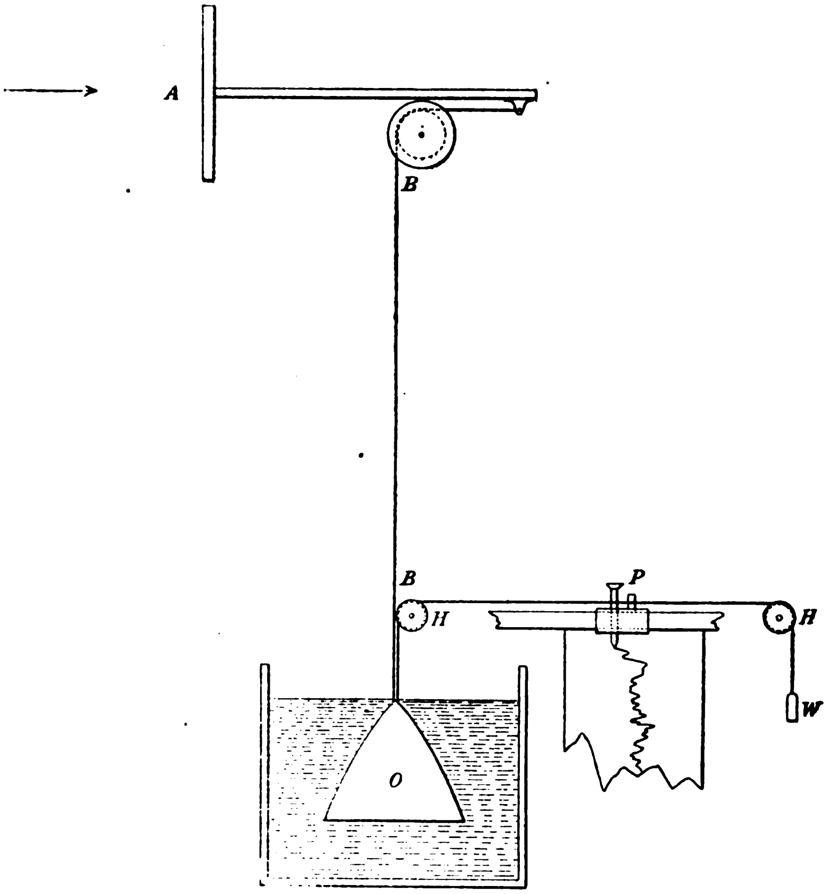


FIG. 3.—Pressure Plate.

will be seen that the pressure which forces back the plate must, when there is equilibrium, be equal to the weight of a volume of water equivalent to the volume of the block, which is raised above the water level in the tank. The plate was a circular one; it presented an area of one square foot to the wind, and the only impediment to the free motion of the air behind it was the 2-in. iron pole on which it was supported. It was assumed that the pressure varied as the square of the velocity, and that a pressure of 30 lbs.

corresponded to a velocity of 100 miles per hour. The floating block (Fig. 4) was shaped in such a manner, that, on the above supposition, a velocity of 10 miles per hour would raise the block 1 inch; 20 miles per hour, 2 inches; and so on. It is clear that if the water level were constant, the vertical section of the block should be a triangle, but when the block is raised, unless the tank be very large, the water level sinks appreciably. This difficulty

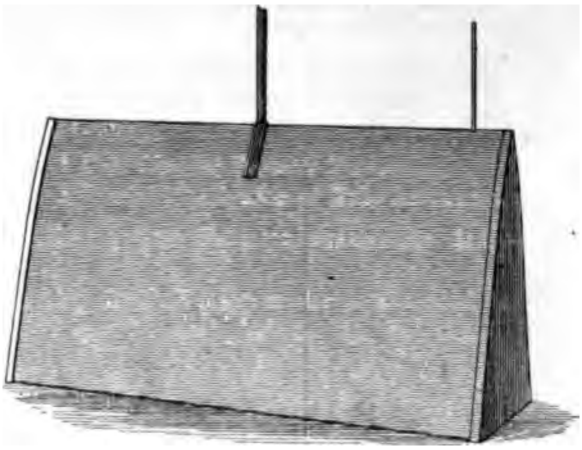


Fig. 4.—Floating Block for Pressure Plate.

was overcome by slightly bulging out the sloping sides, and to prevent the possibility of mistake on account of any incorrect calculation, the arrangement, when complete, was tested by the application of definite pressures. It was found that the actual position of the recording pen did not in any case differ from the calculated position by more than $\frac{1}{16}$ of an inch.

The pressure of the wind acts upon the Plate *A* (Fig. 3). The force is communicated by the tension of the flexible cord *BB* to the block *O*, which, in consequence, is partly raised out of the water. The motion of the block actuates the pen carriage and pen, *P*, by means of a light silk thread, with a weight *W* attached, passing over the small pulleys *HH*.

It will be seen that the position of the pen is in no way dependent upon the stretching of the cord *BB*. It is necessary from time to time to see that the block *O* floats with its edge just immersed, when the tension of the cord *BB* is zero. This is easily adjusted by adding to, or subtracting a few small weights from, *W*.

Tube Anemometer.

It has long been known that the wind blowing against the mouth of an open tube causes an increase of pressure, and that when blowing transversely across the mouth of the tube it causes a partial vacuum. This fact has been partly utilised, and the head of the anemometer, which consists of two parts, is shown in Fig. 5.

[T]he moveable part of the head consists of two pieces of 1 in. tube con-ted at right angles, and a vane.

[T]he horizontal tube is closed at one end, the other end (*A*) is kept facing wind by the vane.

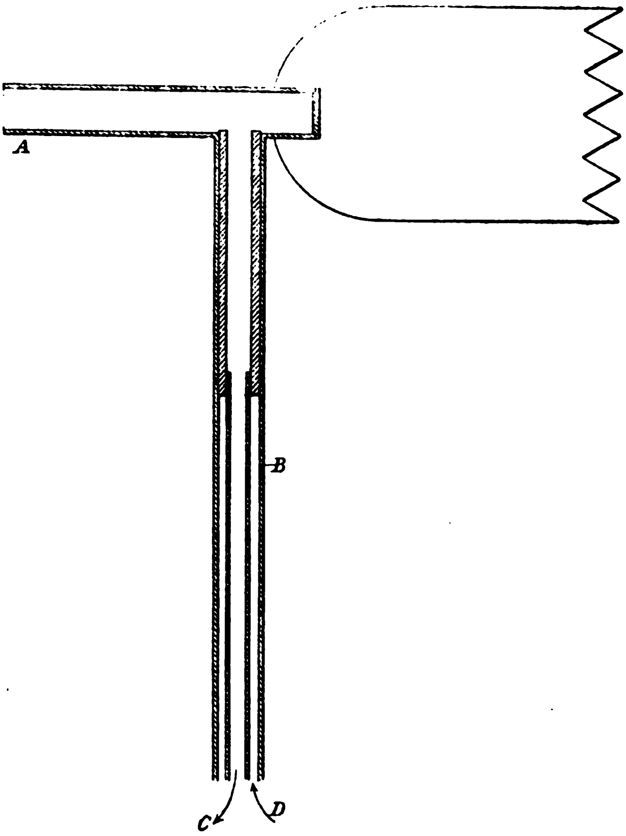


FIG. 5.—Tube Anemometer.

'he fixed part is constructed out of three pieces of brass tube of consecu- sizes. The largest is 1⅛ in. diameter, outside measurement. The lium size is of thicker metal than the others, and just fits into the largest . The smallest piece is ¾-in. diameter, and just fits into the medium-d tube. The two extremes are placed at the bottom, one inside the r, an annular space being thus formed between them. The medium-size drops into this annular space, thus closing it at the top, and is also ied up, thus forming a bearing round which the moveable part turns. r the top of the annular space (at *B*) twelve $\frac{1}{12}$ in. holes are drilled in outer tube in a ring, by which holes the annular space is connected with outer air. (Fig. 6.)

he wind in passing over these holes exerts a small sucking action. At the same time, by blowing against the mouth, it causes an increase of pressure in the tube A. The whole result is a difference of pressure between the spaces (C) and (D), the following values of which have been found by direct trial on the whirling machine :—

		Ins. of water.
At 10 miles per hour, difference of pressure ...	... =	·0731
,, 20 ,, ,, ,, ,, ,, ...	... =	·2924
,, 30 ,, ,, ,, ,, ,, ...	... =	·6579
,, 40 ,, ,, ,, ,, ,, ...	... =	1·1696

and so on, the difference of pressure varying as the square of the velocity.

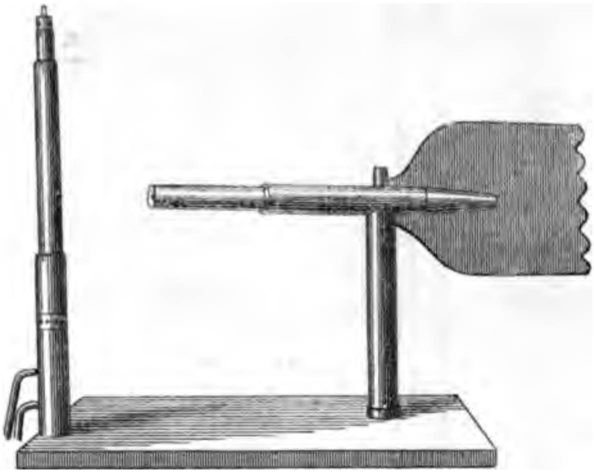


FIG. 6. –Head of Tube Anemometer nearly similar to the one used.

This particular form has been adopted for the following reasons. In experiments made upon the tube anemometer, on the large whirling machine at Hersham, particulars of which will be found in the *Quarterly Journal of the Royal Meteorological Society*, Vol. XVI. p. 208, 1890, it was found that the vacuum produced by the wind blowing over the mouth of an open tube was very dependent upon the exact perpendicularity of the tube, and if that kind of head had been used, a slight inclination of the wind, which might easily be produced by some adjacent building, would have seriously influenced the result.

The partial vacuum, produced by the action of the air in passing over the ring of holes in the upright tube, has been found not to be subject to this objection. The pressure of the air blowing against the mouth of the open tube has also been found to be independent of the inclination of the wind direction to the axis of the tube, so long as the angle does not exceed 15° to 20° ; hence the whole instrument is independent of moderate changes of wind direction either in azimuth or inclination.

The way in which the change of pressure produced by the wind actuates the pen of the recording apparatus is shown in Fig. 7.

A zinc cylinder (G) is filled with water up to the level K. A tube F passes up the centre, the mouth of the tube being about 1 in. above the surface of the water. A cylindrical copper vessel M, which will subsequently be called the float, is placed, mouth downwards, over this tube, so that the air space inside it can only communicate with the outer air through the tube F. On the outer side of the float a sealed air chamber N is formed, and a leaden ring is

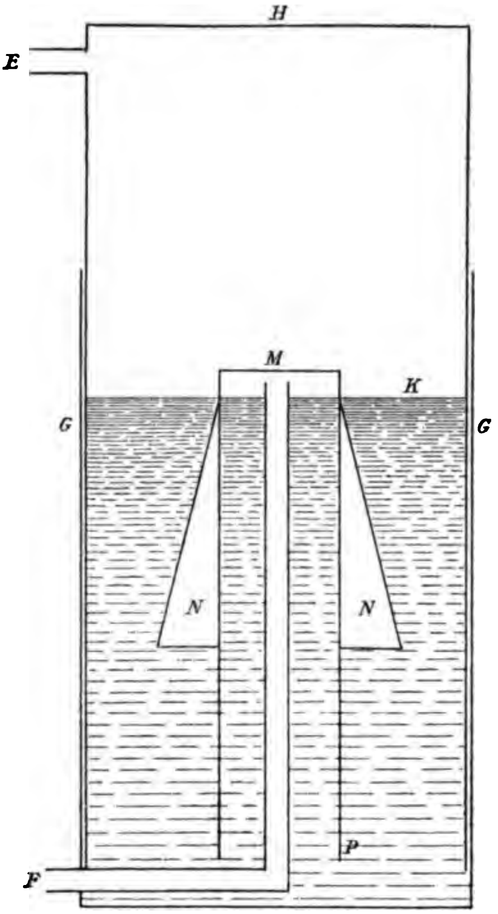


FIG. 7.—Float in connection with Tube Anemometer.

attached to the bottom at P, of such a weight that the whole just floats with the top of the air chamber level with the surface of the water. A second zinc cylinder H is placed mouth downwards in the outer cylinder G, fitting into it as closely as possible, and thus forming a closed air space above the float. This space communicates with the outer air through the tube E. It will be seen that on either blowing into F, or sucking E, the float will rise. It is also clear that if the float be raised by this means, the water level (K) outside the float is not disturbed, for the water which is driven or sucked from the inside exactly makes up for the smaller displacement of the float.

The tube F was connected with the inner tube C of the head (Fig. 5), and the tube E with the annular space D, the connection being made in both cases by about 40 ft. of $\frac{3}{8}$-in. lead tube.

The inside cross section of the float is 20 sq. ins., and hence it is found that a wind velocity of 10 miles per hour causes an upward force of 371 grains to act on the float; 20 miles per hour produces a force of 1,484 grains, and so on. The outer surface of the air chamber N is so shaped that the float must rise 1 in. to displace 371 grains less water; 2 in. to displace 1,484 gr. less water, and so on, and thus the ordinate of the curve is made to correspond to the velocity, instead of to the pressure, of the wind. The chamber N is not exactly conical, but bulges out slightly in the central parts. The float is connected with the pen carriage by a silk thread passing through a very small hole in the top of the zinc cylinder H. The hole is so small and so nearly filled up by the thread, that, in so far as this instrument is concerned, it may be considered air tight.

It is not, of course, absolutely air tight, but the case is similar to that of a small jet of common gas. The use of one small burner does not alter the pressure in the main by any perceptible amount.

It is necessary to point out that the double tube and the closed space above the float are absolutely necessary to render the instrument independent of the accidental variations of pressure which may occur in the room in which the recording apparatus is placed. The pressures on which the action of the Tube Anemometer depends are very small; and hence if the instrument were constructed with one tube only, a slight alteration of the pressure in the room, which might easily be caused by opening or shutting a door or window, would alter the recorded velocity. There can be no doubt that the pressure in a room on the exposed side of a house during a gale is greater than in a room on the sheltered side, and if both doors be shut and both windows open, the difference may be considerable. Also in a closed room with an open grate, making a good fire decreases the pressure by an appreciable amount. However, to test the point practically, the two tubes of the Anemometer were disconnected from the head and carried to two rooms on different sides of the house. The difference of pressure between the two rooms, acting upon the float of the recording apparatus, produced a curve, which, had it been obtained in the ordinary way, would have indicated a mean velocity of about 12 to 15 miles per hour. The actual wind velocity, as shown by the Pressure Plate for the same period, was about 25 miles per hour. In this case care was taken to augment the difference of pressure between the rooms by suitably arranging the doors and windows; but it is clear that in the ordinary way great differences may exist, and if the instrument depended on one tube only, the indicated velocity would most probably be greater when placed in one room than it would be if placed in another.

Method of Registration of Velocity Instruments.

To obtain a record from the velocity instruments upon the same paper, the following plan was adopted:—A pen, which could be jerked aside by the action of an electro-magnet, rested upon the paper, and as the paper moved underneath a line was drawn. On passing a current round the magnet the pen was jerked aside, thus producing the lines of notches shown in Fig. 8. Each velocity instrument had a separate pen and electro-magnet connected with it, and the contacts were made after every 88 ft. ($\frac{1}{60}$th of a mile) registered by the instrument.

Calibration of Velocity Instruments.

The question of the factor of the Kew Pattern Robinson Anemometer is fully discussed in the Report of the Wind Force Committee (*Quarterly Journal*, Vol. XVI. p. 26, 1890). For the purpose of these comparisons, the electric contact was made for every 44 ft. moved over by the centre of the cups, this would be for every 88 ft. of air motion, if the factor were 2·00.

The results of various direct trials of the Self-Adjusting Helicoid Anemometer upon the whirling machine are given in the account of the instrument published in the *Quarterly Journal*, Vol. XIII. p. 218, 1887, and also in the Report of the Wind Force Committee, Vol. XIV. p. 253, 1888.

The air meter was carefully tried on the whirling machine, and electric contact arranged accordingly, but it was found that after the contact piece was attached the meter registered 2½ per cent. too low, doubtless on account of the additional friction. It should be added that the results of the air meter trials on the whirling machine were consistent throughout, and, unlike those with the Robinson Anemometer, were but little affected by the natural wind blowing at the time. The air meter gave a uniform result at speeds between 6 and 30 miles per hour, falling off gradually at higher velocities, until at 70 miles per hour it registered 3 per cent. too low.

Reason for trying only Five Instruments.

The space at my disposal, being limited to a square of about 12 ft. each side, rendered it impossible to try all the instruments proposed by the Council of the Royal Meteorological Society, and the instruments enumerated above were chosen as being fairly representative.

Position of Anemometers.

The Robinson Cups, the Air Meter, and the Tube Anemometer were obtained in the autumn of 1890, and were erected upon the tower at Woodside, Hersham, Walton-on-Thames, in December 1890. Owing to the exceptional calmness of the winter of 1890-91, and also to the fact that I was then living at Esher, two miles from Hersham, the results obtained were comparatively few, and related chiefly to light winds. They are in substantial agreement with those subsequently obtained, but are not incorporated into the final percentages.

In the beginning of May 1891 the three instruments were dismounted, and during the summer the Helicoid and Pressure plate were obtained. In the beginning of September 1891 all five were erected on the roof of a house at Oxshott, to which I had moved during the summer. (Plate VII.)

At first the anemometers were placed 9 ft. above the highest part of the roof, but it was soon found that this was not sufficiently high. The eddies from the chimney stacks and the gables of the house produced discrepancies, amounting, in some instances, to as much as 80 per cent. That the difference in the amounts registered were thus caused, was plainly proved by the fact that the direction of the wind had a most important effect upon the rate of any one instrument expressed as a percentage of any other. For example, with a South-west wind, the tube anemometer was from 15 to 20 per cent. in excess of the pressure plate, but with a North-east wind the conditions were reversed, and the pressure plate was always from 10 to 15 per cent. in excess of the tube. There were numerous similar instances, and although this result was not altogether unexpected, it affords direct proof that the question of exposure is very important. In November the instruments were raised to a height of 18 ft. above the roof. The Robinson was placed on the south-west side; the Helicoid about 9 ft. to the north; the Pressure Plate 18 ft. to the north-east; and the Tube Anemometer about 9 ft. to the east of the cups, the four instruments thus being at the corners of a square, one diagonal of which ran exactly north and south. The air meter was placed in the centre; it was not exposed permanently, but was raised up when required, generally during the day time.

The eddies from the gables and chimney stacks seem to be entirely absent at a height of 18 ft. above the roof, but there is no doubt that the instruments do slightly disturb each other. The effect has been eliminated in a manner subsequently explained.

Method of making the Comparison of the Air Meter.

The comparisons were made, firstly, between the three velocity instruments, viz. Robinson, Helicoid and Air Meter, in the usual way by means of the recording dials, the results being tabulated both for different mean velocities and also for the direction of the wind. Secondly, between the Robinson, Helicoid, Pressure Plate and Tube Anemometer, by means of simultaneous automatic records upon the same sheet of paper. This could only be done for a limited time, because to obtain the value of the velocity from the pressure instruments it was necessary to use a very open time scale.

It was found that the insulation of the electric contact piece was not good during rain, and many of the automatic records on the paper were consequently indistinct, hence the air meter has not been directly compared with the pressure instruments, but only indirectly through the Robinson and Helicoid.

It was not possible to obtain a perfectly distinct line from the pen of the Pressure Plate during a gale unless the paper moved at least 2 inches in each minute, and hence the cost of the paper prevented very extensive observations, The plan adopted has been to run the paper for about five minutes at intervals ranging from one to two hours during every gale, the times of observation being made to coincide as far as possible with the times of highest velocity.

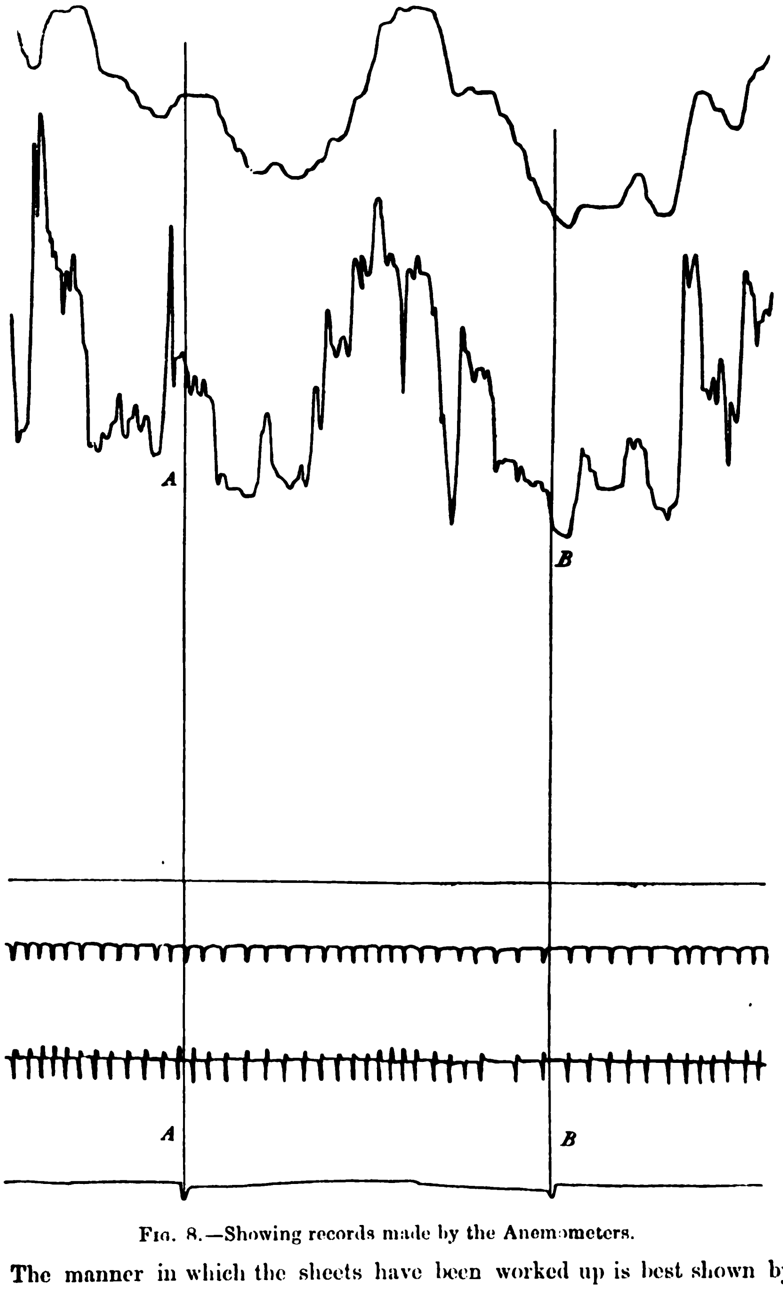


FIG. 8.—Showing records made by the Anemometers.

The manner in which the sheets have been worked up is best shown by reference to an actual case.

Fig. 8 is a reproduction of the marks made by the pens of the various instruments. The bottom line shows the time, the notches being made at intervals of every minute. The second line is made by the Robinson Cups, the pen being moved electrically, and thus making a notch after every 88 ft. of air motion (factor 2). Since 88 ft. = $\frac{1}{60}$th of a mile, the number of these notches which occur per minute is equal to the mean velocity given in miles per hour.

The third line is made by the Helicoid Anemometer, and a precisely similar remark applies to it. The fourth line is the base line of the Pressure Plate curve. The fifth line is made by the Pressure Plate. So far the figure is an exact copy of a portion of one of the sheets, but the next line, which is the curve produced by the Tube Anemometer, has for convenience been brought down exactly 8½ ins., the base line for this instrument being 1½ in. above that for the Pressure Plate.

To make the comparisons, firstly two vertical lines *AA* and *BB* are drawn across the paper at a distance corresponding in general to two or three minutes, but in this particular instance to one minute.

Then the number of notches between *AA* and *BB*, viz. 20·9, made by the Robinson is counted, 20·9 thus being the mean velocity for the minute recorded by this anemometer.

Similarly 20·4 is that given by the Helicoid. Next the area, viz. 4·75 square ins., between the two vertical lines, the base line, and the Pressure Plate curve is ascertained by the use of a Planimeter, and this divided by 1·92, the distance between the two vertical lines, gives the mean value of the ordinate, 2·47, in inches, and is therefore $\frac{1}{10}$th of the mean velocity in miles per hour recorded by the Pressure Plate. A similar process gives 24·9 for the mean velocity recorded by the Tube Anemometer.

It should be added that the calculations have been made throughout by a slide rule. It is satisfactory to find that the percentages relating to the Robinson and Helicoid obtained from these short intervals agree well with those given by the continuous records; and hence there is no reason to suppose that the results given by the Tube and Pressure Anemometers are incorrect, because the time of observation was measured by minutes instead of hours or days.

In the following tables the velocity given by the Kew Pattern Robinson Anemometer is obtained on the supposition that the factor is 2, and hence the values are only ⅔ of those usually, but as is well-known erroneously, received for the same actual number of turns of the cups. None of the observations made before the instruments were raised have been used, but every one made since then has been incorporated into the final result.

Method of tabulating Results.

Since the commencement of the work in December 1890, nearly 100 yards of paper have been passed through the recording apparatus, about 50 yards of which have been used since the instruments were raised in November. The mean values and percentages given in the following tables are based on about 90 separate observations, and have been obtained as follows:—

Firstly, the results were divided into three groups, (1) those in which the velocity recorded by the Robinson (factor 2) was under 15 miles per hour; (2) those in which it was between 15 and 25; (3) those in which it exceeded 25 miles per hour.

The separate observations in each group were then tabulated for winds from each separate point of the compass, and the mean value for all the entries under each point obtained. The final mean was derived from these, equal weight being attached to each mean, independently of the number of observations from which it was derived. Any error which might arise from the preponderance of South-westerly winds has thus been eliminated.

MEAN OF RECORDED VELOCITIES.

Direction of Wind.	Robinson.	Helicoid.	Pressure Plate.	Tube.	No. of Observations.
N	19·0	19·4	23·1	23·8	1
NE by E	22·8	25·6	26·1	26·2	2
NE	18·2	20·3	21·2	21·6	1
ENE	22·0	24·8	27·0	25·9	2
SE	18·0	19·4	20·3	19·6	1
SE by S	18·4	18·1	22·5	21·7	2
S	21·3	20·1	22·0	22·9	1
SSW	14·2	13·4	18·5	18·5	2
	17·5	15·5	19·4	19·5	1
SW by S	17·0	16·9	19·0	20·1	1
SW	19·2	19·8	22·0	22·5	10
	28·3	28·0	30·6	31·5	6
SW by W	13·3	13·6	15·4	16·7	1
	21·7	20·3	24·0	24·9	6
	27·4	25·6	28·5	30·0	6
WSW	20·0	20·4	22·7	23·8	2
	29·5	29·1	31·5	31·9	7
	38·7	36·6	41·6	41·7	2
W by S	12·8	13·5	16·6	16·3	2
	18·9	19·5	22·7	21·9	3
W	13·7	15·2	20·2	20·9	1
	18·1	20·2	22·8	22·0	2
	27·2	28·0	29·9	30·1	2
W by N	18·4	20·3	21·7	21·9	5
	30·0	30·6	33·1	32·9	1
WNW	27·3	27·5	30·2	30·7	1
NW by W	25·3	21·7	25·4	27·1	1
NW	22·5	20·9	23·3	24·5	1

These values give the following results:—

		Robinson.	Helicoid.	Pressure Plate.	Tube.	No.
Group I.	...	13·5	13·9	17·7	18·1	4
„ II.	...	19·6	20·0	22·5	22·6	16
„ III.	...	29·2	28·4	31·4	32·0	8

The values in Group III. occurred exclusively in the South-west and Westerly gales of the beginning of December. There can be no doubt but that an increased number of observations, including winds from the North and East, would raise the mean given by the Helicoid in this group.

Treating the observations relating to the velocity instruments in the same way, the final result is

	Robinson.	Helicoid.	Air Meter.
Group I.	10·3	10·7	11·2
,, II.	18·9	19·4	18·9

There are no observations in Group III. because velocities exceeding 25 miles per hour and lasting for more than an hour or two are entirely wanting.

The whole distance recorded by the Robinson since November 26th, 1891, till now (February 22nd, 1892), has been 11,513 miles, against 11,632 miles registered by the Helicoid.

It is worthy of remark that the pressure instruments, and also the velocity instruments, keep together fairly well at all velocities: the only exception is in the case of the Air Meter, at the lower velocity, but this is easily explained by the fact that the Robinson and Helicoid would not begin to turn with a velocity under 3 miles per hour, whereas the Air Meter began to move at about 2 miles per hour. It is also noticeable that the difference between the two types of instrument decreases, not only as a percentage, but in actual value, as the velocity rises. The reason of this is subsequently explained.

In estimating the true velocity it is inadmissible to use the values given by the Robinson Cups, because the factor 2 has been chosen arbitrarily. It is clear, however, from the second set of figures, that had the Air Meter been substituted for the Robinson in the first set the result would have been the same. If we take the mean of all the values in the first set, giving to each group a weight proportional to the number of observations in it, and then express the reading of each instrument as a percentage of this mean, we obtain the following:—

Robinson.	Helicoid.	Air Meter.	Pressure Plate.	Tube.
93·2	93·8	94·0	105·8	107·2

the 94·0, the percentage for the Air Meter, being obtained from the second set of comparisons.

In addition to the above comparisons, a few have been made with a very different time scale. The recording apparatus was altered so that the paper might move at the rate of 1 in. in the hour instead of 2 ins. in the minute.

It is clear that this alteration taken alone could not alter the mean values given by the pressure instruments, but with this scale the trace given by the Pressure Plate generally became so blotted that it was only possible to obtain the velocity from it in the case of light winds. The oscillations of the Tube Anemometer were damped by introducing a short length of tube with a capillary bore at the point *F* (see Fig. 7) between the head and the recording apparatus, and the values thus obtained are

	Robinson.	Helicoid.	Pressure Plate.	Tube.
Group I. ...	11·4	11·8	14·9	14·3
„ II. ...	17·2	18·5	—	21·9

These are based on 13 separate results lasting during a period of 50 hours. Nearly all were made with a Westerly (WNW to WSW) wind, and on comparison with the other values obtained from the same wind it appears that the damping of the vibrations does not produce much alteration in the mean velocity recorded by the Tube Anemometer.

Differences between the Instruments.

The values given by the different instruments not being the same, the question arises as to which are most likely to be correct. The methods by which the constants of the Tube Anemometer and of the Pressure Plate were determined (*Proceedings of the Royal Society*, Vol. XLVIII. p. 233, and *Quarterly Journal of Royal Meteorological Society*, Vol. XVI. p. 208, 1890) are quite distinct, and hence the close agreement between the two for all velocities affords a very strong argument for the correctness of both instruments. Inasmuch as the mode adopted for finding the constants of the Tube Anemometer upon the whirling machine was one which admitted of great accuracy, there seems to be good ground for thinking that the relation $P = 003v^2$, the relation on which the results given by the Pressure Plate are founded, is very near the truth.

The self-acting Helicoid Anemometer and the Air Meter give nearly identical results, but they are about 13 per cent. less than those given by the tube and pressure plates.

The Helicoid was the only velocity instrument which, when tried upon the whirling machine, was found to give readings entirely independent of the velocity, but the variation in the case of the Air Meter is too small to be of much importance. As previously stated, 2½ per cent. has been added to all amounts given by the Air Meter.

Reasons for the difference.

There are, I think, three points which must be taken into account in considering the records of the different instruments. They were all tried, and their constants determined on a whirling machine, in which case the motion was quite steady. The natural wind is anything but steady either in direction or intensity, and both these differences between the actual wind and the artificial wind of the whirling machine may be important. The third point is the way in which a high or low velocity will affect each instrument.

Effect of a Light Wind.

Taking this first; if the wind drops to a dead calm, both the tube and pressure plate will continue to indicate a velocity exceeding 6 miles per hour, although the friction has been reduced as much as possible. It is probable that most recording pressure instruments require a velocity of at least 10 miles per hour before they move at all. With the velocity instruments the reverse effect occurs—before the velocity has dropped to zero they have ceased to move, and hence it is inevitable that in a light wind the pressure instruments will be too high and the velocity instruments too low.

As the wind increases, this discrepancy is greatly lessened in two ways: the periods of comparative calm become fewer and also of less duration, and the whole amount registered being larger, the error, as well as being numerically less, becomes also of less consequence when compared with the whole. Probably it may be considered to vanish when the mean velocity exceeds 20 miles per hour.

Effect of Variations in Intensity.

With regard to variations in intensity, it can be shown that they cause the mean velocity recorded by the tube anemometer to be too high. If a table be constructed giving the force corresponding to each velocity, it will be seen that when the velocity is high, a slight change in its value produces a considerable change in the force, whereas when the velocity is low a considerable change in its value is required to make the same change in the force. The result is that when the wind drops to a low velocity the pen requires some considerable time to approximate to its proper position, but when the wind rises to a high velocity, the time required is trifling. This may be put in another way. The force required to overcome the friction of the pen and carriage is from 50 to 100 grains, hence when the wind drops to 5 miles per hour, the pen hardly falls below the position indicating 7 miles per hour, because the force then acting upon it becomes less than 100 grains. On the wind rising to 20 miles per hour the pen has to rise above the position corresponding to 19 before the force acting upon it is less than 100 grains. To put the matter to a practical test, artificial pressures corresponding to 5 and 21 miles per hour were produced, changing suddenly from one to the other and back again at intervals of 15 seconds. The curve thus produced gave a mean of 14·4 instead of 13 miles per hour. A precisely similar argument will apply to the pressure plate. It may safely be said that the error thus caused will decrease as the mean velocity increases, but it is doubtful if it ever vanishes. Very great and sudden variations do occur, several times the pen of the pressure plate has jumped up between 3 and 4 inches (30 and 40 miles per hour) in a fraction of a second; during the gale of November 11th, 1891, it rose from zero to above 60 miles per hour in a time which was certainly less than half a second, and variations of from 10 to 20 miles in half a second occur frequently 4 or 5 times a minute in every gale. This must make the mean velocity recorded by the Tube Anemometer and the Pressure Plate too high. This variation has a very marked effect on the Robinson cups, which take up a velocity more quickly than they lose it. For a steady wind of 10 miles per hour the factor appears to exceed 3, but for a natural wind, of a mean velocity of 10, comparison with the Air Meter gives a factor of about 2. As pointed out in the Report of the Wind Force Committee (*Quarterly Journal*, Vol. XVI. p. 33) it is possible to get experimentally as low a factor as 1·50 in this manner.

So far as can be judged the effect upon the Air Meter and Helicoid Anemometer is *nil*.

Effect of Variations in Direction.

There can be no doubt but that sudden variations in the direction also occur. This is shown by the way in which a lightly hung vane will swing completely round, and also by the flapping of a flag or similar object. These variations will not affect the Robinson Anemometer, as it is entirely independent of wind direction. It is probable that they do not act upon either the Pressure Plate or the Tube Anemometer, for the normal pressure upon a square foot plate has been found to vary but little until the angle of incidence exceeds 45° (*Proceedings of the Royal Society*, Vol. XLVIII. p.233), and the Tube Anemometer was found to be independent of wind direction, so long as the axis of the tube was within 15° of the direction of the wind. The case, however, is different with the Helicoid Anemometer and Air Meter. Trials were made upon the whirling machine with the axes of both these instruments inclined at small angles, and it was found that the Air Meter was considerably, and the Helicoid slightly, affected. It may, perhaps, be said that in common use the vane should keep the axis truly pointing to the wind, but it must be remembered that the vane cannot act until the wind direction has changed, and that the air which strikes the vane obliquely and turns it round also strikes the sails of the instruments obliquely. It follows, therefore, that for a wind in which the changes of direction are sudden and frequent, the readings of the Helicoid Anemometer and of the Air Meter will be too low, and that the error in the case of the Air Meter will be the greatest. For strong winds the Air Meter is a little below the Helicoid, and it seems probable that the difference may be due to this cause.

Summary.

A light wind causes the pressure instruments to be too high and the velocity instruments too low, but the error vanishes with a strong wind.

Variations in intensity increase the readings of the Robinson and pressure instruments, but do not affect the Helicoid or Air Meter. The error decreases with increase of velocity, but probably never quite vanishes.

Variations in direction do not affect the Robinson or pressure instruments, but make the readings of the Helicoid and Air Meter too low.

On the whole the mean recorded by the Pressure Plate and Tube must be above the true value, and the mean recorded by the Helicoid and Air Meter must be below the true value.

Remarks on the different Instruments.

It may be well that I should give the result of my experience as to the advantages of the different instruments.

The Robinson Cups are very simple, strong, and independent of the direction of the wind; it also appears from this investigation that the factor of the Kew Pattern type is practically constant. It is an objection that the large sizes offer great resistance to the wind, and therefore require a very strong and rigid support. During light winds the registration must depend on the order in which the instrument is kept, but I think that a Kew Pattern instrument must be in a very bad and dirty condition indeed before its registration is much altered during a gale. It hardly seems necessary to add how very desirable it is that instruments of certain definite sizes and proportions only should be made and used.

The Helicoid Anemometer is quite independent of friction, for all excepting light winds, and different sizes read alike, but it is not so simple in construction as the cup form, and its readings are liable to be altered by comparatively slight damage to the blades.

The Air Meter consists of a single screw blade formed of thin aluminium and made as nearly as possible into the exact shape of a portion of a Helicoid. A similar instrument with a larger blade, and with the dial protected from the weather, would probably form a useful and correct Anemometer. It would be light and offer a very trifling resistance to the wind.

The oscillations of the pressure plate must have been considerably damped by the action of the floating weight, but as it was, they were sufficiently violent. It is perhaps a question as to how far it is desirable to allow these oscillations. The extreme pressures which occur are of very short duration, and they can only be recorded by an instrument which moves quickly. On the other hand, if it move too quickly, its momentum may carry it too far, and it seems probable that the remarkably high values sometimes given by the Osler Pressure Plate may be due to the inertia of the moving parts.

The Tube Anemometer appears to me to possess numerous advantages. The head is simple in construction and so strong that it is practically indestructible by the most violent hurricane. The recording apparatus can be placed at any reasonable distance from the head, and the connecting pipes may go round several sharp corners without harm. The power is conveyed from the head without loss by friction, and hence the instrument may be made sensitive to very low velocities without impairing its ability to resist the most severe gale. The quickness with which the recording apparatus follows the variations of the wind depends on the length and diameter of the connecting pipes, and may be altered at pleasure by a valve placed in one of them. It has been previously shown that the mean recorded seems to be nearly independent of the size of the pipes.

Factor of the Kew Pattern.

With regard to one most important point in connection with this investigation, namely, the determination of the factor of the Kew Pattern Robinson Anemometer, these comparisons prove conclusively that it must lie between 2·00 and 2·27. Reasons have been given which at least partly explain the difference of 13 per cent. between the two classes of instruments; and if these reasons be the right ones, the record of the velocity instruments should be accepted as more likely to be correct, at any rate for the high velocities. In this case the factor is slightly above 2·00. If, however, the pressure instruments give the right value, the factor is 2·27. Probably for a steady wind the higher value is best, but for a gusty wind the lower value, viz. 2·00, is most correct.

I think that if 2·10 be taken as the factor, we may be certain of being within 5 per cent. of the truth, and that there is a very great probability that this value is within 2½ per cent. of the right one.

It should be added that no correction has been made for the height of the barometer, or for temperature. The observations have been made with an average pressure of about 29·50 ins., and within the limits of 32° and 50° F. of temperature.

DISCUSSION.

Prof. J. K. LAUGHTON said he did not feel in a position to criticise the paper. The investigation carried out by Mr. Dines went so far beyond any inquiries or studies of his own, that criticism would, in fact, be almost impudent. On one point, however, he felt a glow of modest pride. Ten years ago, when addressing the Society on the subject of anemometry, he had ventured to remark that some radical reformation of the head of anemometers was required, rather than improvements and modifications of the recording apparatus. He might, perhaps, be allowed to flatter himself that these remarks had exercised some influence in directing the course which Mr. Dines had pursued. He was delighted to learn that Mr. Dines, by his ingenious modification of the tube form of anemometer, had successfully overcome the serious difficulties which had hitherto been experienced with this description of instrument. The tube anemometer had always been a favourite fancy of his own, and it was interesting to find that it could be made to give such satisfactory results as were shown in Mr. Dines's comparisons.

Mr. LATHAM said that he, with other gentlemen interested in this investigation, had visited Mr. Dines's establishment and had witnessed the thorough manner in which the comparisons had been conducted. It was only by personal inspection of the apparatus and means devised by Mr. Dines for efficiently carrying out this inquiry that the value of the work could be properly appreciated. Every meteorologist could not but feel extremely grateful to Mr. Dines for the pains he had taken and the excellent results that had been obtained. Mr. Dines had so thoroughly mastered the whole subject that any criticism of the results of his labours was out of the question. He thought the results of this comparison tended to restore confidence in the indications given by the Robinson cups.

Mr. WHIPPLE said that he sincerely thanked Mr. Dines for his valuable contribution to meteorological knowledge. He had visited Oxshott, in company with Mr. Munro, and had the pleasure of witnessing Mr. Dines's ingenious contrivances for recording the indications of the anemometers, and also of listening to his concise explanation of the methods adopted. He (Mr. Whipple) was particularly delighted with the excellent use which had been made of the tube form of anemometer. The modification of the principle of Hagemann's anemometer, which Mr. Dines had devised in his arrangement of tubes, removed all sources of error which arose when it was desired to record the amount of pressure under the varying conditions of air pressure which were usually to be met with in rooms. He was not disposed to think, as did Mr. Latham, that our confidence in the Kew pattern Robinson anemometer was restored, for recent experience with cup anemometers had shown him that some observers rarely attended to the lubrication of these instruments in a proper manner, and consequently their indications were anything but reliable. The results from the tube anemometer appeared to point to the possibility of having a form of anemometer which did not require the use of mechanism. The nature of the fluid used in Mr. Dines's 'gas-holder' arrangement would perhaps require to be further considered, as, in this country at any rate, it would not always be possible to use water. There was a form of air-meter known as

'Lowne's' which was extensively used by engineers and others for measuring the velocity of air currents in chimney shafts, &c., and he should like to see some results of a comparison between this and other similar instruments in order to test the trustworthiness of its records. A number of these air-meters had been verified at Kew, but always by means of the whirling machine; and from what he knew of their performances the instruments appeared to give better indications in recent years than was formerly the case. He should like Mr. Dines to give some information as to the 'mounting' behind the circular pressure plate. He had been lately working with Richard's Anémo-Cinémographe, an instrument which much resembled the helicoid form of anemometer, and he had noticed that with light wind velocities, the instrument very closely followed the variations of wind force, certainly much better than large anemometers such as the Kew pattern Robinson.

Mr. Symons drew attention to the desirability of anemometers being properly exposed. Although for thirty years past it had been commonly known that anemometers placed on the tops of buildings were liable to be influenced by eddies, nearly every anemometer in the world was so placed. The continued use of the factor 3 for Robinson cups was hardly creditable, seeing that as long ago as 1874 it had been proved to be wrong, and as far back as 1879 the factor had been quoted in the *Quarterly Journal* (Vol. V. p. 211) as 2·3, while Mr. Dines's present paper gives 2·1 as the most probable value. If so, it follows that when a Robinson anemometer records a velocity of 80 miles an hour, the real velocity is 56. It would be very interesting if Mr. Dines would state what he considered to be the greatest real velocity and corresponding pressure that had occurred since his records commenced.

Mr. Dines, in reply, said that Mr. Laughton's remarks in his Address on 'Anemometry,' delivered in 1882, had originally started the idea of carrying out anemometrical investigations. As regarded Mr. Whipple's remarks concerning the use of water in the recording apparatus of the tube anemometer, that part of the instrument could be placed at any distance from the head, so that frost need not interfere with its action. Water, however, evaporated, and its use was open to objection on that account, probably paraffin oil would be a better fluid for the purpose. As regarded inattention to lubrication affecting the records from the Kew pattern Robinson anemometer, there was no doubt that if the cups were allowed to get dirty the indications for light winds were hopelessly wrong, but in a gale he did not think their dirty condition would make much difference. He had never had any experience with Lowne's anemometer, but it had the reputation, whether true or not he could not say, of going to pieces when subjected to a velocity exceeding 20 miles per hour. The circular pressure plate had practically nothing behind it which could influence its indications, the support being so small that it offered very little resistance. He certainly thought that it should not be stated on the Kew Observatory certificate of verification for anemometers that the instrument read so much 'per cent. of the *true amount*,' it having long been known that the factor 3 was wrong, and consequently that the 'true amount' was nothing of the kind. As regarded the question of exposure of anemometers on the top of houses, he had found eddies present at an elevation of 9 feet above the roof, but he thought the question required further experimental investigation. In reply to Mr. Symons's question, he believed that the greatest pressure which had occurred was between 11 and 12 lbs. per square foot during the gale of November 11th, 1891; a gale which had blown down at least ten trees within a quarter of a mile of the instruments.

Mr. Curtis wished to support what had already been said as to the skill and ingenuity shown by Mr. Dines in devising and carrying out his experiments. The whole series, so far as it related to anemometers, had been most complete, and it afforded the data which till now had been wanted for placing on a satisfactory footing the question of wind measurement. He would like to know if it was intended to make any practical use of the data, now that it had been obtained at the expenditure of so much time and trouble? The first thing to be done was to change the admittedly erroneous factor at present in use, for one more in accordance with the result of these experiments, although it must not be forgotten that Mr. Dines had worked only with the "wind-wheel," and without its being geared to the usual shafting and recording apparatus. In this connection he would like to emphasise the remark Mr. Dines had made near the close of paper, as to the desirability of limiting the sizes and proportions of the Robinson instruments, for at present makers seemed to regard this as a matter of absolutely no importance. Then again, these experiments made it clearer than ever that a house top is an entirely unsatisfactory place for an anemometer, owing to the eddies and deflections of the wind which are invariably set up by the building; more attention ought certainly to be paid to the question of exposure, and considerable alterations ought to be made in the conditions under which many anemometers were now kept at work. With regard to the sudden changes of direction, of which Mr. Dines had spoken, it was a fact that in well exposed places these were far less frequent than was generally supposed, and he did not anticipate that the helicoid or air meter would experience much loss from this cause, provided they were well exposed in a position free from artificially-caused eddies.

THE HURRICANE OVER THE WEST INDIES, AUGUST 18th-19th, 1891.

By FRANCIS WATTS.

(Communicated by the Meteorological Council.)

(Plate VIII.)

[Received January 27th—Read April 20th, 1892.]

On August 18th, 1891, a hurricane of great violence swept from the Atlantic into the Caribbean Sea. The following facts have been collected, and from them the extent and movement of the storm can be ascertained.

Taking the information in order from south to north :

From *Barbados* it is reported that on the evening of August 18th the wind was North-west to West, the barometer falling slightly, and the general aspect of the sky indicative of some atmospheric disturbance.

At *St. Lucia* (August 18th) at 4 p.m. the barometer began to fall, and continued falling until 7.30 p.m. when it began to rise again (the extent of fall not ascertained). The changes of the wind were as follows:—

3 p.m.	NNW	force 6
5.30 p.m.	WNW	do 6
6.30 p.m.	WNW	with very heavy rain and some sea from the west.
7 p.m.	WNW	force 4 - 5

Martinique. This Island experienced the full force of the hurricane; the earliest indications of approaching danger were the whitish haze visible on the afternoon of the 17th, and the halo round the moon at night; the following observations from *Le Moniteur de la Martinique* (Journal Officiel), of August 25th, very well describe the progress of the storm over Fort de France.

"The fall of the barometer began at noon, but it did not vary very much from normal rate until 4 p.m. At that time the leaden colour of the sky, the squalls which followed each other with considerable force, the barometer, which had already fallen to 758 mm. (29·84 ins.), were all signs which combined to give the alarm and warned seafaring people to be on their guard.

"At 5.30 p.m. the barometer stood at 757 mm. (29·80 ins.), and we perceived that Fort de France lay on the track of the cyclone. From that moment the gusts of wind became more violent, the barometer continued its downward movement and thick rain began to fall.

"The wind blew from North-east without intermission, proving that we were in the line of the centre.

"From 7 to 8.15 p.m. the wind blew a hurricane from the North-east; then suddenly the wind and rain ceased, the sky cleared, and an inexperienced observer would have believed in this treacherous calm. It was the passing of the centre of the cyclone. The barometer had fallen to 721 mm. (28·38 ins.)

"At 8.30 p.m. the hurricane recommenced, but from the South-west, now coming from a direction directly opposite to that from which it had blown at first; we passed at that moment into the second half circle of the cyclone, called by sailors the 'navigable semicircle.' At 9.30 the hurricane blew furiously, but the barometer rose and the wind veered to the South-east, showing that the phenomenon was leaving us. At 10.30 there were still strong gusts from the South-east, but comparatively weak, and coming like dying gasps of the devouring monster."

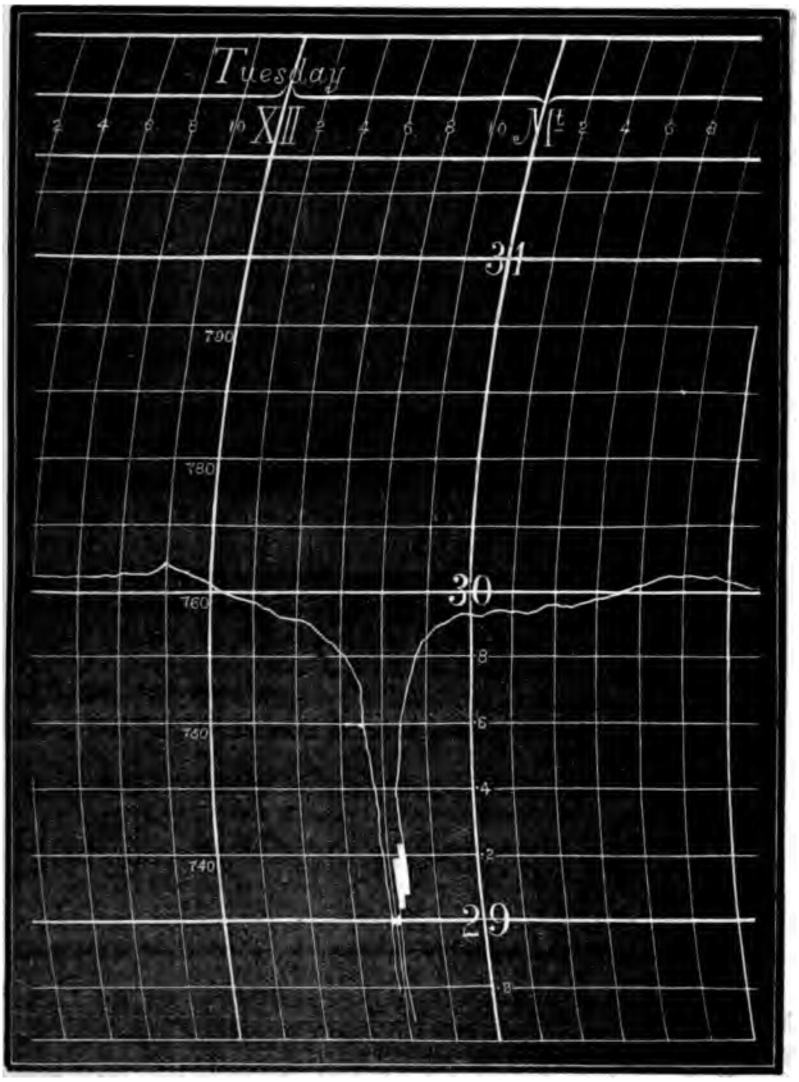
A self-registering barometer is kept at the Club, the Cercle de St. Pierre, and from the diagram[1] (p. 187) the movements of the barometer, and the time at which they occur, can be ascertained with great accuracy. The instrument failed to mark the paper for about 20 minutes, and this unfortunately at the time that the centre of the cyclone was passing, hence the full extent of the fall of the barometer was not registered. From about 8.15 until nearly 9 p.m. the barometer made a series of rapid rises and falls through a range of about a quarter of an inch.

From *Dominica* it is reported that the barometer fell about two-tenths of an inch during the morning of the 18th, and that the total fall during the day was only about ·25 in. or ·30 in. Heavy showers fell during the morning, and in the afternoon the wind began to blow in violent gusts from the East-north-east, increasing in violence up to midnight, the wind slowly veering to East, East-south-east, and by morning to South-east. Lightning was frequent, but there was no thunder.

From the Report of Captain F. W. Powles, R.M.S. *Esk*, the force of the wind from 8 p.m. until 1 a.m., during which time the *Esk* was off the island, was 10 to 11 of Beaufort's scale.

The R.M.S. *Esk* left St. Pierre, Martinique, at 2.30 p.m., thus escaping the full violence of the hurricane. Captain Powles has communicated the following interesting report (p. 187).

[1] We are indebted to Mr. Symons for the loan of this block.—EDITOR.



Barogram at Martinique, August 18th–19th, 1891.

Extracts from the Log R.M.S. *Esk*, August 17th–19th, 1891.		Wind.	Barometer.
August 17th.			In.
5.30 p.m.	Left Barbados for St. Pierre. Fine, but hazy	NE to ENE, 3–4	30·17
Midnight.	Fine and clear. A film over sky and halo round moon	ENE, 3	30·20
August 18th.			
4 a.m.	Squally. Sea moderate	ENE, 3	30·17
6 „	Fine. Arrived at Castries, St. Lucia	ENE, 4	30·19

Extracts from the Log R.M.S. *Esk*, August 17th–19th, 1891—*Continued.*

		Wind.	Barometer.
AUGUST 18th.			
8 a.m.	Rainy; at 8.30 left St. Lucia. Prolonged squalls and rain	NE, 7–8	In. 30·15
9 "	Overcast with rain	NE to NNE, 7	30·20
10 "	Do.	NE to NNE, 6	30·17
11 "	Overcast sky	NE to NNE, 5	30·16
Noon.	Fine and cloudy	ENE, 3	30·13
1 p.m.	Arrived at St. Pierre, Martinique. Moderate and cloudy	NNE, 4	30·10
2 "	Moderate and cloudy. 2.30 left Martinique	NE, 5	30·07
3 "	Strong squalls and heavy rain. Sea rising from ENE	NE, 7	30·03
4 "	Heavy rain and high sea	ENE, 6	30·00
5 "	Overcast, with rain at times	ENE, 7–9	29·96
6 "	Very threatening sky, but less wind; a break in the sky to the West; observed the sun for a few minutes	ENE, 6–4	29·96
7 "	At Dominica. Heavy rain	ENE, 4	30·01
7.30 "	Violent squalls and heavy rain	ENE, 7–10	29·99
8 "	Do. do. Left Dominica and steered NW by N	ENE, 10	29·99
9 "	Violent gale, with terrific squalls and rain	ENE, 11	29·97
10 "	Do. do. Lightning to the southward	ENE to E, 11	30·02
11 "	Do. do. Heavy rain	E, 11	30·03
Midnight.	More moderate	E, 7–8	30·02
AUGUST 19TH.			
1 a.m.	Violent squalls. Lightning, thunder and heavy rain	ENE to E, 10–11	30·02
2 "	Overcast; squalls less violent	E to ESE, 9–10	30·03
3 "	Do. do.	ESE to SE, 9	30·04
4 "	Very heavy rain and hard squalls	ESE to SE, 9	30·03
5 "	Do. do.	ESE, 9	30·06
6 "	Violent squalls and heavy rain	SE, 9	30·11
7 "	Less rain; sky clearer. Guadeloupe in sight, SE	SE, 9	30·10
8 "	Weather clearing to SE. Sea high from SE to S	SE to ESE, 9	30·15
To Noon.	Weather clearing up rapidly. A heavy bank of clouds sinking to the WNW	..	..

"The hurricane was of small diameter, probably not more than 80 miles, but of great violence, the centre passing over Fort de France between 8.15 p.m. and 8.30 p.m. of the 18th August; the direction of the wind changing from North-east to South-west at that time (*Le Propagateur*, quoting Journal Officiel, August 26). The hurricane was of greatest extent north of the centre, for at St. Lucia, 30 miles south of the centre, the wind did not blow with great force. From information I obtained from the Harbour Master there, the wind was at 3 p.m. North-north-west, force 6; at 5.30 p.m. West-north-west, force 6; at 6.30 West-north-west, with very heavy rain and some sea from the westward; at 7 p.m. the rain ceased and the sea went down. But at Dominica at 8 p.m. the wind was East-north-east, force 10, nearly 50 miles from the centre. The disturbance did not reach very high in the atmosphere. While the hurricane was approaching occasional breaks in the sky showed the higher clouds to be nearly motionless. Cumulus was seen travelling slowly from north-east. At 6 p.m. on the 18th at Dominica the sun was seen for a few minutes, when the upper clouds were not moving with any rapidity. The air was drier than usual in the advancing portion of the storm.

"At Dominica I am told that the wind came from the Southward about 11 p.m., and at 2 a.m. the heaviest sea was experienced.

"At Martinique the fall of the barometer is reported to have been as follows:—

At St. Pierre	1·417 ins.
At Fort de France	2·165 ins.
At Morne Rouge	3·149 ins.

"This last is so great that I think it probable the height of the barometer above sea level may not have been allowed for.

"The earliest signs were in the sky. The haze seen on the afternoon of the 17th and the halo round the moon were unusual. The barometer did not give any decided warning on board the *Esk*.

"The fall of the barometer at St. Pierre was very rapid while the centre was passing over Fort de France, from 6 to 8 p.m. it fell 1·101 ins., and rose again in the next two hours to about the same height."

From *Montserrat* an interesting series of observations has been forwarded by Mr. F. Driver.

August.	Time.	Wind Direction.	Force.	Barometer.[1]
				Ins.
18......	10 p.m.	ENE	6	29·65
19......	2 a.m.	NE	7	29·62
	9 ,,	E	8	29·64
	10 ,,	ESE	7	29·68
	10.30 ,,	ESE	6	29·70
	12.30 ,,	ESE	3	29·65
	2 p.m.	ESE	6	29·64
	4 ,,	SE	5	29·63
	7 ,,	SE	3	29·65

[1] The barometer is an aneroid, situated 400 feet above sea level; the readings are uncorrected.

Antigua was so far removed from the hurricane track as to experience little more than a moderate gale; the barometer fell very little, but the rapid motion of the lower clouds, together with the steady veering of the wind, pointed to a cyclonic disturbance to the southward. At 5.30 p.m. the wind was blowing from North-north-east to North-east, and the lower clouds were moving with some rapidity, while an upper stratum of cirro-cumulus cloud appeared quite motionless; thus confirming Captain Powles' observation that the "disturbance did not reach very high in the atmosphere." By about 9·30 the wind was East, force 5, slowly veering to South-east by morning with force 2 to 3 at 9 a.m. on the 19th. The greatest force of the wind during the night of 18th did not exceed 6-7. The following were the readings of the barometer at the Government Laboratory (corrected for height above sea level):—

August.	Time.	Wind.	Force.	Barometer.
				Ins.
18......	9 a.m.	ENE	4	30·193
,, ...	3 p.m.	NE	4	30·128
19......	9 a.m.	SE	2	30·122
,, ...	3 p.m.	SE	2	30·078

The record of the self-recording barometer during the same period shows how slight was the barometric disturbance at this spot. The disturbance on the morning of August 24th was much more evident; but no information respecting a cyclone on this date has been received.

The following extracts from the Log of R.M.S. *Tyne* serve to show the conditions on the extreme northern edge of the cyclonic area:—

August.	Time.	Position.	Wind.	Force.	Barometer.
					Ins.
18......	4 p.m.	Anguilla	NNE	4	30·12
,, ...	8 ,,	Off St. Martin's	NE	4	30·09
,, ...	Midnight	Off Saba	ENE	5	30·06
19......	2 a.m.	....	E	6	30·02
,, ...	4 ,,	Off Eustatius	E	5	30·04
,, ...	6 ,,	St. Kitts	E	5	30·04
,, ...	8 ,,	Nevis	E	5	30·06
,, ...	10 ,,	Off Nevis	ESE	5	30·06

Weather very hazy on evening of 17th and morning of 18th.

The subsequent course of the storm is described in the *Pilot Chart* of the North Atlantic for September, 1891, published by the United States Hydrographic Office:—"The data thus far received are too incomplete to allow of plotting the track of the hurricane with any certainty, although it appears to have moved about North-north-west over Santo Domingo, and thence northward and eastward." The accompanying chart (Plate VIII.) gives the track as plotted on the Pilot Chart, which traces it up to the 28th in 60°W and 35°N.

The facts here given summarise the whole of the information received respecting this particular storm.

CLIMATOLOGY.

Thirteenth Annual Exhibition of Instruments,

Held, by permission of the Council of the Institution of Civil Engineers, at 25 Great George Street, Westminster, S.W.,

MARCH 15TH TO 22ND, 1892.

THERMOMETERS AND SCREENS.

Climatological Station. Instruments necessary for the equipment of a Climatological Station, viz.:

Stevenson Thermometer Screen, fitted with
Dry Bulb Thermometer.
Wet Bulb "
Maximum "
Minimum "
Rain Gauge and Measuring Glass.

Exhibited by THE METEOROLOGICAL COUNCIL.

Richard's Thermograph. The thermometer consists of a very thin curved metal case (a Bourdon tube) containing alcohol, one end being a fixture and the other moveable. As the alcohol expands or contracts with the changes of temperature it alters the curve of the tube, making it flatter or otherwise. The end of the tube communicates its motion by means of a metal rod to a lever carrying a pen, which marks on a graduated paper wound on a cylinder. A clock turns the cylinder round once in seven days. *Exhibited by* MM. RICHARD FRÈRES.

Casella's Mercurial Minimum Thermometer. At a short distance from the bulb a small bent tube with a large bore joins the indicating tube. At the upper end of this bent tube there is a flat glass diaphragm, which is formed by the abrupt junction of a small chamber, the inlet to which is larger than the bore of the indicating tube. The result of this is that on the thermometer being set, the contracting force of the mercury in cooling withdraws the fluid in the indicating stem only, whilst on its expanding with heat the long column does not move, the increased bulk of mercury finding an easier passage through the larger bore into the small pear-shaped chamber attached.

Exhibited by L. P. CASELLA, F.R.Met.Soc.

Bifurcated Grass Minimum Thermometer. Extra sensitive for observations of terrestrial radiation.

Exhibited by L. P. CASELLA, F.R.Met.Soc.

Symons's Earth Thermometer. This consists of a sluggish thermometer mounted in a short weighted stick attached to a chain, and an iron pipe which is drawn out at the bottom to a point for driving into the earth. The thermometers exhibited are for the depths of 1 and 4 feet.

Exhibited by L. P. CASELLA, F.R.Met.Soc.

6. **Case for holding Meteorological Instruments under a Thatch Shelter at Stations in Tropical Africa.** This is the first made, and future ones will be slightly modified. The dimensions are such that all the instruments, including the rain gauge, can be sent inside; the stand is wholly of metal, so as not to be deranged by changes of the hygrometric condition of the air. *Exhibited by* H. S. WALLIS, F.R.Met.Soc.

7. **Pneumatic Thermometer for recording the variations of temperature at a distance.** *Exhibited by* Messrs. NEGRETTI AND ZAMBRA.

SUNSHINE RECORDERS AND ACTINOMETERS.

8. **Campbell's Sunshine Bowls,** exhibiting the effects of Sunshine during the half years ending June 21st and December 21st, 1891. *Exhibited by* THE METEOROLOGICAL COUNCIL.

9. **Campbell-Stokes Sunshine Recorder.** This consists of a sphere of glass 4 inches in diameter, supported on a pedestal in a metal zodiacal frame, which is grooved for holding the cards. *Exhibited by* THE METEOROLOGICAL COUNCIL.

10. **Sunshine Recorder,** with adjustments for use in any latitude. *Exhibited by* Messrs. NEGRETTI AND ZAMBRA.

11. **Whipple-Casella Sunshine Recorder.** The instrument is furnished with divided latitude and declination circles, and thus can be easily set for any locality and for any day in the year. *Exhibited by* L. P. CASELLA, F.R.Met.Soc.

12. **Jordan's Sunshine Recorder.** First Pattern. (March 1885.) This instrument consists of a cylindrical box, on the inside of which is placed a strip of cyanotype paper. Sunlight being admitted into this box by three small apertures, is received on the paper, and travelling over it by reason of the earth's rotation, leaves a distinct trace of chemical action. *Exhibited by* J. B. JORDAN.

13. **Jordan's Sunshine Recorder.** Improved pattern. (November 1885.) In this instrument two apertures are used instead of three. *Exhibited by* Messrs. NEGRETTI AND ZAMBRA.

14. **Jordan's Sunshine Recorder.** New pattern. (March 1888.) The improvement in this instrument over the others consists in using two hemi-cylindrical boxes, one to contain the morning and the other the afternoon record. An aperture for admitting the beam of sunlight is placed in the centre of the rectangular side of each box, so that the length of the beam within the chamber is the radius of the cylindrical surface on which it is projected; its path therefore at all seasons follows a straight line on the paper. The hemi-cylinders are placed with their diametral planes at an angle of 60°. *Exhibited by* Messrs. NEGRETTI AND ZAMBRA.

15. **McLeod's Photographic Sunshine Recorder.** This instrument consists of a glass sphere silvered inside and placed before the lens of a camera, the axis of the instrument being placed parallel to the polar axis of the earth. The light from the sun is reflected from the sphere, and some of it passing through the lens forms an image on a piece of cyanotype paper within the camera. In consequence of the rotation of the earth, the image describes the arc of a circle on the paper, and when the sun is obscured this arc is broken. *Exhibited by* THE KEW COMMITTEE.

Chemical Photometer devised by Sir H. Roscoe, M.P., F.R.S. By means of this instrument a strip of paper is so exposed to daylight that the time requisite to produce a definite chemical effect can be calculated to seconds. The paper is prepared by pasting pieces of standard sensitive paper upon a band, and inserting this into a thin metal slide having a small opening at the top, furnished with a cover, which can be made instantly to open or close the hole under which the sensitive paper is placed. (First Pattern, 1863.) *Exhibited by* THE KEW COMMITTEE.

Herschel's Actinometer, for ascertaining the absolute heating effect of the solar rays, in which time is considered one of the elements of observation. The instrument consists of a large cylindrical thermometer bulb, with a very open scale, so that minute changes may be easily seen. The bulb is of transparent glass filled with a deep blue liquid, which is expanded when the rays of the sun fall on it. When taking an observation the actinometer is shaded for one minute and read off; it is then exposed for one minute to sunshine, and its indication recorded; it is finally shaded again, and its reading noted. The mean of the two readings in the shade, subtracted from that in the sun, indicates the expansion of the liquid produced by the sun's rays in one minute of time. *Exhibited by* THE KEW COMMITTEE.

Hodgkinson's Actinometer. This instrument consists of a thermometer with a spherical bulb one inch in diameter, and a tube, of which an inch and a half next the bulb is graduated. The fluid employed is alcohol coloured with a drop of pure aniline blue. The principle of the instrument is the same as that of Sir J. Herschel's. It was devised for mountain use, where the weight of Herschel's instrument and the fragility of its internal thermometers are elements of difficulty. A plain telescope tube of bright metal 18 ins. long and 2½ ins. in diameter, open at both ends, is pierced in its central section with a circular hole 1¼ to 1½ in. in diameter, from which springs a flanged shoulder projecting about ½ in. to receive a perforated split bung, which clasps the thermometer stem and holds the bulb firmly in the centre of the axis of the tube. Two caps, fitted with clear plate glass, are made to slide off and on at the two ends, to admit of the glasses being readily wiped. (*Proc. Roy. Soc.* Vol. XV. p. 321.) *Exhibited by* THE KEW COMMITTEE.

Pouillet's Direct Pyrheliometer. This instrument is composed of a shallow cylinder of steel which is filled with mercury. Into the cylinder a thermometer is introduced, the stem of which is protected by a piece of brass tubing. As the surface on which the sun's rays fall and the quantity of mercury within the cylinder are both known, the effect of the sun's heat upon any area can be expressed by stating that it is competent in five minutes to raise a given quantity of mercury so many degrees in temperature. *Exhibited by* THE KEW COMMITTEE.

Violle's Actinometer. *Exhibited by* THE KEW COMMITTEE.

Watkin's Actinometer. *Exhibited by* THE KEW COMMITTEE.

Decoudon's Photometer. *Exhibited by* THE KEW COMMITTEE.

SOLAR RADIATION INSTRUMENTS.

Black and Bright Bulb Thermometers in vacuo, mounted in an upright position with the bulbs uppermost (as used at the Montsouris Observatory, Paris). *Exhibited by* Messrs. NEGRETTI AND ZAMBRA.

Solar Radiation Thermometer in vacuo, with mercurial test gauge. *Exhibited by* Messrs. NEGRETTI AND ZAMBRA.

25. **Richard's continuously recording Black and Bright Bulb Solar Radiation Thermometers.** *Exhibited by* MM. RICHARD FRÈRES.

26. **Hicks's Black-bulb Maximum Thermometer** *in vacuo*, with platinum wires and battery for testing the vacuum.
Exhibited by J. J. HICKS, F.R.Met.Soc.

27. **Hicks's Radio-Solar Thermometer.** This is the ordinary Black-bulb Maximum Thermometer *in vacuo*, but having at the end of the outer jacket a second chamber in which is mounted vertically one of Crookes' radiometers for indicating the vacuum.
Exhibited by J. J. HICKS, F.R.Met.Soc.

28. **Frankland's Self-registering Differential Solar Thermometer** for recording the maximum solar intensity (*Proc. Roy. Soc.* Vol. XXXIII. p. 338). *Exhibited by* L. P. CASELLA, F.R.Met.Soc.

29. **Southall's Helio-Pyrometer,** for testing the accumulated heat of the sun in a confined blackened space, under glass. A black bulb maximum thermometer is laid on a cushion at the bottom of a box, the sides of which are also cushioned, and a thick piece of plate glass covers the top to prevent currents of air carrying off the heat, also with the view of preventing the cooling effects of terrestrial radiation. The box is placed in such a position that the sun's rays may strike as nearly as possible perpendicularly on the glass. A small vessel is also added, in which water boils in the box, a piece of tube carrying off the steam.
Exhibited by L. P. CASELLA, F.R.Met.Soc.

30. **Experimental Black-bulb Maximum Thermometers** *in vacuo* and apparatus for comparing the same with the heat radiated from an Argand gas burner. *Exhibited by* THE KEW COMMITTEE.

HYGROMETERS.

31. **Saussure's Hair Hygrometer.** This consists of a brass frame with a hair fastened at one end by an adjustable screw and at the other passed round a wheel carrying a long arm which travels over a graduated arc. A counterpoise weight is used to keep equal tension upon the hair.
Exhibited by G. J. SYMONS, F.R.S.

32. **Two Old Patterns of Saussure's Hair Hygrometers.**
Exhibited by G. J. SYMONS, F.R.S.

33. **Richard's Self-recording Hair Hygrometer.** The recording portion is similar to that of the barographs and thermographs made by this firm. The actuating portion is a wisp of about a dozen hairs fastened at each end, and stretched laterally by a small weighted lever, the elongation and contraction of the hairs causes motion of the lever and is thereby recorded on the cylinder. *Exhibited by* MM. RICHARD FRÈRES.

34. **Klinkerfues's Hair Hygrometer.** This differs from the Saussure hygrometer, as it is the stiffness of the hair which actuates the instrument and not the variation in its length. A wisp of half a dozen hairs, each two inches long, is fixed at each end, and in the middle is slightly twisted by a spring. The greater the dryness the more does the rigidity of the hairs stretch the spring, and on the contrary in damp weather the spring overcomes the power of the hairs. This variation is by simple mechanical means made to turn a hand on a graduated dial. The indications of the instrument are given in degrees of relative humidity.
Exhibited by THE METEOROLOGICAL COUNCIL.

35. **Kater's Hygrometer.** The active agent in this hygrometer is a twisted filament of the Indian Grass (*Andropogon contortum*). It is graduated from 0 to 1,000, 0 being laid off when the instrument was immersed in unslaked lime, and 1,000 when saturated with moisture.
Exhibited by G. J. SYMONS, F.R.S.

36. **Oat Beard Hygrometer**, or Pocket Damp Detector.
Exhibited by F. C. BAYARD, F.R.Met.Soc.

37. **Nicolle's Aqueous Meter.** A thin piece of wood cut across the grain contracts and expands according to whether the air is getting more dry or more moist; the change in the length of the wood is conveyed to a pointer on a dial which indicates by figures the relative humidity.
Exhibited by B. C. WAINWRIGHT, F.R.Met.Soc.

38. **Daniell's Hygrometer.** This consists of a glass tube bent at right angles at two points, with a bulb at each extremity. One of the bulbs, which is of black glass, is nearly filled with ether, in which is placed the bulb of a thermometer; the other bulb is covered with muslin. This muslin being wetted with a few drops of ether, evaporation takes place, which quickly cools the bulb, and thus condenses the vapour of the ether within. In consequence of this the ether inside the other bulb evaporates, and its temperature being thereby reduced, a ring of dew begins to be formed outside the black glass bulb. At this instant, the thermometer inside is to be read, as the reading gives the dew point of the air at the time, and the temperature of the air is to be read from the thermometer attached to the pedestal of the instrument.
Exhibited by G. J. SYMONS, F.R.S.

39. **Regnault's Hygrometer.** This consists of two very delicate thermometers, the bulbs of which pass through collars nearly to the bottom of two thin and highly polished silver cylinders. From near the bottom of these cylinders two tubes, which subsequently unite, pass to an aspirator. One of the silver cylinders has to be supplied with sufficient ether to completely immerse the bulb of the thermometer. The aspirator being filled with water and the tap at its base turned, air is drawn past the thermometer bulbs and through the two cylinders; in passing, however, through the one partly filled with ether, rapid evaporation is produced, the temperature falls, and when the cylinder is dimmed by the deposition of dew, that thermometer shows the dew-point temperature, and the other one that of the air.
Exhibited by Messrs. NEGRETTI AND ZAMBRA.

40. **Alluard's Hygrometer.** In 1877, Mons. Alluard introduced a somewhat modified form of Regnault's hygrometer. The modification consists in replacing the silver thimble by a brass tube of square section provided with various metal tubes to allow of the passage of air through the ether contained in the tube. Instead of the glass upon which Regnault's thimble was mounted, there are two windows in opposite sides of the square tube, near to the top. These enable the bubbling of the air through the ether to be watched. The sides of the tube are gilt and highly polished, and one of them is framed by a broad band of brass, gilt and polished in like manner. This surrounding band is very near to, but does not touch, the brass tube. The dew is therefore deposited on a flat gilt surface, and the identification of a deposit is rendered easier by the proximity of an unaltered surface with which to compare the cooled one. *Exhibited by* THE METEOROLOGICAL COUNCIL.

41. **Leslie's Hygrometer.** A glass tube bent siphon fashion is fixed with the bend downwards. Each upper extremity terminates in a hollow bulb. The tube contains rather more than enough coloured sulphuric acid to fill the whole of one leg. One of the bulbs is of blue glass, the other is covered with wet muslin like a wet bulb thermometer; the result of the cooling thereby produced is to cause the air in that bulb to contract, and the liquid to rise in the vertical tube of which it is the terminal. Hence the readings indicate the rate of evaporation.
This is an application of Leslie's Differential Thermometer.
Exhibited by Messrs. NEGRETTI AND ZAMBRA.

42. **Jones's Hygrometer.** The tube of the thermometer is bent so as to bring its bulb vertical and parallel with its stem. The bulb is 1 in. long and of a conical shape with a flattened top or surface of black glass projecting a little beyond the sides. Below the flat surface this bulb is covered with black silk. The hygrometer is mounted and supported on a brass stand in such a manner that the black surface can be inclined towards the light. When used the thermometer is first to be read, ether is then poured on the silk cover of the bulb, and the condensation of moisture takes place upon the black surface of the bulb. Then by again noting the temperature the dew point may be known.
Exhibited by Messrs. NEGRETTI AND ZAMBRA.

43. **Dines's Dew Point Hygrometer.** A little water and ice, or cold water only, is put into the cup and allowed by a tap to flow gently through a small chamber, whence it rises through a perforated diaphragm into the space under a slab. In this space, which is covered water-tight by a thin smooth piece of silver, or of black glass, rests the bulb of a sensitive thermometer, the water flowing gently from the spout cools the cover and the contained thermometer; when the temperature reaches the dew point, a decided film of dew will be visible, the temperature being shown by the thermometer. The tap enables the rate of flow of the water to be regulated with accuracy, and the temperature of the water under the glass slab to be thereby kept at any required point.
Exhibited by L. P. CASELLA, F.R.Met.Soc.

44. **Dines's Dew Point Hygrometer with latest improvements.** This instrument can be used with water, but has been mainly designed for use with ether. When ether is used, it is poured down the inclined pipe, and remains in the front part of the chamber. A piece of metal tube, ground so as to fit closely the inclined pipe, and with an aspirator attached, is then inserted, and the dew-point is ascertained in the same way as by Regnault's hygrometer. (*Quarterly Journal Roy. Met. Soc.* Vol. VI. p. 39.) *Exhibited by* L. P. CASELLA, F.R.Met.Soc.

45. **Early pattern of Mason's Dry and Wet Bulb Hygrometer.**
Exhibited by G. J. SYMONS, F.R.S.

46. **Negretti and Zambra's Recording Hygrometer.** This consists of a Dry and Wet bulb thermometer (constructed on the principle of Messrs. Negretti and Zambra's Deep Sea registering thermometer) attached to a carrier and actuated by a timepiece. This may be set for any hour, and at the proper time it will cause the thermometers to turn upside down, and thus record the temperature at that moment. This instrument has the improved water receptacle arrangement suggested by Mr. Bayard. *Exhibited by* F. C. BAYARD, F.R.Met.Soc.

47. **Richard's Self-Recording Dry and Wet Bulb Thermograph.** This consists of a pair of thermometers similar to No. 2 which are placed side by side; but they are curved reversely and are placed as far apart as possible. The wet bulb thermometer is covered with muslin, and is kept moist by a water vessel below into which the muslin dips, and also by a capillary siphon from a second water vessel above.
Exhibited by MM. RICHARD FRÈRES.

48. **Aspirated Psychrometer,** a standard apparatus for the determination of the true temperature and humidity of the air. A special outfit of the instrument, adapted for the use of scientific travellers in the tropics, is also shown. *Exhibited by* Dr. R. ASSMANN.

49. **Lowe's Graphic Hygrometer.**
Exhibited by THE METEOROLOGICAL COUNCIL.

50. **Slide Rule for Hygrometric Calculations,** by J. Welsh, F.R.S.
Exhibited by THE KEW COMMITTEE.

51. **Stewart's Slide Rule.** *Exhibited by* THE KEW COMMITTEE.

51*. **Table to facilitate finding the Humidity of the Air,** by H. C. Russell, F.R.S. *Exhibited by* THE KEW COMMITTEE.

52. **Moisture Meter, or Scale for calculating at sight the Relative Humidity** from the readings of the dry and wet bulb thermometers. This consists of a metal disc graduated from 32° to 90°, with an outer moveable scale graduated from 25 to 100. To ascertain the relative humidity the outer scale is adjusted so that the 100 line with the arrow corresponds on the inner disc to the reading of the dry bulb. The index hand is then moved along the inner disc to the reading of the wet bulb, when it will at once indicate on the outer scale the Relative Humidity. *Exhibited by* W. MARRIOTT, F.R.Met.Soc.

RAIN GAUGES.

53. **Snowdon Rain Gauge,** with deep funnel for collecting snow. *Exhibited by* L. P. CASELLA, F.R.Met.Soc.

54. **Livingstone's Rain Gauge.** This is a 3-inch copper gauge with upright rim, copper receiver, and glass measure, as made for the late Dr. Livingstone. *Exhibited by* L. P. CASELLA, F.R.Met.Soc.

55. **Electric Self-Recording Rain Gauge.** This gauge is constructed on the assumption that all drops falling from an orifice or tube are identical in weight as long as the dimensions of the orifice are not varied. (*See Quarterly Journal Roy. Met. Soc.* Vol. XVIII. p. 6.) *Exhibited by* W. J. E. BINNIE, B.A.

56. **Wild's Rain Gauge as used in Russia.** This consists of two cylindrical zinc vessels. The upper receiver is fitted with a brass rim to prevent possible loss by splashing. The water passes from the upper receiver through a kind of sieve into the lower vessel, and any air forced in with it escapes through the lateral turned up tube. The water in the lower vessel is let into a graduated glass by the tap. *Exhibited by* THE METEOROLOGICAL COUNCIL.

57. **Tomes's Self-Recording Rain Gauge.** The funnel is connected by a tube with the receiving vessel, which contains a float; this is connected by means of a cord to a glass pen working in guides. The pen marks on a sheet of paper attached to a drum, which revolves once in twenty-four hours. The area of the rain gauge can be so proportioned to the area of the receiving vessel that the diagram can be drawn to any scale that may be desired. *Exhibited by* J. E. TOMES.

BAROMETERS.

58. **The Langdon Elbow Barometer.** This is a new form of mercurial barometer fitted with a movable cistern, which can be raised or lowered by a convenient mechanical arrangement from the front or top of the instrument. By this means a short oblique tube, not more than about 6 inches long, can be used, and great sensitiveness is obtained, the scale being sufficiently open to enable a reading to be easily noted to ·001 inch without the use of a vernier. The perpendicular height of the mercurial column is shown in inches—28, 29, 30, as the case may be—by an indicator which is acted upon by the same mechanical arrangement as is used for adjusting the movable cistern. By a special arrangement the correction for elevation can be made within certain limits, so that the barometer would indicate sea-level readings. *Exhibited by* J. H. STEWARD, F.R.Met.Soc.

59. **Self-recording Aneroid Barometer.** This is a small instrument, made to hang up, and fit into a mahogany case with glass front. The pen makes a dot on the paper every quarter of an hour.
Exhibited by J. J. Hicks, F.R.Met.Soc.

ANEMOMETER.

60. **Electrical Wind Indicator.** Consists of a vane revolving on a steel spindle, the extra weight of the tail of vane being sufficient to form contact round a small commutator on the spindle. The commutator plates are connected to an Electro Magnet Indicator by a small 8 wire cable, and showing 16 points of the compass.
Exhibited by G. W. Higham, Assoc.M.Inst.C.E.

MODELS, &c.

61. **Model of the Thames Valley**, contoured at intervals of 100 feet.
Exhibited by J. B. Jordan.

62. **Piece of Plate Glass starred during a Thunderstorm** on August 21st, 1879, at Wood House, near Finchley.
Exhibited by A. L. Ford, F.R.Met.Soc.

63. **Isothermals showing the mean monthly and annual temperature of the British Isles** on an average of 24 years ending 1880, by A. Buchan, LL.D. *Exhibited by* A. Buchan, LL.D.

64. **Isobars, showing the mean monthly and annual atmospheric pressure of the British Isles** on an average of 24 years ending 1880, by A. Buchan, LL.D. *Exhibited by* A. Buchan, LL.D.

65. **Mean Annual Rainfall of the British Isles** for the 24 years 1860 to 1884, by A. Buchan, LL.D. *Exhibited by* A. Buchan, LL.D.

MAPS AND DIAGRAMS.

66. **Isotherms, Isobars and Prevailing Winds of the Globe, by A. Buchan, LL.D.** A series of 52 maps from the Report of the Scientific Results of the voyage of H.M.S. *Challenger*.
Exhibited by A. Buchan, LL.D., F.R.S.E.

67. **Atlas der Meteorologie, Dr. Julius Hann.** Twelve maps printed in colour 1887. *Exhibited by* Justus Perthes.

68. **Atlas de la Distribution Géographique des Maladies** dans leurs rapports avec les Climats, par Dr. H. C. Lombard. Twenty-five maps printed in colours, 1880. *Exhibited by* Dr. W. Marcet, F.R.S.

69. **The Influence of Weather on Mortality in London** on different diseases at different ages, by A. Buchan, LL.D. and Sir A. Mitchell.
Exhibited by A. Buchan, LL.D.

70. **Diagram showing Death rate in London during the three recent Epidemics of Influenza** with the accompanying Weather.
Exhibited by C. Harding, F.R.Met.Soc.

71. **Map showing the Distribution of Blue Suns and Sunset Phenomena** round the world after the Krakatoa eruption, 1883.
Exhibited by Hon. F. A. R. Russell, F.R.Met.Soc.

72. **Chart of Curves showing the diurnal period** of nine meteorological elements at the Blue Hill Meteorological Observatory, Readville, Mass., U.S.A. *Exhibited by* A. L. ROTCH, F.R.Met.Soc.

73. **Rainfall of the Globe.** Comparative chronological charts of proportional fall at various stations on the basis of the means and extremes for the following complete periods respectively, viz.:—1846-85, 1851-85, 1861-85, and 1866-85. *Exhibited by* W. B. TRIPP, F.R.Met.Soc.

74. **Sketches of large Rain drops and Snow flakes.** *Exhibited by* E. J. LOWE, F.R.S.

75. **Maps showing the Mean Seasonal Temperatures** of the Counties of England and Wales. 4 maps. *Exhibited by* A. HAVILAND, M.R.C.S.

76. **Maps showing the Wheat Yield** in English and Welsh Counties. 4 maps. *Exhibited by* A. HAVILAND, M.R.C.S.

77. **Maps showing the mean percentage of Sunshine** over the British Isles. *Exhibited by* A. HAVILAND, M.R.C.S.

78. **Map showing the Geological Distribution of Deaths by Lightning** in England and Wales during the 15 years 1859 to 1873. Total deaths 241. *Exhibited by* A. HAVILAND, M.R.C.S.

PHOTOGRAPHS.

79. **A series of 32 Photographs of Clouds** taken under the direction of the Rev. Padre Denza by Sig. Mannucci at the Vatican Observatory. *Exhibited by* THE BRITISH ASSOCIATION COMMITTEE ON THE APPLICATION OF PHOTOGRAPHY TO METEOROLOGY.

80. **Photographs of Clouds** taken at the Säntis Observatory, Switzerland, in 1891. *Exhibited by* Prof. A. RIGGENBACH-BURCKHARDT.

81. **Photographs of Clouds** taken at Tunbridge Wells, August 3rd, 1891. Five views. *Exhibited by* Dr. F. G. SMART, F.R.Met.Soc.

82. **Photographs of Cumulus and Stratus Clouds.** *Exhibited by* Capt. D. WILSON-BARKER, F.R.Met.Soc.

83. **Lawrence Tornado, Mass., U.S.** Twenty Photographs, showing damage caused by this destructive Tornado. *Exhibited by* H. P. CURTIS.

84. **Photograph of Lightning** taken at Rosebank, near Cape Town, July 1888. *Exhibited by* E. H. ALLIS.

85. **Photograph of Lightning** taken at St. Palais-sur-Mer (Charante Inférieure), July 26th, 1891. *Exhibited by* PÈRE G. BASTOUL.

86. **Photographs of Lightning** taken at Newark, New Jersey, U.S., September 25th, 1891. Eight views. *Exhibited by* W. ARCHIBALD.

87. **Photographs of Lightning** taken at Uddevalla, Cattegat, Sweden, by Mons. O. Berggren, October 22nd, 1891. *Exhibited by* Prof. H. H. HILDEBRANDSSON, Hon.Mem.R.Met.Soc.

88. **Photograph of Lightning** taken at Melbourne, October 29th, 1891. *Exhibited by* R. LAW.

89. **Photographs of Lightning** taken at Calcutta. Four views. *Exhibited by* H. HAWARD.

90. **New York Blizzard.** Three Photographs. *Exhibited by* H. P. CURTIS.

91. **Blizzard at Shirenewton Hall, near Chepstow,** March 1891. Three Photographs. *Exhibited by* E. J. LOWE, F.R.S.

92. **Snow Scene.** The Bridle Path, Beddington, December 15th, 1890. *Exhibited by* G. CORDEN, F.R.Met.Soc.

93. **Hoar Frosts.** Seven Photographs of trees covered with rime, taken (in feeble daylight) in a garden at Upton, near Windsor, December 14th, 1890. *Exhibited by* R. BENTLEY, F.R.Met.Soc.

94. **Frost and Rime at Driffield,** December 22nd, 1891. *Exhibited by* J. LOVEL, F.R.Met.Soc.

95. **Snow and Rime on Trees.** Two views, taken in Switzerland, 1891. *Exhibited by* Prof. A. RIGGENBACH-BURCKHARDT.

96. **Aysgarth.** Three views:—1. Middle Force (from the South side). 2. Bridge, November 1890. 3. Upper Force, January 1891. *Exhibited by* Rev. F. W. STOW, F.R.Met.Soc.

97. **Engadine Scenery in Winter.** Three coloured Photographs. *Exhibited by* Dr. C. THEODORE WILLIAMS, P.R.Met.Soc.

98. **Two Photographs of Mentone.** 1 from the East; 2 from the West. *Exhibited by* Dr. C. THEODORE WILLIAMS, P.R.Met.Soc.

99. **Photograph of Funchal, Madeira.** *Exhibited by* Dr. C. THEODORE WILLIAMS, P.R.Met.Soc.

100. **Photograph of U.S. Signal Station, summit of Pike's Peak, Colorado,** altitude 14,115 feet. *Exhibited by* E. B. STURGE.

101. **Two Photographs of the Anemometer for vertical currents** recently installed at the Blue Hill Meteorological Observatory, together with specimen record from the anemometer. *Exhibited by* A. L. ROTCH, F.R.Met.Soc.

102. **Photographs of a new Aspirated Meteorograph for use in balloons,** especially in captive balloons, with specimens of traces obtained from the apparatus when attached to the captive balloon "Meteor," of the "Deutscher Verein zur Forderung der Luftschiffahrt." *Exhibited by* Dr. R. ASSMANN.

103. **Photographs showing the arrangement of the meteorological instruments** adopted for the ascents of the free balloon owned by the above Association. *Exhibited by* Dr. R. ASSMANN.

104. **Photograph of Contoured Model of the British Isles, and surrounding sea area.** Contoured at intervals of 250 feet. *Exhibited by* J. B. JORDAN.

105. **Photograph of Model of London and neighbourhood,** contoured at intervals of 25 feet. *Exhibited by* J. B. JORDAN.

106. **Photograph of the late Dr. R. J. Mann,** President of the Royal Meteorological Society, 1873-1876. *Exhibited by* Dr. C. THEODORE WILLIAMS, P.R.Met.Soc.

G. J. SYMONS, F.R.S., }
JOHN W. TRIPE, M.D., } *Secretaries.*

WILLIAM MARRIOTT, *Assistant Secretary.*

PROCEEDINGS AT THE MEETINGS OF THE SOCIETY.

March 16th, 1892.

Ordinary Meeting.

C. Theodore Williams, M.A., M.D., President, in the Chair.

William Price Biden, L.R.C.P., La Tour Jeanne, Hyères, Var, France;
Arthur Frank Bowker, F.R.G.S., Halling Cottage, near Rochester;
John Langdon Haydon Langdon-Down, M.D., 81 Harley Street, W.; and
Sir Richard Quain, Bart., M.D., LL.D., F.R.S., 67 Harley Street, W.,
were balloted for and duly elected Fellows of the Society.

The following Letter was read:—

"Whitehall, 18 February 1892.

"Sir,

"I have had the honour to lay before The Queen the loyal and dutiful Resolution which has been adopted at the Annual General Meeting of the Royal Meteorological Society, on the occasion of the death of His Royal Highness The Duke of Clarence and Avondale, K.G.; and I have to inform you that Her Majesty was pleased to receive the Resolution very graciously.

"I have the honour to be,
"Sir,
"Your obedient servant,
"Henry Matthews."

"The Secretary of the
"Royal Meteorological Society,
"22 Great George Street, S.W."

The following Paper was read:—

"The Value of Meteorological Instruments in the Selection of Health Resorts." By C. Theodore Williams, M.A., M.D., President. (p. 153.)

On the motion of Mr. Inwards, seconded by Mr. Scott, the thanks of the Society were given to the Exhibitors for the loan of their Instruments, &c.

The Meeting was then adjourned in order to afford the Fellows an opportunity of inspecting the Exhibition of Instruments relating to Climatology which had been arranged in the rooms of the Institution of Civil Engineers. (p. 191.)

April 20th, 1892.

Ordinary Meeting.

C. Theodore Williams, M.A., M.D., President, in the Chair.

Rafael Aquilar y Santillan, Sociedad Cientifica "Antonio Alzate," Mexico;
Sir Andrew Clark, Bart., M.D., LL.D., F.R.S., 16 Cavendish Square, W.;
Frederick William Cross, Assoc.M.Inst.C.E., 72 Corporation Street West, Walsall;
Herbert Hancock, M.A., Bancroft's School, Woodford Green, N.;
William Buller Heberden, 14 Gloucester Place, Portman Square, W.;
Hermann D. Weber, M.D., F.R.C.P., 10 Grosvenor Street, W.; and
Ernest Jenkins Williams, Sea Cliffe, Strete, near Dartmouth,
were balloted for and duly elected Fellows of the Society.

The PRESIDENT stated that he had, with great regret, to announce the death of Dr. TRIPE, which occurred on April 7th.

The following resolution, moved by Mr. SYMONS, seconded by Mr. BREWIN, and supported by Mr. MARRIOTT and Dr. BARNES, was unanimously adopted:—

"The Council and Fellows of the Royal Meteorological Society have heard with deep regret of the death of their esteemed Secretary, Dr. J. W. Tripe. He joined the Society in 1856, and since the year 1858, with the exception of one year, he has continuously held office, having served 3 years as Member of Council, 6 years as Vice-President, 2 years as President, and 23 years as one of the Secretaries.

"Dr. Tripe showed from the very first that he had the interests of the Society at heart. He took an active part in all schemes for rendering it more useful, and he was a most constant attendant at all its Meetings.

"The Council and Fellows desire to express their sincere sympathy with Mrs. Tripe and the other members of the family in their bereavement."

The following Papers were read:—

"ANEMOMETER COMPARISONS." By W. H. DINES, B.A., F.R.Met.Soc. (p. 165.)

"THE HURRICANE OVER THE WEST INDIES, AUGUST 18TH-19TH, 1891." By FRANCIS WATTS. (p. 185.)

CORRESPONDENCE AND NOTES.

"THE MAURITIUS HURRICANE, APRIL 29TH, 1892." By C. MELDRUM, LL.D., F.R.S.

Dr. C. MELDRUM, F.R.S., the Director of the Royal Alfred Observatory, Mauritius, has given the following account of the disastrous hurricane which swept over the island on April 29th, 1892:[1]—

The hurricane which raged for a few hours on April 29th, has in many respects been unprecedented in Mauritius.

Never till now has the island been visited by a hurricane at any time between April 15th and December 1st. Hitherto the hurricane season of Mauritius has been supposed to begin on the latter, and to end on the former day; and till now there has been no exception to the rule.

Nor was there any sign of danger till yesterday (April 29th), when the barometer began to fall rapidly and the wind to increase to a heavy gale. The suddenness, rapidity, and extent of the changes, which took place in the course of a few hours, are unparalleled in the annals of the colony.

The following Table will convey an idea of what changes took place in the barometric pressure and in the direction and velocity of the wind from 9 a.m. on the 24th to 9 p.m. on the 29th.

In the annexed Table the fall or rise in the barometric pressure is corrected for the daily variation, and from 9 a.m. on the 24th to 9 a.m. on the 29th, the mean hourly velocities of the wind are given, whereas, from 10 a.m. to 5 p.m. on the 29th, the rates of velocity per hour are given as obtained for intervals of two to five minutes.

It will be seen that at 2 p.m. on the 29th the barometer was at 27·990 ins.; that from noon to 2 p.m. it fell 1·045 in.; that from 3 to 5 p.m. it rose 1·012 in.;

[1] *The Daily Publisher and Les Petites Affiches.* Port Louis, Mauritius, May 13th, 1892.

Hour.	Barometer.		Wind.	
	Cor. & Red. to Sea Level.	Fall or rise per hour cor. for var.	Mean direction.	Velocity in miles per hour.
	Ins.	Ins.		
24th 9 a.m.	30·059	..	SE by E ½ E	8
27th 9 a.m.	29·903	..	E by S	15
28th 9 a.m.	·905	..	NE by E	12
4 p.m.	·816	—·003	NE by E	14
9 p.m.	·850	—·006	NE	12
29th 6 a.m.	·660	—·018	NE by E	22
8 a.m.	·630	—·029	NE, ¼ E	34
9 a.m.	·576	—·063	NE by E	35
10 a.m.	·480	—·094	NE by E ¼ E	40
11 a.m.	·338	—·131	NE by E	52
Noon	29·066	—·251	NE ¼ E	68
1 p.m.	28·517	—·532	NE ¼ E	96
2 p.m.	27·990	—·513	N	56
3 p.m.	28·034	+·048	WNW	68
4 p.m.	28·520	+·483	WSW	112
5 p.m.	29·059	+·529	SW	82
9 p.m.	29·719	+·151	SWrd.	26

and that from 5 to 9 p.m. it rose ·660 in. The absolutely lowest reading was 27·961 at 2.30 p.m., which is the lowest on record in Mauritius.

From 9 a.m. on the 28th to 1 p.m. on the 29th the mean direction of the wind did not vary much, but occasionally it showed a tendency to veer towards North, being at times from North-east by North to North-north-east. Between 1 and 2 p.m. on the 29th it, on the whole, veered to North, and between 2 and 3 p.m. to West-north-west, oscillating considerably, and soon after settling down at West-south-west.

After 11 a.m. the velocity of the wind increased much, being at 1 p.m. at the rate of 96·5 miles an hour, and at 1.20 p.m. at the rate of 104 miles. But from 1.30 to 2.30 p.m. there was a lull, the velocity decreasing to the rate of 43 miles an hour at 2.23 p.m. It then began to increase again, and at 3.47 p.m. was at the rate of 121·2 miles an hour; but it soon began to abate, being at the rate of 71 miles at 5.23 p.m., 60 miles at 6 p.m., 47 miles at 7 p.m., and 26 miles at 9 p.m. By this time the weather was fine, the sky partially clear, and here and there stars shining brightly.

Seeing that from 9 a.m. on the 24th to 9 a.m. on the 27th the barometer had fallen from 30·059 ins. to 29·903 ins., and that the wind, though light, had veered from South-east by East half East to East by South, a note was sent to the newspapers on the latter day stating that there was "heavy weather to the Northward," and that it had existed since the 24th; which, as usual in such circumstances, meant that there were indications of a cyclone away to the Northward, and that it was travelling from North-eastward to South-westward.

But the wind having by 9 a.m. on the 28th reached North-east by East, and the barometer at the same hour being higher than on the 27th, there was no apprehension; and in the afternoon of that day, the wind being still moderate from the North-east, and the barometer falling at the rate of only ·003 in. an hour, it was announced that there was no fear.

As already stated, it was only on the 29th that the conditions became unfavourable, and at 9.40 a.m. a telegram was despatched announcing that the barometer was falling at an accelerated rate.

Another telegram despatched at 11 a.m. announced that the wind was at the rate of 52 miles an hour in the squalls, and that probably its velocity would not exceed 56 miles an hour.

Soon afterwards the telegraph wires were broken, and all communication ceased.

The barometer continuing to fall at an accelerating rate, and the mean direction of the wind being nearly constant, it was inferred, contrary to long experience (the wind being from North-east), that the centre of the depression would probably pass over the island, and that the wind would then come from nearly the opposite direction. The centre, however, did not pass over the Observatory, but over a point about 8 miles to the westward of it, and apparently it travelled from that point across the island on an East-south-easterly course.

As a rule, when the wind is from North-east there is no danger of a hurricane in Mauritius. All our great hurricanes have commenced, not with a North-east, but with a South-east wind; and this is why, when the wind was from North-east by East at 11 a.m., and the barometer at 29·338 ins., it was considered probable that the velocity of the wind would not exceed 56 miles an hour. On February 12th last, the barometer fell to 29·325 ins., and the greatest velocity of the wind for one hour was 47·5 miles from North-east, the barometer soon afterwards rising, and the wind decreasing.

There are apparently only two ways of, in a measure, accounting for the passage of the centre of a hurricane over the island yesterday from West-north-west to East-south-east. Firstly, the cyclone which had been travelling to the Northward and North-westward of the island on a South-westerly course from the 24th to the 27th, recurved to the South and South-east and then bore down on Mauritius; or secondly, a secondary small cyclone which was generated in the South-east quadrant of the larger cyclone, travelled to East-south-eastward. The latter is perhaps the more probable hypothesis; for yesterday's small but violent hurricane exhibited, with respect to its extent, duration, &c., the characteristics of a local atmospheric disturbance.

On the night of the 27th and morning of the 28th there was a great deal of thunder and lightning, and also frequent lightning during the night of the 28th, but the hurricanes of Mauritius are seldom, if ever, immediately preceded by thunder and lightning.

It may be stated also that from April 25th to 29th there were from five to six groups of sunspots, indicating a considerable increase of solar activity, and that from the 25th to the 28th there were large magnetic disturbances, the portion of the sun's disc on which there was a very large group of spots on February 12th being again on or near the sun's central meridian.

Dr. Meldrum also gives the following note on "Hurricanes and Gales in April:"—

Fifteen years ago I prepared a list of all the hurricanes and gales which, as far as could be ascertained, had been experienced in Mauritius from 1695 to 1877.

From that list, which is given in *Kyshe's Almanac* for 1878, it will be seen that the dates of all the known hurricanes and gales experienced in April, with the lowest barometric pressures, and the direction and maximum force of wind, are as follows:—

Years.	April.	Lowest Barometer.	Wind.		Remarks.
			Direction.	Pres. in lbs. on Sq. Foot.	
		Ins.			
1754	20th	?	?	?	Strong Gale.
1773	9th	?	?	?	Hurricane.
1814	19th	29·343	NNE	?	Strong Gale.
1824	11th	29·138	SE by E to NE	?	Hurricane.
1830	4th	29·485	?	?	Strong Gale.
1833	10th	29·547	South	?	" "
1834	30th	29·822	SE to E & N	?	" "
1840	10th	28·965	SE to E & NW	?	Hurricane.
1855	30th	29·921	ESE to NE	17	No damage.
1856	3rd to 6th	29·631	SE to S & SW	24	" "
1866	13th to 19th	29·825	SE to E	13	" "
1867	9th to 14th	29·762	SE to S	13	" "
1870	4th to 8th	29·801	SE to NE	16	" "

In all there were, from 1695 to 1877, three hurricanes and ten gales in April.

The hurricanes occurred respectively on April 9th, 1773; April 11th, 1824; and April 10th, 1840.

The lowest barometric pressure in 1773 is not known, but in the other two hurricanes it was respectively 29·138 ins. and 28·965 ins.

From 1853 to 1867 the pressure of the wind was registered by an anemometer, and during that period the greatest pressure in April was 24 lbs. per square foot, on April 4th, 1856.

Since 1870 there has been no gale in April, the greatest velocity of the wind having been only 31 miles an hour on April 4th, 1877.

There have been gales in Mauritius even in May and June, but no hurricane. On May 7th, 1868, the barometer fell to 29·710 ins., with the wind from South-east to East, and the maximum pressure was 16 lbs. to the square foot. On June 21st, 1860, there was a pressure of 18 lbs., with the wind from South. But, so far as is known, there has never been a hurricane in Mauritius between April 12th and December 1st till April 29th, 1892.

As to the other months of the year, the lowest readings of the barometer and the directions and force of the wind in the severest of our hurricanes were as follows:—

Years.	Date.	Lowest Barometer.	Wind.	
			Direction.	Pres. in lbs. on Sq. Foot.
		Ins.		
1818	March 1	28·000	SSE to NE & NW	?
1819	Jan. 25	28·782	SSE to SW & W	?
1824	Feb. 23	28·161	SE to E, NE & NW	?
1828	March 6	28·517	SE to E & N	?
1836	March 5	28·114	SE to E & NW	?
1848	March 8	28·790	SE to E & NE	?
1861	Feb. 16	29·041	SSE to E, N & NW	45
1868	March 12	28·813	SE to E, N & W	50
1874	March 27	28·665	SE to E, N & NW	36
1879	March 21	29·032	SE to E, N & NW	40

In all these and other hurricanes the wind began to increase from the South-eastward; whereas in the hurricane of April 29th, 1892, it began to increase from the North-eastward. The lowest known barometric pressure in Port Louis was 28·000 ins., on March 1st, 1818. But on April 29th, 1892, the barometer fell to 27·961 ins. at sea level; and the maximum pressure of the wind for 5 minutes was 73 lbs., corresponding to a velocity of 121 miles for an hour.

There are only two instances on record of a cyclone having approached the Island from the North-westward. One of these cyclones occurred in January 1863, and the other in January 1868. In the former, the barometer fell to 29·231 ins., and in the latter to 29·512 ins., and very little damage was done.

In my last communication I gave the rates of the velocity of the wind per hour, as observed for intervals of two to five minutes. Since that time the hourly velocities, as registered by the anemometer, have been ascertained. From 10.30 a.m. to 11.30 a.m. (on April 29th) the mean velocity was 50·6 miles. It then increased to 89 miles from 0.30 to 1.30 p.m.; decreased to 65 miles from 1.30 to 2.30 p.m.; increased to 103·3 miles from 3.30 to 4.30 p.m.; and then decreased to 50 miles from 6.30 to 7.30 p.m.

A velocity of 103 miles for an hour represents a pressure of 53 lbs. on a square foot (by James' Table).

It has been reported that on the day of the hurricane balls of fire (or electricity) were seen in different parts of the island.

Remarkable Wind and Rain Phenomenon in the Argentine Republic. By W. Bower (in a letter dated "The Santa Fé Land Company, Limited, Colonia Romang, Santa Fé, March 28th, 1892").

I left the estancia to run up the Northern boundary with five men, horses, packs, &c., and on the second day out (we were travelling nearly due north) we crossed a swamp which happened at that time to be dry and full of long grass. As a North wind was blowing we waited till we reached the other side and then set the grass on fire, so as to have a clear road for our return journey, and perhaps get a buck or other beast as they fled from the fire. This was at about 9 o'clock in the morning. The fire spread rapidly, and produced an immense cloud of smoke which we saw behind us all the afternoon. At night we camped about 36 miles from the estancia, and about 18 miles from the fire. About an hour before sunset I was astonished to see that the smoke, which hung almost motionless, the wind having dropped, was capped by a brilliant white cloud, and soon after this began to give off other clouds, the separation being very clearly seen, until the southern sky was quite overcast and very dark near the horizon, presenting all the features of the preparation of one of our usual rain storms. That night we got a thorough soaking, which is nothing unusual, but the curious part was that on our return journey we found that the rain had commenced just where the fire was, and further south there had been neither rain nor wind. Perhaps some of the rain-making experimentalists would be interested in this. As far as the rain is concerned, it seems to be reasonably explained on the supposition that the moisture was deposited on the smoke particles;—but why wind? That there was wind I very distinctly remember as it rooted up the stakes on my side of the tent, and I spent the rest of the night squatting on my saddle with one poncho round me, which I managed to keep dry, all my saddle rugs having been swamped before we could stake out the tent again. I had a cold at the time, but it was most effectually cured.

The Indian Monsoon Current.

Mr. H. N. Dickson, in an interesting paper on "The Meteorology of India and the surrounding Sea-areas,"[1] gives the following account of the Monsoon current:—

Recent investigations leave little doubt that the Monsoon current is an extension of the South-east Trades of the southern hemisphere which are drawn towards the low pressure system over the land, breaking through, as it were, the equatorial belt of calms. The sudden bursting of the rains has not as yet been fully explained. It appears reasonable that the extension of the Trades over the equatorial belt should take place suddenly, but the regularity of the time and manner of its occurrence make it difficult to account for it by the heating of the surface of the peninsula alone. The rise of temperature over that area takes place most rapidly some time before the burst of the Monsoon, and no circulation of great intensity is set up, the indraught from the sea giving rise only to local intermittent currents of the nature of sea breezes, which are powerless to penetrate inland or to feed an ascending current even where condensation commences. The moderate elevation of the peninsula, and its limited area, would seem to render even the intense insolation inadequate to produce an ascending current of the required volume.

The cause may be, perhaps, most hopefully looked for over the continental surface of Central Asia. From the nature of that surface, its position, and greater elevation, the annual rise of temperature not only occurs later than in India, but the establishment of cyclonic conditions, i.e. of an ascending current, takes longer, on account of the intensity of the high-pressure conditions produced by the great cold of winter; thus, even in May, the prevailing winds over a large part of it still indicate anticyclonic circulation. When the ascending current, however, finally replaces that circulation, the same circumstances which delayed its commencement will give it a volume and extent enormously greater than any similar current over the peninsula.

Now, the Himalayas form a complete barrier to all surface winds, hence we have two ascending currents, one, the smaller, fully developed over the peninsula, and another, much the greater, in process of formation, and gradually extending into the upper atmosphere. These are at first practically independent of each other, until the second attains an elevation of 10,000 feet or more and

[1] *The Scottish Geographical Magazine*, May 1892, Vol. IX., p. 248.

the barrier is surmounted. It is possible that on reaching that point the larger vortex absorbs the smaller, just as two cyclones unite at ordinary levels, and we can conceive that the junction will cause a sudden demand on the lower portion of the latter, which is in this case supplied by the South-west Monsoon. Some such process is at least suggested by the fact that prolonged and excessive snow-fall on the Himalayas and in Tibet and Kashmir, which means a severe and protracted winter, and therefore a late ascending current over Central Asia, is followed by a weak and late Monsoon, and that such a Monsoon is often replaced in Northern India by descending currents from the Baluchistan highlands, again probably a result of a weak ascending current over, or at least weak indraught towards, Central Asia. The data for discussing these questions must be derived from observing stations in Tibet and Mongolia, and from observations of cirrus clouds in the neighbourhood of the Himalayas, and are as yet very meagre.

The Monsoon current may be imagined as advancing with a wedge-shaped front, increasing in height towards the rear, although never attaining a great elevation. The condensation set up on its meeting an obstacle must therefore depend largely on the angle at which that obstacle lies to the advancing front. Thus on the Malabar and Konkan coasts, and again to the north of the Bay of Bengal, where it encounters ranges of mountains almost at right angles, the current is forced to ascend a slope which covers but a small area on account of its steepness, and excessive rainfall is recorded. With this there is also liberation of vast quantities of heat, and the current in the former case easily surmounts the Western Ghâts, and is strong and steady over the Deccan. On the face of the Ghâts the average precipitation may amount to 250 inches, while on the Khasia mountains as much as 264 inches has been recorded during August alone, the annual mean at Cherra Punji being 474 inches.

The South-west Monsoon continues throughout July, which is in general the month of heaviest rain, and August; it begins its retreat early in September, and before the close of that month has ceased over the Deccan, the Central Provinces, and the western coast, where the increasing pressure causes an extension of light North-easterly winds. The rains continue in Assam and Bengal until October, and as the current retreats into the Bay it is deflected to the westward, and from a course almost parallel to the eastern coast turned to one at right angles. Hence, as the centre of low pressure moves southward, the heaviest rainfalls of the year are experienced in the Sarkars and the Karnatik during October and November.

RECENT PUBLICATIONS.

American Meteorological Journal. A Monthly Review of Meteorology. Vol. IX. Nos. 1 and 2. May and June 1892. 8vo.

Prof. Harrington and Mr. Rotch have given up their positions as editors, but they will both continue their interest in the Journal as contributors. The new editor is Mr. R. de C. Ward.

The principal contents of these numbers are :—Meteorology in the Schools: by Prof. W. M. Davis (20 pp.).—Thunderstorms in New England during the year 1886: by R. de C. Ward (8 pp.). This investigation confirms the main results of the study of the previous year, viz. the general features, the excess in the late afternoon hours, the fact that most of the New England storms come ready-made from the west of the district, and that they are not distributed evenly through the summer, but appear in considerable numbers for a few days and then disappear for a time. In regard to the dependence of the thunderstorms on the larger atmospheric disturbances of cyclonic storms, the results of 1886 in New England tend to show that this dependence, although marked, is not so striking or so definite as many of the foreign results have shown it to be in Europe. Over 60 per cent of the thunderstorms of this year occurred in the southern or south-western quadrant of cyclonic areas. Some of the best developed storms occurred under distinctly anticyclonic conditions.—The storm of March 1-4, 1892: by J. Warren Smith (6 pp.).—Flood-stage river predictions: by Prof. T. Russell (12 pp.).—The first scientific balloon voyage: by R. de C. Ward (5 pp.).—Snowstorms at Chicago: by A. B. Crane (4 pp.). The author has examined the weather records from 1879-1891, and has found that there have been 25 storms, each with a fall of 4 inches or more of snow.—The eye of the storm: by S. M. Ballou (18 pp.).—Shall we erect lightning rods?: by A. McAdie (8 pp.).

Annuaire de la Société Météorologique de France. 89me Année. 1891. December. Large 8vo.

Contains: Sur l'anomalie magnétique du Bassin de Paris: par T. Moureaux (3 pp.).—Les Nuages et la Pluie: par M. Hauvel (6 pp.).—Rapport sur la classification des nuages: par H. H. Hildebrandsson (10 p.).—Note sur l'importance pour la météorologie des mesures du mouvement et de la hauteur des nuages: par H. H. Hildebrandsson (8 pp.).

Diurnal Fluctuations of Atmospheric Pressure at Twenty-nine Selected Stations in the United States. By Brigadier General A. W. Greely, Chief Signal Officer, U.S. Army. 4to. 1891. 25 pp.

This consists of tables of corrections to reduce the mean pressure at any hour of the day to the true daily mean. These values have been obtained from free-hand curves representing the daily march of pressure at twenty-nine selected stations in the United States, drawn from all the available observations from January 1877 to June 1888, covering a period of eleven years and six months, except for Assinniboine, where the period is about eight years only. The daily fluctuations of pressure show, as a rule, primary maximum and minimum and secondary maximum and minimum phases. The secondary fluctuations diminish from south to north, especially during the summer months, at which time these secondary phases entirely disappear at certain places. The daily variations appear, as a rule, to be governed largely by geographical location, and decrease with increasing latitude. This is especially true for the winter months, when the daily range varies from ·117 in. at San Antonio to ·068 in. at Dodge City, ·059 in. at North Platte, and ·038 in. at Bismarck. In summer the same conditions exist, except that the daily range also increases inland from the coast. The tendency to increased inland range is shown in the Lake region also, diminishing as the Lakes are approached. The annual range in diurnal fluctuation of pressure shows a slight tendency to increased range from north to south, but the most prominent characteristics are the changes from the coast inland, varying from an average of about ·015 in. east of the meridian to ·028 in. at Denver, ·038 in. at Salt Lake City, ·049 in. at Winnemucca, attaining a maximum of ·069 in. at Boisé City, and decreasing again to the Pacific coast, where, at San Francisco, the range is about ·018 in. The changes in daily fluctuations from month to month vary according to geographic location, and may be divided into two principal types, the inland and the coast types. These types are better defined as the location approaches more nearly a purely continental or marine condition. The principal maximum occurs over the whole of the United States in January about 9.45 a.m., except along the New England coast at Boston and Eastport, where it occurs at earlier hours, 8.45 a.m. at the latter and 9.15 a.m. at the former station. As the year advances the hour gradually shifts towards the earlier morn. This change continues until June, when the hour is the earliest of the year, after which a reversal gradually occurs. The delay in the hour of the principal minimum is, however, much more decided. This phase in January occurs along the Atlantic coast and in the region of the Great Lakes at about 2.30 p.m. Becoming later with the growing year it falls at about 5 p.m. in June for the Atlantic coast region, while in the Lake region it is delayed until 5.45 or 6 p.m. In the Pacific coast region the change is gradually from the earliest hour in January to the latest in June, the winter minimum being at about 4 p.m., and the summer at about 6 p.m. It appears from this that in the United States the principal minimum gradually becomes later with increasing longitude, and that the most decided lagging of the summer minimum is in the neighbourhood of the Great Lakes.

Journal of the Royal United Service Institution. Vol. XXXVI. 1892. 8vo.

This contains a paper on "Atlantic Weather and its connection with British Weather," by Mr. R. H. Scott, F.R.S. (14 pp. and plate). After describing the broad principles which govern the weather system of the Atlantic, the author describes some of the results brought out by a discussion of the daily synchronous charts of the North Atlantic for the 13 months ending August 1883, which have been published by the Meteorological Office. It appears that there were 273 depressions during the 13 months whose tracks were clearly traceable. By omitting those which appeared in August 1882, the number is reduced to 264, which lasted as follows:—

Duration in Days	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
No. of Depressions	36	33	40	31	27	23	22	14	7	13	6	3	3	2	..	1	1	1	..	1

Of these, 140 lasted less than five days. Those of longest duration were confined entirely to the autumn months. During the 13 months there were 37 severe gales felt on the coasts of the British Isles, which were classified as follows:—

Appearing westward of Long 40°.	17
„ in Mid Atlantic	8
Formed close to the British Isles	9
Appearing to the eastward	3

Of the 17 cases given above, as starting near the American coast, only 12 came within the area of observation on the other side of the Atlantic. For the 12 storms, the times taken to cross the Atlantic were:—

4 storms took 2 days
3 „ „ 3 „
1 „ „ 4 „
1 „ „ 5 „
2 „ „ 6 „
1 „ „ 10 „

The author is of opinion that storm warnings from America are not of much service to this country.

Mémoires de la Société de Physique et d'Histoire Naturelle de Genève. Volume supplémentaire 1890 No. 9. 4to. 1891. (32 pp. and plate).

This contains: Observations météorologiques faites au Col du Géant du 5 au 18 Juillet 1788: par H. B. de Saussure. This gives *in extenso* the original observations made by Mons. H. B. de Saussure in his ascent of the Col du Géant in July 1788. The results of these observations have only hitherto been published, but as they are of great historic and scientific interest, the grandson, Mons. H. de Saussure, has carefully transcribed the original observations, and communicated them to the Société de Physique et d'Histoire naturelle de Genève.

Monthly Weather Review. January to March 1892. Prepared under the Direction of Mark W. Harrington, Chief of Weather Bureau. 4to.

The January No. contains a copy of a section of the thermograph record sheet at Fort Assinniboine, Mont., for January 18th and 19th, which shows a remarkable temperature change caused by the Chinook wind which commenced at that station early on the morning of the 19th, a rise of about 43° being registered in fifteen minutes.

The March No. contains tables showing for the several seasons and for the year the average hourly amount, frequency, and intensity of precipitation at Washington for 16 years, and at New York for 22 years. The annual results are as follows:—

WASHINGTON.

Hour.	Amount.	Frequency.	Intensity.	Hour.	Amount.	Frequency.	Intensity.
	In.				In.		
1 a.m.	1·168	30·7	·038	1 p.m.	1·373	23·1	·059
2	1·194	30·9	·039	2	1·816	28·1	·064
3	1·460	31·5	·046	3	1·843	29·4	·062
4	1·342	33·7	·036	4	2·071	31·0	·067
5	1·341	33·8	·039	5	1·637	32·0	·051
6	1·361	34·6	·039	6	1·613	31·7	·051
7	1·503	36·0	·042	7	1·907	32·8	·058
8	1·350	36·2	·037	8	1·833	32·4	·056
9	1·375	36·8	·037	9	2·027	32·1	·063
10	1·578	38·3	·041	10	1·688	33·0	·051
11	1·570	37·7	·041	11	1·357	32·8	·041
Noon	1·655	34·3	·048	Midnight	1·217	31·6	·038
Total					37·279		

NEW YORK.

Hour.	Amount.	Frequency.	Intensity.	Hour.	Amount.	Frequency.	Intensity.
	In.				In.		
1 a.m.	1·694	33·8	·051	1 p.m.	1·773	34·1	·052
2	1·737	35·4	·049	2	1·855	35·5	·052
3	1·847	36·1	·051	3	2·123	36·5	·058
4	1·836	37·1	·049	4	2·014	36·4	·055
5	1·840	38·5	·048	5	2·106	37·0	·057
6	1·617	38·2	·042	6	1·880	36·7	·051
7	1·602	36·2	·044	7	2·039	36·9	·055
8	1·904	35·0	·054	8	1·899	37·2	·051
9	1·584	33·4	·047	9	2·000	36·9	·055
10	1·650	33·7	·049	10	1·749	36·7	·048
11	1·780	34·1	·052	11	1·645	35·8	·046
Noon	1·725	33·8	·051	Midnight	1·750	34·7	·050
Total					43·649		

PROCEEDINGS OF THE ROYAL SOCIETY. Vol. LI., No. 308. 1892. 8vo.

Contains an abstract of the Bakerian Lecture "On the grand currents of atmospheric circulation": by Prof. James Thomson, F.R.S. (5 pp. and plate). After giving a historical sketch of the progress of observational and theoretical researches into the nature and causes of the Trade Winds and other great and persistent currents of atmospheric circulation, the author propounds a new theory, which is as follows:—

"That at the equator, or near to it, there is a belt of air ascending because of its high temperature and consequent rarefaction; that its supply of air is maintained by inflow from both sides towards the zonal region at its base, which is a region of diminished pressure; that from its upper part currents float away to both sides, northward and southward; and that these currents continue in the upper regions of the atmosphere, each of them advancing towards, and in part to, the high latitudes of its own hemisphere, until by cooling, its substance becomes less buoyant and sinks down gradually in various latitudes of that hemisphere, and forms itself into a return current towards the equator in the lower part of the atmosphere. That the air of this great cap of atmosphere, covering the middle and higher latitudes and including portions of the currents just described, having come from the equatorial regions, which were moving absolutely from west to east in the earth's diurnal rotation with a velocity of about 1,000 miles per hour, must on coming into those new regions much nearer to the earth's axis have greater velocity from west to east than the earth below i in those new regions has. That in the central or polar part of this great revolving cap of air the barometric pressure must be abated in consequence of the centrifugal tendency due to the extra speed of this great whirling cap of atmosphere. That the bottom layers of this great cap of atmosphere, being by friction on the earth's surface retarded as to this extra velocity of rotation eastward, must have a diminished centrifugal tendency as compared with the quicker revolving air above them, and consequently tend to flow, and actually do flow, inwards towards the region of abated barometric pressure at the centre of the revolving cap of air. That thus over the middle, or middle and higher latitudes, there are three currents:—

(1.) A top main current towards the pole.

(2.) A bottom subordinate current towards the pole.

(3.) A middle main current in direction from the pole, and constituting the joint return current, for both the preceding currents; and that all these three have a prevailing motion from west to east, in advance of the earth. That the great return current, flowing in direction from the pole towards the equator, arrives at a certain part of its course at which it ceases to revolve eastward in advance of the earth; and for the rest of its course to the foot of the equatorial rising belt, it blows along the surface of the earth as the Trade wind of the hemisphere in which it is situated."

Rainfall in the East Indian Archipelago. Twelfth year, 1890. By Dr. J. P. van der Stok. 8vo. 1891. 418 pp.

This organisation embraces 192 stations; 104 being in Java and Madura, and 88 in Sumatra and the different islands of the Eastern Archipelago. The daily rainfall is given *in extenso* for each station. The results show that the rainfall during the months of May to September was abnormally high in the eastern parts of the Archipelago.

Results of the Meteorological Observations made at the Government Observatory, Madras, during the years 1861-1890, under the direction of the late N. R. Pogson, C.I.E., F.R.A.S. Edited by C. Michie Smith, B.Sc., F.R.A.S., and published by order of the Government of Madras. 4to. 1892. 394 pp.

This contains the results of the daily meteorological observations made at the Madras Observatory for the thirty years 1861-90, during the whole time, with the exception of the first few weeks, the late Mr. Pogson was Government Astronomer, and had charge of the Observatory. The hours of observation from 1861 to 1889 were 10 a.m., 4 p.m., and 10 p.m., but in 1890 they were changed to 8 a.m., 2 p.m., and 8 p.m. The following are the mean monthly results for some of the principal elements:—

Months.	Barometer reduced to Sea-Level and to Gravity at Lat. 45°.	Mean Maximum Temperature.	Mean Minimum Temperature.	Rainfall.	Amount of Cloud.	Relative Humidity.	Tension of Vapour.
	Ins.	°	°	Ins.		%	In.
January	29·949	83·4	67·7	·79	3·7	73	·638
February	·918	85·9	68·2	·31	2·4	73	·672
March	·863	89·1	72·3	·29	2·3	73	·756
April	·780	92·7	77·3	·48	2·8	73	·858
May	·686	97·7	80·9	1·78	3·8	67	·860
June	·655	98·1	80·6	2·61	6·4	62	·786
July	·678	95·6	78·7	4·12	7·1	65	·777
August	·701	93·5	77·4	4·81	6·7	70	·802
September ..	·727	92·8	77·2	4·34	6·3	72	·812
October	·794	88·7	75·4	10·80	5·8	78	·819
November	·876	84·5	72·4	13·60	5·9	79	·748
December ..	29·933	82·7	70·1	5·75	5·2	77	·684
Year	29·797	90·4	74·9	49·68	4·9	72	·768

The absolute highest temperature registered during the thirty years was 112°·9 on May 21st, 1881; and the absolute lowest temperature was 57°·6 on January 27th, 1876. The greatest rainfall in 24 hours was 18·01 ins. on May 18th, 1877. The days with lowest relative humidity were May 28th, 1866, and May 10th, 1870, the mean daily value on each occasion being 17 per cent.

SYMONS'S MONTHLY METEOROLOGICAL MAGAZINE. April-June 1892. Vol. XXVII. 315-317. 8vo.

The principal articles are:—Dr. Angot's "Instructions" (3 pp.).—Who Firminus was (2 pp.).—Town Fogs: by Rev. J. Slatter and T. W. Backhouse (2 pp.).—Anemometer Comparisons (3 pp.).—Exceptional weather in March and April (4 pp.).—The Mauritius Hurricane, April 29th, 1892 (7 pp.).[1]—Thunderstorms of May 31st and June 1st (4 pp.).

U.S. DEPARTMENT OF AGRICULTURE. EXPERIMENT STATION BULLETIN. No. 10. Washington, 1892. 8vo.

Meteorological Work for Agricultural Stations: by M. W. Harrington (23 pp.). The author gives numerous suggestions for work of research proper for agricultural colleges and experiment stations, and which should be of service in the planning and execution of much needed investigations regarding the relations of climate to agriculture.

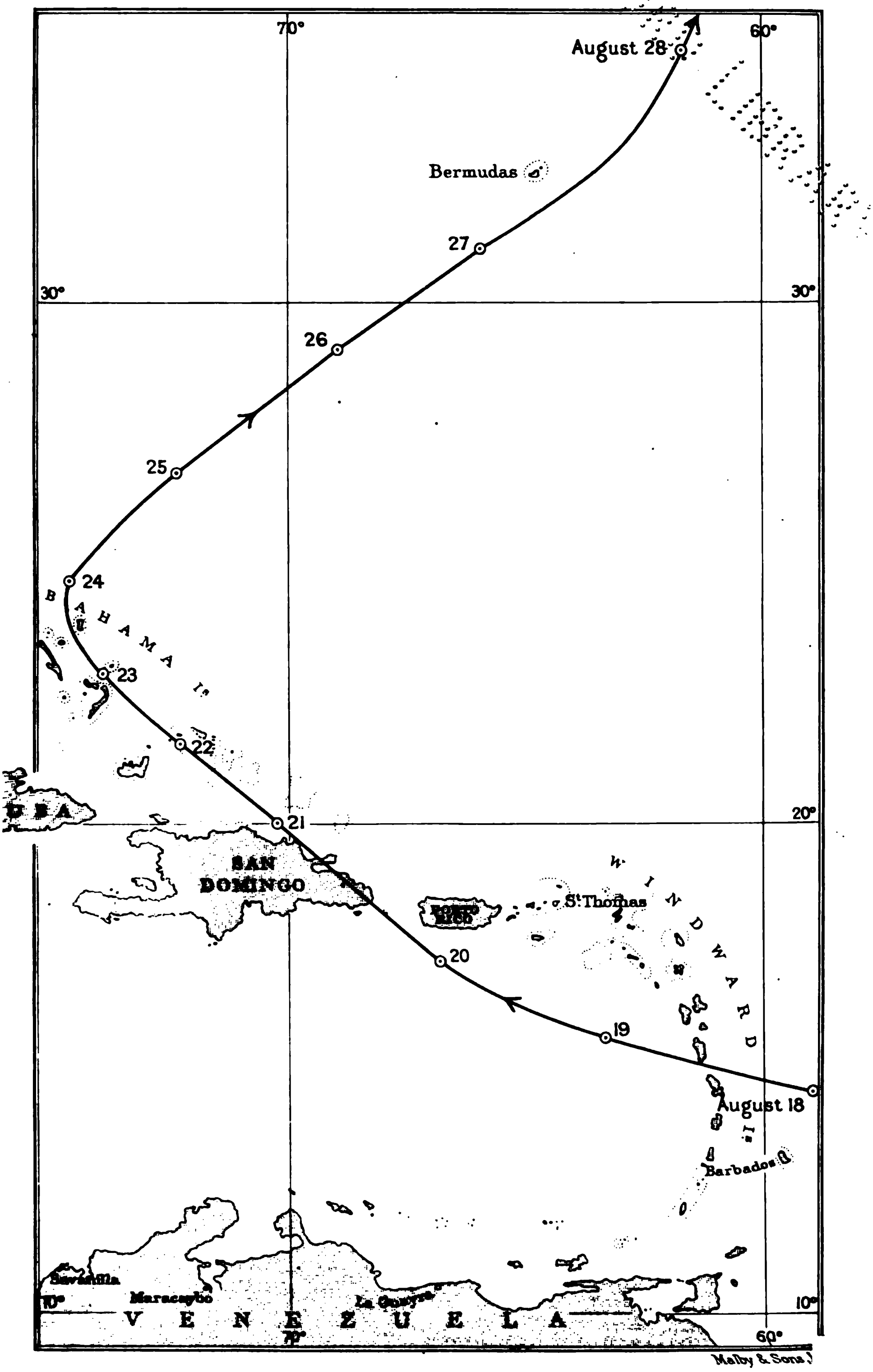
[1] See p. 202 of the present number.

A. Helicoid. B. Pressure Plate. C. Air Meter. D. Robinson. E. Tube.

Quart. Journ. Roy. Met. Soc. Vol. XVIII. Pl. 8.

TRACK OF WEST INDIAN HURRICANE, AUGUST 18TH–28TH 1891.

From the "Pilot Chart of the North Atlantic Ocean," Sept: 1891.



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ENGLISH CLIMATOLOGY 1881-1890.

BY FRANCIS CAMPBELL BAYARD, F.R.Met.Soc.

(Plate IX.)

[Received May 27th.—Read June 15th, 1892.]

WITH a view to obtain a series of reliable observations the Royal Meteorological Society, in 1875, organised a series of Second Order Stations at which observations are made at fixed hours, 9 a.m. and 9 p.m. The number of these stations being limited owing to the difficulty of finding suitable observers willing to take observations twice a day, the Society in 1880 organised a series of Climatological Stations at which observations are made at 9 a.m. only. The observations of these two sets of stations have been included in the Climatological portion in the *Meteorological Record*, and Mr. Ellis has shown that "monthly mean temperatures (mean of maximum and minimum) on the Climatological plan may be considered to be practically similar to means on the Second Order system."[1] As the time of the staff is fully occupied, I have, with the concurrence of the Council, undertaken to

[1] *Quarterly Journal*, Vol. XVI. p. 219.

discuss the observations, and now submit the results for the ten years 1881-1890.

The Society's stations as given in the December part of the *Meteorological Record* for 1890 numbered 78, and on carefully going through these it was found that there were 52 of which the observations were sufficiently complete for the ten years to justify their reduction. A list of these stations, with their heights and the observers' names, is contained in Table I., the names of the Second Order Stations being printed in italics. The position of the stations is also shown on the map (Plate IX.).

At all stations Stevenson screens, or modifications thereof, 4 ft. above the ground, have been employed for the exposure of thermometers, excepting at Brampford Speke and Ilfracombe. At Brampford Speke the thermometers are mounted " in a wall screen fixed to a garden wall with a north aspect; the wall is about 10 ft. high and is whitewashed."[1] At Ilfracombe " the instruments are exposed in a large screen, like a summer house, the rain gauge being on the top and having a pipe with a tap below. The stand is about 6 ft. square, has large louvres half way down, and then lattice work; it is painted green, and has a slated pyramidal roof. It is placed over the shingle promenade of the Ilfracombe Hotel, and is 8 ft. or 10 ft. from the embankment, which rises about 16 ft."[2]

The rain gauges, as a rule, are 1 ft. above the ground except at Ilfracombe.

No change in the exposure of the instruments has been made at any of the stations except at Scarborough, Kenilworth, Norwood, Beddington, Marlborough, Ramsgate, Worthing, Portsmouth, Blackpool, Llandudno, Sidmouth, Teignmouth, and Falmouth, the particulars of which are given in Table I. In these excepted stations, the distances and difference in elevation being small, the observations have been treated as continuous throughout.

There are two stations where the records are incomplete, viz. Margate, with rain observations only for 1881, and Weymouth, which has no records at all for that year; but the observations for the remaining nine years were so good and complete that it was decided to interpolate in each case for that year. All the required interpolations were done in the Society's office by Mr. Marriott. With reference to Falmouth the observations for January to September 1881 were taken from the *Report of the Royal Cornwall Polytechnic Society*; and with reference to Londonderry for the years 1881-3, and to Dublin for the year 1881, the figures were taken from the *Observations of the Second Order Stations* published by the Meteorological Office, the Society's observations being merely a continuation of those previously taken and published of these respective stations. To Dr. Newsholme, the Society's observer at Brighton, I am indebted for the Brighton observations for 1881-8. And lastly, I must not forget my obligations to Mr. Marriott, whose valuable hints and knowledge of the stations and observers have greatly lightened my labours, and have tended to elucidate several points which at first sight seemed almost hopelessly obscure.

[1] *Quarterly Journal*, Vol. IX. p. 93.
[2] *Quarterly Journal*, Vol. VII. p. 109.

For the purpose of discussion I propose to divide this paper into four sections, viz. (1) Temperature; (2) Relative Humidity; (3) Amount of Cloud; (4) Rainfall. No correction has been applied for the effect of elevation above mean sea level, it being thought desirable to give the actual means at the different stations. Should anyone wish to reduce the temperatures to their equivalent sea-level values, this can readily be done by applying to the values given in this paper the approximate correction of +1°·0 for every 300 ft. of elevation above sea level.

TEMPERATURE.

Before going into details I would draw attention to two great facts which seem to underlie the whole of this portion, viz. (*a*) the great influence of the sea, and its tendency to increase the temperature of the sea coast stations in winter and diminish it in summer; and (*b*) the fact that the temperature rises much more rapidly than it falls, that is to say, that the average rise in temperature between April and July is from 12° to 17°, whilst the average fall between July and October is only from 8° to 13°. After October the temperature diminishes very rapidly, owing no doubt in part to the October and November rains.

With reference to the mean temperature at 9 a.m., Table II., I would remark that it gives a very close approximation to the mean temperature (the mean of the maximum and minimum), Table V., except during the months of May, June, July and August, when the 9 a.m. figure is generally higher than the mean. The difference, however, in no case exceeds 3°, and the general result is that the yearly mean temperature at 9 a.m. in no case varies from the yearly mean temperature more than 1°.

With respect to the mean temperature, Table V., we have in *January* the lowest (35°·1) at Buxton and the next lowest (36°·4) at Cheadle; then follow with a temperature between 36°·6 and 37°·5 two groups of inland stations, viz. Macclesfield, those in the Midland and Eastern Counties, with the exception of those in the Counties of Hereford and Gloucester, and also Lowestoft, and a small group on the Chalk Downs south of the Thames; then come, with a temperature between 37°·6 and 38°·5, the stations in the Northern Counties, the Hereford and Gloucestershire ones, Lowestoft, the stations in the vicinity of London, with Harestock, and Southampton; and I think that it will be somewhat surprising to learn that Blackpool, Scarborough, Lowestoft, and Southampton, have in January practically the same mean temperature as London. The next in the higher scale, that is between 38°·6 and 39°·5, are Margate, Ramsgate, Worthing, Portsmouth, Cullompton, and Brampford Speke; then come with a temperature between 39°·6 and 40°·5 the stations of Londonderry, Carmarthen, Weston-super-Mare, Southbourne, and Brighton; then with a temperature of from 40°·6 to 41°·5 Bude, Ashburton, Sidmouth, Weymouth, the Welsh station of Llandudno, which has the same mean temperature as Weymouth: then with a temperature between 41°·6 and 42°·5 the stations of Killarney, Dublin, Babbacombe, Teignmouth, and Ventnor; and finally the very warm stations of Guernsey (48°·4), Ilfracombe (48°·8), and Falmouth (48°·6).

As to the mean minimum temperature, Table III., the three months January, February, and March, are very much alike, and the general grouping is very similar to that given above, with the exception that the next lowest mean minimum after Buxton (30°·0) is found at Hillington (31°·5), and certain other minor differences, the principal being the warmth of Weston-super-Mare (36°·1), and the coldness of Carmarthen (34°·5). As to the mean maximum temperature, Table IV., there is a gradual increase during the first three months of about 1° per month.

In *April* the first great change occurs in the mean temperature, Table V., and we may say that with the exception of Hillington (45°·0) and Llandudno (45°·5), the whole of England and Wales north of latitude 52°·5 N. is cold, with a temperature not exceeding 44°·5; then come Llandudno, Hillington, Cheltenham, Kenilworth, and Aspley Guise, and the three stations of Marlborough, Swarraton, and Harestock, with a temperature between 44°·6 and 45°·5; then come, with the few exceptions hereinafter mentioned, all the stations south of latitude 52°·5 N. with Dublin, Londonderry, and Killarney, with a temperature between 45°·6 and 46°·5; then Regent's Park, Portsmouth, Ventnor, Brampford Speke, Falmouth, Ilfracombe, and Weston-super-Mare, with a temperature between 46°·6 and 47°·5, and lastly Teignmouth and Guernsey with a temperature between 47°·6 and 48°·5. The rise in temperature, as I have mentioned before, now becomes very rapid, and this culminates in July.

In *July* we have in the mean temperature, Table V., rather a singular state of things: Buxton as before is the coldest with 56°·8; then come with between 57°·6 and 58°·5 Scaleby, Seathwaite, Macclesfield, Cheadle, Churchstoke, Londonderry, and Killarney; then with between 58°·6 and 59°·5, Scarborough, Belper, Blackpool, Llandudno, Carmarthen, Bude, Sidmouth, and Marlborough, a rather remarkable group; then with between 59°·6 and 60°·5 come Dublin, Wakefield, Hodsock, Somerleyton, Lowestoft, Kenilworth, Cheltenham, Swarraton, Harestock, Southbourne, Cullompton, Babbacombe, Ilfracombe, Ashburton, and Falmouth; then, with between 60°·6 and 61°·5, the whole of the remaining stations and Guernsey, except Regent's Park, Norwood, Strathfield Turgiss, and Portsmouth, which, with a temperature between 61°·6 and 62°·5, form the last group and have the highest mean temperature.

With respect to the July mean maximum, Table IV., we have the singular fact that the western stations, except Scaleby, with Killarney, Buxton, Cheadle, and Falmouth, with a temperature between 63°·6 and 65°·5, are the coldest; then come Scarborough, Scaleby, Macclesfield, Dublin, Londonderry, Sidmouth, and Guernsey, with between 65°·6 and 66°·5; then with between 66°·6 and 67°·5 come Belper, Churchstoke, Carmarthen, Weston-super-Mare, Babbacombe, Weymouth, Southbourne, Ventnor, Worthing, and Lowestoft; then with between 67°·6 and 68°·5 Wakefield, Kenilworth, Ashburton, Teignmouth, Swarraton, Harestock, Brighton, and Margate; then with between 68°·6 and 69°·5 Hodsock, Somerleyton, Cheltenham, Marlborough, Cullompton, Brampford Speke, and Ramsgate; then with between 69°·6 and 70°·5, Hillington, Burghill, Aspley Guise, Croydon, and Southampton; then with between 70°·6 and 71°·5, Ross, Regent's Park, Norwood, Beddington, and Portsmouth; and lastly the warmest, Strathfield Turgiss, with 72°·1.

Mean temperature, Table IV., now falls more gradually than it has risen, and in *October* we have considerable changes. Buxton again has the coldest mean temperature, 44°·7, and then with a temperature between 45°·6 and 46°·5 come Macclesfield, Cheadle, Belper, and Churchstoke; then with between 46°·6 and 47°·5 come Scaleby, Seathwaite, Hodsock, Kenilworth, Cheltenham, Aspley Guise, Marlborough, and Swarraton; then with between 47°·6 and 48°·5, Scarborough, Wakefield, Blackpool, Hillington, Burghill, Ross, Croydon, Beddington, Strathfield Turgiss, Harestock, Brampford Speke, and Londonderry; then with between 48°·6 and 49°·5, Carmarthen, Cullompton, Southampton, Regent's Park, Norwood, Somerleyton, Lowestoft, Dublin, and Killarney; then with between 49°·6 and 50°·5, Llandudno, Ashburton, Babbacombe, Sidmouth, Southbourne, Worthing, Margate, and Ramsgate; then with between 50°·6 and 51°·5, all the remaining stations on the south and south-west coasts, except Ilfracombe, Falmouth, and Ventnor, which are between 51°·6 and 52°·5, and Guernsey (53°·0), the warmest station.

The mean temperature, Table V., now falls rapidly up to the end of the year, the fall being from 8° to 10° in two months.

In considering the yearly mean temperature, Table V., we have, as might be expected, the lowest 44°·7 at Buxton, and the next lowest 46°·2 at Cheadle; then come a long series of stations with low readings, between 46°·6 and 47°·5, comprising all the stations north of latitude 52° N. (except the three Irish stations, Llandudno, Wakefield, Burghill, and the three stations in the Eastern Counties), and Marlborough, and Swarraton; next with between 47°·6 and 48°·5 come Wakefield, Burghill, Cheltenham, the three stations in the Eastern Counties, Harestock, Beddington, and Londonderry; then with a temperature between 48°·6 and 49°·5 come the remaining two Irish stations, the two Welsh stations, Ross, Regent's Park, Norwood, Croydon, Margate, Ramsgate, Worthing, Southampton, Strathfield Turgiss, Southbourne, Sidmouth, Cullompton, and Brampford Speke; then with between 49°·6 and 50°5, Brighton, Portsmouth, Weymouth, Teignmouth, Babbacombe, Ashburton, Bude, and Weston-super-Mare; and finally with between 50°·6 and 51°·5, the stations of Ilfracombe, Falmouth, Ventnor, and Guernsey.

As to the yearly mean maximum temperature, Table IV., the lowest stations with between 51°·6 and 52°·5 are Scarborough, Seathwaite, Buxton, and Cheadle; then with between 52°·6 and 53°·5 come Blackpool, Macclesfield, and Belper; then with between 53°·6 and 54°·5, Scaleby, Wakefield, Llandudno, Churchstoke, Kenilworth, Somerleyton, and Lowestoft; then between 54°·6 and 55°·5 come Londonderry, Dublin, Hodsock, Hillington, Aspley Guise, Cheltenham, Weston-super-Mare, Ilfracombe, Sidmouth, Weymouth, Southbourne, Marlborough, Swarraton, Harestock, Worthing, Ramsgate, and Margate; and then with between 55°·6 and 56°·5 come all the remaining stations except Strathfield Turgiss, Southampton, and Portsmouth, which, with a temperature of between 56°·6 and 57°·5, form the last group.

The yearly mean minimum temperature, Table III., is very different from the above. Here again Buxton is the lowest with 37°·7; then comes Churchstoke with 39°·3; then with between 39°·6 and 40°·5 come Scaleby, Hodsock, Macclesfield, Cheadle, Belper, Cheltenham, Kenilworth, Aspley Guise, Hillington, Marlborough, Strathfield Turgiss, and Swarraton; then with between 40°·6 and 41°·5 come Seathwaite, Wakefield, Somerleyton, Beddington, Harestock, Southampton, Cullompton, Burghill, and Ross; then with between 41°·6 and 42°·5, Blackpool, Scarborough, Lowestoft, Regent's Park, Norwood, Croydon, Brampford Speke, Carmarthen, Londonderry, and Killarney; then with between 42°·6 and 43°·5, Ramsgate, Worthing, Portsmouth, Southbourne, Sidmouth, and Ashburton; then with between 43°·6 and 44°·5 Dublin, Llandudno, Weston-super-Mare, Bude, Babbacombe, Brighton, and Margate; then with between 44°·6 and 45°·5, Ventnor, Weymouth, and Teignmouth; then Falmouth with 45°·9; and lastly Ilfracombe and Guernsey with 46°·9.

Relative Humidity.

This branch of our subject, Table VI., need not detain us long, for owing to the very great uniformity there is not so much to say. In January Relative Humidity is higher in the Midland Counties than elsewhere, and varies from 94 at Aspley Guise, to 85 at Seathwaite and Llandudno; the months of May, June, and July are dry, the percentage of Relative Humidity being low especially in the neighbourhood of London. After July Relative Humidity gradually rises at all stations, but the distribution remains much the same, the Midland Counties having the highest percentage. As respects the mean yearly percentage I shall deal a little more in detail. If we look carefully at Table VI. we shall be struck with the fact that the percentage of Relative Humidity is lowest, comparatively, at our sea coast stations, with the exception of the three stations of Ilfracombe, Sidmouth, and Guernsey. This low percentage is probably due to the alternate Land and Sea breezes. Llandudno has the lowest percentage (79); this station is situate on a neck of land joining the Great Orme's Head with the main land, and consequently the wind is comparatively constant. I would call attention to the low Relative Humidity (81) at Seathwaite, a place well known as having one of the largest yearly rainfalls in the British Isles, a fact which would seem to show that a large rainfall has apparently little or no effect on the percentage of Relative Humidity. The percentage in the Thames Valley also seems low. The highest percentage occurs in a group of stations in the hilly district round Buxton.

I wish to emphasise the fact that the above remarks on Relative Humidity refer to 9 a.m. only; whether the same conclusions would be arrived at with observations at other hours of the day, I cannot say.

Amount of Cloud.

This part of the subject again, Table VII., need not detain us long, for there is great uniformity in the figures. In January, which is the most cloudy month in every district, as appears from Table VII., the south-western district has most cloud. The amount gradually diminishes in all districts till we come to May, which seems to be the month of least cloud, the lowest amount being in the south district. From this month the amount rises slightly until the end of July and then falls somewhat for August, the southern district being the least cloudy. Thence the amount rises rather more rapidly till November, when our south-western districts seem to be the most cloudy. The amount then falls slightly for December.

In dealing with the yearly mean amount of cloud more at length, we shall at once be struck with the fact, that with the exceptions of Llandudno, Babbacombe, Sidmouth, and Guernsey, our sea coast stations have the least cloud, a fact specially noticeable in the cases of Weymouth and Worthing, which have 5·4 and 5·9 respectively: then in order, having between 6·0 and 6·4, the three neighbouring stations of Portsmouth, Ventnor, and Southbourne, and Ashburton; then, with between 6·5 and 6·9, we have Blackpool, Macclesfield, Cheadle, Dublin, Carmarthen, Ross, Ilfracombe, Bude, Falmouth, Teignmouth, Cullompton, Southampton, Ramsgate, Margate, Beddington, Norwood, Aspley Guise, Somerleyton, Lowestoft, Scarborough, and Guernsey; then, with 7·0 to 7·4, come Scaleby, Wakefield, Hodsock, Buxton, Llandudno, Killarney, Burghill, Cheltenham, Kenilworth, Hillington, Weston-super-Mare, Brampford Speke, Babbacombe, Sidmouth, Harestock, Swarraton, Strathfield Turgiss, Marlborough, and Croydon; and lastly, with from 7·5 to 7·9, come Seathwaite, Churchstoke, and Londonderry.

These remarks of course refer to the amount of cloud at 9 a.m. only. The largeness of the amount in the winter months as compared with the summer months is probably due to the fact that the morning mists in winter have not been dissipated by 9 a.m. The smallness of the amount at the coast stations is perhaps due to the sea breezes dispersing the morning mists earlier than they disappear at the inland stations.

Rainfall.

In dealing with this last branch of our subject I am met with a difficulty, because gentlemen of far greater knowledge than myself have expressed the opinion that a ten-years mean in rainfall is of very little value. This I do not pretend to deny, and shall only plead in extenuation that a ten years mean is better than none at all. The mean Rainfall is given in Table VIII.

In *January* the lowest rainfall between 1 and 2 inches occurs between latitudes 51° to 53° N., and longitude 2° E. to 1° W., that is in our Eastern and South-eastern Counties, and round about London. Between 2 and 3 inches we have nearly all the rest of the stations with Dublin, and Guernsey, except Seathwaite, Buxton, Carmarthen, Falmouth, Bude, Babbacombe,

TABLE I.—Stations and Observers.

Station.	County.	Height above Sea Level.	Observer.
England, N.E.		Ft.	
Scarborough	Yorkshire	130	F. Shaw. A. Rowntree.
		160	W. Robinson.
England, E.			
Hillington	Norfolk	88	Rev. H. E. B. Ffolkes, M.A., F.R.Met.Soc.
Somerleyton	Suffolk	50	Rev. C. J. Steward, M.A., F.R.Met.Soc.
Lowestoft	Suffolk	85	S. H. Miller, F.R.Met.Soc.
Midland Counties.			
Wakefield	Yorkshire	96	H. Clarke, L.R.C.P., F.R.Met.Soc.
Hodsock, Worksop	Notts	56	H. Mellish, J.P., F.R.Met.Soc.
Buxton	Derby	987	E. J. Sykes, M.B. W. H. Beck.
Belper	Derby	344	J. Hunter, F.R.Met.Soc.
Cheadle, Tean	Stafford	646	J. C. Philips, J.P.
Churchstoke	Montgomery	540	P. Wright, F.R.Met.Soc.
Burghill	Hereford	275	T. A. Chapman, M.D.
Ross	Hereford	213	H. Southall, F.R.Met.Soc.
Cheltenham	Gloucester	184	R. Tyrer, B.A., F.R.Met.Soc.
Kenilworth	Warwick	290	F. Slade, F.R.Met.Soc.
		300	T. G. Hawley, F.R.Met.Soc.
Aspley Guise, Woburn	Bedford	410	E. E. Dymond, J.P., F.R.Met.Soc.
England, S.			
Regent's Park	London	125	W. Sowerby, F.R.Met.Soc.
Norwood	Surrey	184 220	W. Marriott, F.R.Met.Soc.
Croydon, Addiscombe	Surrey	201	E. Mawley, F.R.Met.Soc.
Beddington	Surrey	102 120	S. Rostron, J.P., F.R.Met.Soc.
Marlborough	Wilts	471	Rev. T. A. Preston, M.A., F.R.Met.Soc.
		424	C. E. B. Hewitt, B.A.
Strathfield Turgiss	Hants	197	Rev. C. H. Griffith.
Swarraton, Alresford	Hants	310	Rev. W. L. W. Eyre, M.A., F.R.Met.Soc.
Harestock, Winchester	Hants	300	Lt.-Col. H. S. Knight, F.R.Met.Soc.
Southampton, Highfield	Hants	136	Rev. H. Garrett, M.A., F.R.Met.Soc.
Margate	Kent	83	J. Stokes, F.R.Met.Soc.
Ramsgate	Kent	105	Revs. T. E. Egan, & J. S. Swanson, O.S.B.
		90	M. Jackson, J.P., F.R.Met.Soc.
Brighton	Sussex	31	A. Newsholme, M.D.
Worthing	Sussex	21 33	W. J. Harris, M.R.C.S., F.R.Met.Soc.
Portsmouth	Hants	20	R. E. Power, L.R.C.P.
		18	B. H. Mumby, M.D., F.R.Met.Soc.
Ventnor	Isle of Wight	80	J. Codling, H. Sager, and H. Cleeland.
Southbourne-on Sea	Hants	90	T. A. Compton. B.A., M.D., F.R.Met.Soc.
Weymouth	Dorset	79	T. B. Groves, F.R.Met.Soc.
Scotland, W.			
Scaleby	Cumberland	111	R. A. Allison, M.P., J.P., F.R.Met.Soc.
England, N.W.			
Seathwaite	Cumberland	422	W. Dixon and Mrs. Hughes.
Blackpool	Lancashire	31	Rev. C. T. Ward, B.A.
		62	J. Wolstenholme, Assoc.M.Inst.C.E.
Macclesfield	Cheshire	501	J. Dale and C. Roscoe.
Llandudno	Carnarvon	79 88	J. Nicol, M.D., J.P., F.R.Met.Soc.
England, S.W.			
Carmarthen	Carmarthen	188	G. J. Hearder, M.D.
Weston-super-Mare	Somerset	20	W. E. Perrett.

TABLE I.—STATIONS AND OBSERVERS—*Continued.*

Station.	County.	Height above Sea Level.	Observers.
ENGLAND, SW.—*Cont.*		Ft.	
Ilfracombe	Devon	25	M. W. Tattam.
Bude	Cornwall	16	J. Arthur.
Cullompton	Devon	202	T. Turner, J.P.. F.R.Met.Soc.
Brampford Speke	Devon	113	W. H. Gamlen and Miss M. B. Gamlen.
Sidmouth	Devon	186 148	W. T. Radford, M.D., F.R.Met.Soc.
Teignmouth	Devon	50 70	W. C. Lake, M.D.
Babbacombe	Devon	293	E. E. Glyde, F.R.Met.Soc.
Ashburton	Devon	584	F. Amery, J.P.
Falmouth	Cornwall	210 175 167	W. L. Fox, F.R.Met.Soc. E. Kitto, F.R.Met.Soc.
IRELAND.			
Londonderry	Londonderry	74	J. Conroy, F.R.Met.Soc.
Dublin	Dublin	54	J. W. Moore, M.D., F.R.Met.Soc.
Killarney	Kerry	91	Ven. Archdeacon Wynne, M.A., F.R.Met.Soc.
CHANNEL ISLANDS.			
Guernsey	Channel Isles	180	F. E. Carey, M.D., F.R.Met.Soc.

NOTE.—The names of the Second Order Stations are printed in *italics*.

Cullompton, Ashburton, and the two Irish stations of Londonderry and Killarney; between 3 and 4 inches we have Bude, Babbacombe, Cullompton, and Londonderry; between 4 and 5 inches, Buxton, Carmarthen, and Falmouth; and over 5 inches we have Ashburton (5·15 ins.), Killarney (7·38 ins.), and the wet station of Seathwaite (13·58 ins.).

In *April*, which, contrary to what might be imagined, seems to be in all districts nearly, if not quite, the driest month, we have a fall of between 1 and 2 inches over very nearly the whole of England, with Londonderry and Guernsey, except at the following stations, which have a greater fall; between 2 and 3 inches are Falmouth, Babbacombe, Teignmouth, Sidmouth, Brampford Speke, Cullompton, Marlborough, Ross, Carmarthen, Churchstoke, Belper, Buxton, Wakefield, Scarborough, and Dublin; between 3 and 4 inches we have Ashburton and Killarney; and over 4 inches we have Seathwaite (6·43 ins.). As a rule the rainfall seems gradually to diminish between January and April.

From April to July the rainfall seems to increase gradually, so that in July we have only one station with a rainfall below 2 inches, viz. Weymouth; between 2 and 3 inches we have nearly the whole of England, with Dublin, and Guernsey, except the stations after mentioned; between 3 and 4 inches are Falmouth, Ashburton, Cullompton, Hillington, Macclesfield, Blackpool, Scaleby, and the Irish stations of Londonderry and Killarney; and over 4 inches we have Carmarthen (4·61 ins.), Buxton (4·43 ins.), and Seathwaite (11·44 ins.).

TABLE II.—MEAN TEMPERATURE AT 9 A.M. 1881–1890.

Station.	January.	February.	March.	April.	May.	June.	July.	August.	September.	October.	November.	December.	Year.
ENGLAND, N.E.	°	°	°	°	°	°	°	°	°	°	°	°	°
Scarborough	38·1	38·9	40·4	44·9	51·2	56·6	60·5	59·3	55·5	48·4	43·3	38·2	47·9
ENGLAND, E.													
Hillington	35·6	37·5	40·2	46·8	54·4	59·9	62·6	61·4	57·1	48·1	42·2	36·1	48·5
Somerleyton	36·9	38·1	40·4	45·8	53·1	58·2	62·1	61·1	57·6	49·6	43·7	37·5	48·7
Lowestoft	37·5	38·4	40·4	45·7	52·7	58·1	62·3	61·5	58·1	50·1	44·0	38·0	48·9
MIDLAND COUNTIES.													
Wakefield	37·6	38·3	39·4	44·6	52·2	57·4	60·6	59·0	55·0	47·2	42·6	37·4	47·6
Hodsock	36·1	37·9	40·2	45·7	52·9	58·5	61·6	59·8	55·6	47·7	41·9	36·2	47·8
Buxton	34·8	35·6	37·5	42·4	50·3	55·7	58·2	56·8	53·3	45·3	40·4	34·7	45·4
Belper	36·0	37·3	38·7	43·9	51·1	56·5	59·3	57·3	53·4	45·7	41·6	36·4	46·4
Cheadle	35·1	35·8	37·7	42·9	50·0	55·3	57·7	56·2	53·1	45·3	40·8	35·3	45·4
Churchstoke	36·9	37·9	39·6	44·3	51·7	57·2	59·8	58·4	54·7	47·3	42·8	36·9	47·3
Burghill	36·8	38·3	41·0	45·9	53·7	59·5	62·4	61·1	56·0	47·6	43·0	36·8	48·5
Ross	37·6	38·9	41·8	46·6	54·4	60·4	63·0	61·8	56·7	48·6	44·0	37·7	49·3
Cheltenham	37·6	38·5	40·6	46·0	53·2	58·6	61·5	60·7	55·8	47·5	43·5	37·8	48·4
Kenilworth	36·2	37·3	39·4	44·7	52·3	57·7	60·8	59·4	54·9	46·7	41·9	36·3	47·3
Aspley Guise	36·4	37·3	40·3	45·7	53·8	59·0	62·7	61·3	56·5	48·3	42·8	36·3	48·4
ENGLAND, S.													
Regent's Park	37·9	38·5	40·2	46·3	54·1	59·4	62·5	61·0	56·6	47·8	43·9	38·1	48·9
Norwood	37·5	38·3	40·7	46·8	54·7	60·0	63·1	61·6	57·1	48·3	43·5	37·5	49·1
Croydon	37·2	38·1	40·2	46·2	54·1	59·1	62·4	61·2	56·6	48·1	43·5	37·2	48·7
Beddington	36·9	37·9	40·2	46·5	54·5	59·9	63·3	61·6	56·8	47·6	43·1	36·8	48·8
Marlborough	36·2	37·2	39·4	45·0	52·8	58·3	61·6	60·5	55·7	46·8	41·9	36·2	47·6
Strathfield Turgiss	37·1	38·6	41·1	47·0	55·0	60·1	63·3	62·0	57·0	47·8	43·3	37·1	49·1
Swarraton	36·6	37·6	39·6	45·1	52·9	57·9	60·8	60·1	55·8	47·4	42·5	36·9	47·8
Harestock	37·1	37·9	40·2	45·8	53·3	58·4	61·5	60·8	56·5	48·1	43·4	37·2	48·4
Southampton	37·9	39·1	41·4	47·2	54·8	60·2	62·6	62·1	57·5	49·4	44·4	38·2	49·6
Margate	38·3	39·1	41·2	46·5	53·4	58·5	62·3	62·0	58·6	50·2	45·1	39·2	49·5
Ramsgate	38·2	39·2	41·2	46·7	53·7	59·0	62·6	62·4	58·9	50·3	44·9	39·0	49·7
Brighton	39·6	40·0	41·6	47·1	55·7	60·2	63·0	63·4	59·4	51·8	46·2	40·2	50·7
Worthing	38·8	39·6	41·3	47·0	54·4	59·4	62·2	62·3	58·9	50·8	45·7	39·5	50·0
Portsmouth	39·3	39·8	41·6	47·0	54·9	60·0	63·1	62·8	58·5	50·4	45·6	39·8	50·2
Ventnor	41·1	41·1	43·0	47·4	54·2	59·1	61·9	62·6	59·5	52·5	47·7	42·0	51·0
Southbourne	39·2	39·7	41·4	47·0	54·0	59·1	62·2	62·3	58·1	50·2	45·4	39·7	49·9
Weymouth	41·4	41·2	42·3	46·5	53·1	58·3	61·5	61·8	58·1	51·6	47·5	42·0	50·4
SCOTLAND, W.													
Scaleby	36·9	37·3	39·0	44·9	51·8	57·2	58·9	58·0	54·5	46·9	41·4	36·4	46·9
ENGLAND, N.W.													
Seathwaite	38·0	37·4	38·0	43·9	51·2	57·2	58·1	56·9	53·5	46·4	42·1	37·9	46·7
Blackpool	38·1	38·7	40·3	45·7	52·3	57·7	59·7	59·2	56·2	49·0	43·9	38·5	48·3
Macclesfield	36·2	36·4	37·9	43·2	50·9	56·0	58·2	56·7	53·3	45·4	41·4	36·0	46·0
Llandudno	41·3	41·3	42·2	46·5	52·9	58·1	60·3	59·8	57·4	50·7	46·5	41·5	49·9
ENGLAND, S.W.													
Carmarthen	39·6	40·8	42·8	48·2	54·9	60·6	62·0	61·2	57·9	50·3	45·5	39·5	50·3
Weston-super-Mare	39·9	40·0	41·8	46·5	53·4	58·8	61·9	61·3	57·6	50·2	45·8	40·3	49·8
Ilfracombe	43·3	43·0	44·0	47·3	52·8	57·9	61·0	61·3	58·8	52·9	48·8	43·8	51·2
Bude	41·3	40·7	42·1	46·9	53·4	58·2	60·6	61·0	57·4	50·7	47·1	41·7	50·1
Cullompton	39·0	39·6	41·9	47·0	54·4	60·0	62·3	61·8	57·3	49·3	44·6	38·7	49·7
Brampford Speke	39·0	39·6	41·7	47·3	54·7	60·0	62·3	60·9	56·4	48·7	44·6	38·7	49·5
Sidmouth	40·4	40·3	41·7	46·0	52·9	57·8	60·5	60·6	56·9	50·0	46·2	40·8	49·5
Teignmouth	41·4	41·1	42·8	47·9	54·5	59·6	62·3	62·1	58·0	50·4	46·6	41·3	50·7
Babbacombe	41·2	41·2	43·1	47·0	53·5	59·2	62·2	62·1	57·9	51·4	46·8	41·4	50·6
Ashburton	40·4	40·4	42·7	47·2	53·6	59·3	61·4	61·1	57·4	50·9	46·1	40·7	50·1
Falmouth	43·4	42·9	44·2	47·9	53·6	58·9	61·4	61·4	58·4	52·5	48·5	43·7	50·4
IRELAND.													
Londonderry	39·4	40·0	41·6	46·7	53·5	58·2	59·6	58·2	54·9	48·0	43·2	39·3	48·6
Dublin	40·8	41·2	42·2	46·4	53·4	58·6	60·4	59·0	55·5	48·7	45·0	40·2	49·3
Killarney	42·4	42·3	43·4	47·2	52·9	58·2	59·8	58·9	56·0	50·1	46·1	41·1	49·9
CHANNEL ISLANDS.													
Guernsey	42·8	42·6	44·0	47·5	53·3	57·6	60·8	61·5	59·1	52·8	48·8	43·8	51·2

TABLE III.—MEAN MINIMUM TEMPERATURE, 1881–1890.

Station.	January.	February.	March.	April.	May.	June.	July.	August.	September.	October.	November.	December.	Year.
ENGLAND, N.E.	°	°	°	°	°	°	°	°	°	°	°	°	°
Scarborough	34.5	35.3	35.3	38.7	43.7	49.4	52.6	52.0	49.8	43.9	39.5	34.6	42.4
ENGLAND, E.													
Hillington	31.5	32.6	32.7	36.7	42.2	47.5	50.9	50.0	47.4	41.0	37.1	31.9	40.1
Somerleyton	32.2	33.3	33.5	37.9	43.4	48.8	52.0	51.5	49.9	42.9	38.6	32.7	41.4
Lowestoft	33.8	34.3	34.5	38.7	43.9	49.3	52.5	52.4	50.7	43.5	39.3	34.0	42.2
MIDLAND COUNTIES.													
Wakefield	33.8	34.0	33.9	37.1	42.6	48.0	51.5	50.4	47.3	41.7	37.8	33.5	41.0
Hodsock...........	31.6	33.1	32.9	36.2	41.7	47.3	50.9	49.4	46.6	40.6	36.9	31.7	39.9
Buxton	30.0	30.6	30.0	34.1	39.5	44.9	48.4	47.3	44.1	38.7	34.8	29.7	37.7
Belper...........	31.8	33.3	33.0	37.1	42.7	48.2	51.5	50.3	47.4	40.6	37.3	32.0	40.4
Cheadle	31.9	32.5	32.7	36.3	41.9	47.5	50.4	49.5	47.1	40.5	37.0	31.7	39.9
Churchstoke	31.9	32.7	32.2	35.4	40.7	46.2	49.3	48.3	45.7	39.8	36.9	32.0	39.3
Burghill..........	32.5	33.6	34.0	37.4	43.1	48.4	51.2	50.0	47.0	40.5	38.1	32.5	40.7
Ross	33.1	33.8	34.2	37.8	43.3	48.8	52.0	50.7	47.6	41.0	38.8	33.2	41.2
Cheltenham	32.4	32.9	33.1	36.8	42.5	48.1	51.2	49.7	46.9	39.8	37.7	32.7	40.3
Kenilworth	31.7	33.1	33.0	36.7	42.3	47.8	51.4	49.9	47.2	40.2	37.2	32.1	40.2
Aspley Guise......	32.0	32.5	32.9	36.5	42.1	47.9	51.4	50.5	47.7	40.9	37.4	31.7	40.3
ENGLAND, S.													
Regent's Park	33.8	34.4	34.8	38.9	44.9	50.5	53.8	52.9	49.7	42.3	39.2	33.7	42.4
Norwood	34.0	34.6	34.6	38.4	44.2	50.1	53.2	52.3	49.4	42.1	38.9	33.8	42.1
Croydon..........	33.3	34.1	34.4	38.1	44.0	49.6	52.9	52.0	49.1	41.7	38.9	33.1	41.8
Beddington	32.3	33.6	33.5	37.2	42.8	48.4	51.6	50.5	47.8	40.5	37.6	32.2	40.7
Marlborough.......	32.2	33.0	32.5	36.4	42.0	47.4	50.3	49.1	46.1	39.3	36.8	31.6	39.7
Strathfield Turgiss	31.8	33.4	33.0	36.7	42.5	48.2	51.1	50.9	47.3	40.1	37.3	31.8	40.3
Swarraton........	32.0	33.2	32.8	36.4	42.0	47.5	50.9	49.8	47.1	40.0	37.3	32.1	40.1
Harestock	32.8	33.5	33.1	36.8	42.5	48.1	51.3	50.7	47.9	40.9	37.9	32.9	40.7
Southampton	32.6	33.9	33.5	37.3	43.1	48.4	51.6	50.6	48.1	40.9	38.0	32.9	40.9
Margate..........	34.8	35.4	35.9	40.1	45.6	51.1	54.0	54.4	52.4	44.9	40.5	35.1	43.7
Ramsgate	34.4	35.0	35.6	40.1	45.5	50.7	53.6	53.6	52.0	44.3	40.4	34.7	43.3
Brighton	35.0	36.0	35.6	40.3	46.4	51.6	55.1	54.8	52.3	44.7	42.2	36.2	44.2
Worthing	34.5	35.6	35.3	39.8	45.9	50.9	54.2	53.9	51.6	44.0	40.8	35.2	43.5
Portsmouth	33.8	34.9	35.1	38.8	45.3	50.4	53.7	53.7	50.8	43.7	40.6	35.2	43.0
Ventnor..........	37.4	37.7	37.6	41.2	47.1	51.8	55.3	55.8	53.7	47.0	43.7	38.2	45.5
Southbourne.....	35.5	35.7	35.4	38.9	44.8	50.3	53.5	52.7	50.0	43.4	40.8	35.6	43.1
Weymouth	37.1	37.2	37.2	40.6	46.3	51.5	54.6	54.8	52.6	46.0	43.2	37.7	44.9
SCOTLAND, W.													
Scaleby	32.5	33.1	33.0	36.1	41.4	46.6	49.8	49.1	46.3	40.3	36.3	31.6	39.7
ENGLAND, N.W.													
Seathwaite	33.9	33.8	33.6	37.5	42.9	48.4	51.3	50.4	47.5	41.3	38.1	33.4	41.0
Blackpool	33.5	34.5	34.6	37.6	43.2	48.8	52.8	52.1	49.2	43.1	39.1	33.9	41.9
Macclesfield	32.2	33.0	32.9	36.8	42.4	47.6	50.9	50.2	47.3	40.4	37.4	32.0	40.3
Llandudno	37.0	36.8	36.8	39.8	45.2	50.6	53.7	53.3	50.9	45.4	41.7	37.2	44.0
ENGLAND, S.W.													
Carmarthen	34.5	35.3	35.0	38.4	44.2	49.2	51.9	50.6	48.4	42.3	39.6	34.5	42.0
Weston-super-Mare	36.1	36.2	36.7	40.4	46.2	51.7	55.1	54.4	51.3	45.3	41.8	36.3	44.3
Ilfracombe	39.4	39.4	39.6	42.7	47.8	53.1	55.7	56.5	54.0	48.6	45.2	40.3	46.9
Bude	36.4	36.3	36.5	39.6	45.1	50.1	53.5	52.8	50.3	44.7	42.4	36.9	43.7
Cullompton	33.9	34.5	34.3	37.7	43.0	48.3	51.2	49.8	47.2	41.3	39.0	33.5	41.1
Brampford Speke..	34.0	34.7	34.7	38.3	44.3	49.8	52.5	51.2	48.0	41.9	39.1	33.9	41.9
Sidmouth	36.2	36.5	36.2	39.4	45.0	50.1	53.1	52.7	50.3	44.4	41.7	36.6	43.5
Teignmouth	37.4	37.3	37.2	41.0	46.4	51.7	54.6	53.9	51.2	45.1	42.5	37.2	44.6
Babbacombe......	37.2	36.9	36.6	40.0	45.4	50.6	53.3	52.9	50.5	44.5	41.9	37.1	43.9
Ashburton........	36.2	36.1	36.0	39.5	45.0	50.3	53.0	52.7	50.2	44.5	41.5	36.4	43.5
Falmouth	39.8	39.1	39.1	41.9	46.8	51.8	54.4	54.5	52.4	47.2	44.5	39.8	45.9
IRELAND.													
Londonderry......	35.2	35.5	35.6	38.2	43.0	48.1	50.6	50.1	47.2	42.2	38.4	34.7	41.6
Dublin	37.3	37.5	36.8	40.4	45.6	51.0	53.7	52.8	49.9	44.1	41.1	36.5	43.9
Killarney	36.9	36.4	36.2	38.2	43.3	48.4	51.0	51.1	47.9	42.3	40.2	35.2	42.3
CHANNEL ISLANDS.													
Guernsey	39.7	39.9	40.1	43.2	47.7	51.9	55.1	55.8	54.4	48.7	45.7	40.7	46.9

TABLE IV.—Mean Maximum Temperature, 1881–1890.

Station.	January.	February.	March.	April.	May.	June.	July.	August.	September.	October.	November.	December.	Year.
England, N.E.	°	°	°	°	°	°	°	°	°	°	°	°	°
Scarborough	42.2	43.2	45.6	49.1	55.7	61.2	65.6	64.2	60.4	52.8	47.5	42.1	52.5
England, E.													
Hillington	41.5	43.8	47.7	53.2	61.2	67.1	70.5	69.0	63.9	54.8	47.8	41.3	55.2
Somerleyton	42.7	43.6	47.1	51.2	59.0	64.1	68.8	67.6	63.5	55.3	48.9	42.7	54.5
Lowestoft	42.6	43.3	46.0	49.8	57.0	62.9	67.4	66.8	63.3	55.3	49.2	42.7	53.9
Midland Counties.													
Wakefield	43.2	44.1	46.4	51.7	59.9	65.1	67.7	66.6	62.2	53.8	48.7	42.7	54.3
Hodsock...........	42.7	44.5	47.7	52.8	60.5	66.0	69.0	67.6	63.3	54.5	48.4	42.3	54.9
Buxton	40.1	41.3	43.6	49.6	57.1	63.0	65.1	63.9	59.8	50.6	45.4	39.8	51 6
Belper	41.5	42.9	46.1	51.7	59.1	64.7	67.2	65.6	61.2	52.5	47.1	41.3	53.4
Cheadle	40.9	42.3	45.1	51.0	58.1	63.3	65.5	64.4	60.6	51.8	46.5	40.5	52.5
Churchstoke	42.7	43.9	46.3	52.1	59.0	64.8	66.9	66.2	61.9	53.3	48.2	42.5	54.0
Burghill...........	43.7	45.4	48.9	54.6	62.3	67.9	70.4	69.4	64.4	55.3	49.4	43.4	56.3
Ross	43.6	45.5	49.2	55.1	62.7	68.6	70.8	69.9	64.6	55.2	49.5	43.3	56.5
Cheltenham	42.8	44.5	47.5	53.6	61.1	66.9	69.2	68.4	63.7	54.4	49.1	42.7	55.3
Kenilworth	41.8	43.4	46.9	52.4	59.9	65.8	68.5	67.2	62.9	53.8	47.7	41.5	54.3
Aspley Guise	41.4	43.0	47.1	53.1	60.7	66.6	69.9	68.6	63.6	54.0	47.5	41.0	54.7
England, S.													
Regent's Park	42.9	44.1	48.1	54.3	62.1	68.1	71.0	70.0	64.9	55.2	49.2	42.9	56.1
Norwood..........	42.8	44.3	48.3	54.3	62.5	68.1	71.2	70.1	65.1	55.6	49.2	42.7	56.2
Croydon	42.9	44.0	47.9	53.9	61.6	67.0	70.0	69.3	64.4	55.2	49.2	42.8	55.7
Beddington	42.8	43.9	48.1	54.1	62.2	67.9	71.1	70.1	64.7	55.2	49.2	42.4	56.0
Marlborough......	42.3	43.7	47.2	53.0	60.4	66.1	68.6	68.0	63.3	54.4	48.1	42.0	54.8
Strathfield Turgiss	43.2	45.1	49.3	55.6	63.4	69.0	72.1	70.8	65.7	56.3	49.6	43.0	56.9
Swarraton	42.5	43.8	47.2	53.3	60.5	65.7	68.3	67.8	63.2	54.6	48.7	42.4	54.8
Harestock	42.6	44.1	47.6	53.5	60.3	66.0	68.5	68.1	63.7	55.1	49.1	42.8	55.1
Southampton	43.9	45.4	49.0	55.2	62.2	67.9	69.9	69.5	65.1	56.5	50.2	43.8	56.6
Margate..........	43.1	43.6	46.7	51.2	58.6	64.0	68.5	67.8	63.6	55.2	49.7	43.5	54.6
Ramsgate	43.5	44.0	47.2	52.6	59.7	65.1	69.0	68.4	64.4	55.6	50.1	43.5	55.3
Brighton	44.8	44.9	47.6	52.3	60.4	65.4	67.9	66.9	64.0	56.8	51.8	45.8	55.7
Worthing.........	43.5	44.4	47.3	52.6	59.5	64.6	67.0	67.4	64.6	56.4	50.3	44.0	55.1
Portsmouth	44.4	45.4	48.8	54.6	62.2	68.0	70.7	70.4	66.1	57.6	51.1	44.6	57.0
Ventnor	45.7	46.1	48.6	53.4	59.6	64.8	67.0	67.9	64.6	57.2	51.9	46.4	56.1
Southbourne......	44.2	45.1	47.9	53.1	59.3	64.7	67.5	68.0	64.1	56.3	50.5	44.7	55.5
Weymouth........	45.7	45.3	47.5	51.9	58.3	63.8	66.8	66.9	63.4	56.2	51.2	45.9	55.2
Scotland, W.													
Scaleby ...	42.6	43.9	46.3	51.8	59.2	64.9	66.2	65.0	62.0	53.3	47.5	41.8	53.7
England, N.W.													
Seathwaite.......	42.2	43.0	44.6	50.9	58.1	63.8	63.8	63.3	60.0	52.3	46.5	42.0	52 5
Blackpool	42.5	43.3	45.0	50.9	57.5	62.5	64.3	63.7	60.9	53.4	48.1	42.7	52.9
Macclesfield	41.6	42.5	45.1	51.1	58.7	64.3	65.8	64.8	61.0	52.2	47.0	41.1	52.9
Llandudno.......	45.6	45.6	46.8	51.1	57.5	62.7	64.8	64.2	61.5	54.5	50.4	45.5	54.2
England, S.W.													
Carmarthen	44.9	46.4	48.6	54.1	59.9	65.3	66.6	66.7	63.6	56.0	50.8	45.2	55.7
Weston-super-Mare	44.9	45.8	48.0	53.1	59.5	64.8	66.9	67.0	63.8	56.0	50.7	45.0	55.5
Ilfracombe	47.2	46.8	47.9	51.9	58.0	62.5	64.9	65.2	62.5	56.4	52.4	47.6	55.3
Bude	46 4	46.8	48.4	53.3	58.8	63.8	65.3	65.9	63.5	56.7	51.7	46.8	55.6
Cullompton	45.0	45.9	48.9	54.3	61.4	66.9	68.9	68.3	64.3	56.2	50.5	44.8	56.3
Brampford Speke..	44.8	45.8	49.0	55.0	62.1	67.1	68.9	67.3	62.9	55.0	50.3	44.4	56.1
Sidmouth	45.5	45.5	47.5	52.1	58.1	63.3	65.7	66.0	62.6	55.7	51.0	45.8	54.9
Teignmouth......	46.3	46.4	49.4	54.2	60.3	65.7	67.6	67.9	64.5	56.7	51.6	46.5	56.4
Babbacombe......	46.0	46.2	48.3	52.7	58.8	65.0	67.4	67.4	63.3	56.4	51.4	46.4	55.8
Ashburton........	45.6	46.1	48.7	53.3	59.8	65.6	67.8	67.3	63.6	56.5	51.4	46.0	56.0
Falmouth	47.3	46.9	48.4	51.8	57.5	63.2	65.4	65.3	62.1	56.1	52.1	47.7	55.3
Ireland.													
Londonderry	45.5	46.6	48.7	54.1	60.4	63.3	65.9	64.7	61.8	54.5	49.4	45.0	55.2
Dublin	46.0	46.5	48.1	52.2	58.8	64.2	66 1	64.9	61.1	54.2	50.1	45.3	54.8
Killarney	47.8	48.2	49.4	53.3	58.6	64.1	65.1	64.9	61.7	55.7	51.6	47.3	55.6
Channel Islands.													
Guernsey	47.0	46.6	48.9	52.8	59.1	63.2	66.5	67.1	64.4	57.3	52.8	47.7	56.1

TABLE V.—MEAN TEMPERATURE, 1881–1890.

Station.	January.	February.	March.	April.	May.	June.	July.	August.	September.	October.	November.	December.	Year.
ENGLAND, N.E.	°	°	°	°	°	°	°	°	°	°	°	°	°
Scarborough......	38·4	39·2	40·4	43·9	49·7	55·3	59·1	58·2	55·1	48·3	43·5	38·4	47·5
ENGLAND, E.													
Hillington...... ..	36·6	38·2	40·1	45·0	51·7	57·3	60·8	59·4	55·6	47·9	42·5	36·6	47·6
Somerleyton......	37·5	38·4	40·3	44·5	51·2	56·4	60·4	59·6	56·8	49·1	43·8	37·7	48·0
Lowestoft	38·2	38·8	40·3	44·2	50·5	56·1	59·9	59·6	57·0	49·4	44·3	38·3	48·1
MIDLAND COUNTIES.													
Wakefield	38·5	39·0	40·2	44·5	51·2	56·5	59·7	58·5	54·7	47·7	43·2	38·1	47·7
Hodsock	37·1	38·9	40·2	44·5	51·1	56·7	59·9	58·6	54·9	47·5	42·7	37·0	47·4
Buxton	35·1	35·9	36·8	41·9	48·3	53·9	56·8	55·5	52·0	44·7	40·2	34·7	44·7
Belper	36·7	38·1	39·5	44·4	50·9	56·5	59·3	58·0	54·3	46·5	42·2	36·6	46·9
Cheadle	36·4	37·4	39·0	43·6	50·0	55·3	58·0	56·9	53·9	46·2	41·2	36·1	46·2
Churchstoke	37·3	38·3	39·2	43·7	49·9	55·5	58·1	57·3	53·8	46·5	42·6	37·2	46·6
Burghill..........	38·1	39·6	41·3	46·1	52·7	58·2	60·7	59·7	55·7	47·9	43·8	37·9	48·5
Ross..............	38·4	39·6	41·7	46·5	53·0	58·7	61·4	60·3	56·1	48·1	44·2	38·2	48·9
Cheltenham	37·6	38·7	40·3	45·2	51·8	57·4	60·3	59·0	55·3	47·1	43·4	37·7	47·8
Kenilworth	36·8	38·2	40·0	44·6	51·0	56·9	59·9	58·6	55·0	47·0	42·5	36·7	47·3
Aspley Guise	36·7	37·8	40·0	44·8	51·4	57·3	60·6	59·6	55·6	47·5	42·4	36·3	47·5
ENGLAND, S.													
Regent's Park	38·4	39·3	41·4	46·6	53·5	59·3	62·4	61·4	57·3	48·7	44·3	38·3	49·2
Norwood	38·4	39·5	41·4	46·1	53·3	59·1	62·2	61·2	57·2	48·9	44·1	38·2	49·2
Croydon	38·2	39·1	41·1	46·0	52·7	58·3	61·5	60·7	56·7	48·4	44·0	38·0	48·7
Beddington	37·6	38·8	40·8	45·7	52·5	58·1	61·3	60·3	56·2	47·9	43·3	37·4	48·3
Marlborough......	37·2	38·4	39·9	44·7	51·2	56·7	59·5	58·5	54·7	46·8	42·5	36·8	47·2
Strathfield Turgiss	37·5	39·2	41·2	46·1	53·0	58·6	61·6	60·9	56·4	48·2	43·4	37·4	48·6
Swarraton.........	37·3	38·5	40·0	44·9	51·1	56·7	59·6	58·8	55·2	47·2	43·0	37·3	47·5
Harestock	37·7	38·8	40·3	45·2	51·4	57·1	59·9	59·4	55·8	48·0	43·5	37·9	47·9
Southampton	38·3	39·7	41·2	46·2	52·6	58·2	60·7	60·1	56·6	48·7	44·1	38·4	48·7
Margate..........	38·9	39·6	41·2	45·7	52·1	57·5	61·3	61·0	58·0	50·1	45·1	39·4	49·2
Ramsgate	39·0	39·5	41·5	46·3	52·6	57·9	61·3	61·0	58·2	50·0	45·2	39·1	49·3
Brighton	39·9	40·5	41·6	46·3	53·3	58·5	61·5	60·9	58·1	50·8	47·0	41·0	50·0
Worthing	39·0	40·0	41·3	46·2	52·8	57·7	60·6	60·7	58·1	50·1	45·6	39·6	49·3
Portsmouth	39·1	40·2	41·9	46·7	53·7	59·3	62·2	62·1	58·4	50·6	45·9	39·9	50·0
Ventnor..........	41·6	41·9	43·1	47·4	53·3	58·3	61·2	61·8	59·1	52·1	47·8	42·3	50·8
Southbourne......	39·9	40·4	41·6	46·0	52·1	57·5	60·5	60·4	57·0	49·8	45·6	40·2	49·3
Weymouth . ..	41·4	41·3	42·3	46·2	52·3	57·7	60·7	60·9	57·9	51·2	47·1	41·8	50·1
SCOTLAND, W.													
Scaleby	37·6	38·5	39·5	44·0	50·3	55·7	58·1	57·1	54·1	46·8	41·9	36·7	46·7
ENGLAND, N.W.													
Seathwaite	38·1	38·4	39·1	44·2	50·5	56·1	57·6	56·8	53·8	46·8	42·2	37·7	46·8
Blackpool	38·0	38·9	39·8	44·3	50·3	55·6	58·6	57·9	55·1	48·2	43·6	38·3	47·4
Macclesfield	36·9	37·8	39·0	44·0	50·5	56·0	58·3	57·5	54·1	46·3	42·2	36·6	46·6
Llandudno	41·3	41·2	41·7	45·5	51·3	56·7	59·2	58·8	56·2	49·9	46·0	41·4	49·1
ENGLAND, S.W.													
Carmarthen	39·7	40·9	41·8	46·2	52·0	57·3	59·2	58·7	56·0	49·2	45·2	39·9	48·8
Weston-super-Mare	40·5	41·1	42·3	46·7	52·9	58·2	61·1	60·7	57·5	50·6	46·3	40·6	49·9
Ilfracombe	43·3	43·1	43·8	47·3	52·9	57·8	61·3	60·8	58·3	52·5	48·8	43·9	51·1
Bude	41·4	41·6	42·4	46·4	52·0	57·0	59·4	59·4	56·8	50·7	47·2	41·8	49·7
Cullompton	39·5	40·2	41·6	46·0	52·2	57·6	60·0	59·1	55·8	48·7	44·8	39·1	48·7
Brampford Speke..	39·4	40·3	41·9	46·6	53·2	58·5	60·7	59·4	55·4	48·5	44·7	39·1	49·0
Sidmouth	40·8	41·0	41·9	45·8	51·5	56·7	59·4	59·3	56·5	50·1	46·3	41·3	49·2
Teignmouth	41·9	41·8	43·3	47·6	53·3	58·7	61·1	60·9	57·9	50·9	47·0	41·9	50·5
Babbacombe	41·6	41·6	42·5	46·3	52·1	57·7	60·4	60·1	56·9	50·5	46·6	41·8	49·9
Ashburton.........	40·9	41·1	42·4	46·3	52·4	57·9	60·4	60·0	56·9	50·5	46·5	41·2	49·7
Falmouth	43·6	43·0	43·7	46·9	52·1	57·5	59·9	59·9	57·2	51·7	48·2	43·8	50·6
IRELAND.													
Londonderry......	40·4	41·1	42·2	46·1	51·7	56·7	58·2	57·4	54·5	48·3	44·0	39·8	48·4
Dublin	41·7	42·0	42·7	46·3	52·2	57·6	59·9	58·8	55·5	49·2	45·7	40·9	49·4
Killarney	42·4	42·3	42·8	45·8	50·9	56·3	58·1	57·9	54·8	49·0	45·9	41·3	49·0
CHANNEL ISLANDS.													
Guernsey	43·4	43·2	44·6	47·9	53·4	57·6	60·8	61·4	59·4	53·0	49·3	44·2	51·5

TABLE VI.—MEAN RELATIVE HUMIDITY AT 9 A.M., 1881–1890.

Station.	January.	February.	March.	April.	May.	June.	July.	August.	September.	October.	November.	December.	Year.
ENGLAND, NE.	%	%	%	%	%	%	%	%	%	%	%	%	%
Scarborough	91	87	86	82	77	77	76	76	84	86	88	89	83
ENGLAND, E.													
Hillington	92	90	85	81	76	75	75	78	85	89	91	92	84
Somerleyton	89	88	84	79	75	76	74	76	83	85	88	89	82
Lowestoft	91	89	86	81	79	78	75	75	82	84	90	90	83
MIDLAND COUNTIES.													
Wakefield	91	90	87	82	77	78	78	79	84	86	89	90	84
Hodsock	90	88	82	77	72	73	72	75	83	84	89	90	81
Buxton	92	92	87	84	78	75	78	80	84	88	91	91	85
Belper	91	90	86	81	79	79	80	83	88	89	91	91	86
Cheadle	92	91	85	81	77	80	82	82	87	89	93	92	86
Churchstoke	89	89	83	78	75	77	77	80	83	86	88	89	83
Burghill	92	89	83	78	75	73	74	75	84	88	91	92	83
Ross	90	87	81	77	74	74	74	76	83	85	89	89	82
Cheltenham	90	88	83	78	76	77	77	78	85	88	89	90	83
Kenilworth	90	88	84	79	74	76	75	78	85	88	91	89	83
Aspley Guise	94	91	84	78	73	73	73	74	83	86	92	93	83
ENGLAND, S.													
Regent's Park	89	87	83	76	71	73	73	76	82	86	88	87	81
Norwood	90	87	81	75	69	70	70	73	80	85	90	89	80
Croydon	90	88	82	75	70	71	71	73	81	85	89	89	80
Beddington	91	87	82	76	71	72	70	75	82	86	89	90	81
Marlborough	93	91	86	79	75	77	75	76	84	88	92	92	84
Strathfield Turgiss	91	90	84	77	74	76	74	76	83	88	90	92	83
Swarraton	..	..	..	..	..	..	..	..	..	..	..	..	..
Harestock	90	88	81	76	72	72	73	73	81	85	88	89	81
Southampton	92	88	82	75	72	72	73	74	82	85	90	90	81
Margate	90	87	84	79	77	77	74	77	80	84	88	88	82
Ramsgate	90	87	84	79	76	75	74	77	80	86	88	90	82
Brighton	87	85	82	74	71	74	77	70	80	80	86	85	80
Worthing	90	89	84	80	76	76	78	77	82	85	90	90	83
Portsmouth	91	89	84	78	75	75	75	77	82	86	90	90	83
Ventnor	88	86	81	79	77	78	79	76	80	80	85	86	81
Southbourne	89	88	82	76	75	75	77	74	82	85	89	89	82
Weymouth	87	85	82	78	77	76	77	75	79	80	84	85	80
SCOTLAND, W.													
Scaleby	89	89	87	80	79	79	80	83	85	89	91	92	85
ENGLAND, N.W.													
Seathwaite	85	87	86	77	73	75	77	79	83	83	85	86	81
Blackpool	90	91	87	80	77	75	78	78	83	84	89	90	84
Macclesfield	93	90	88	83	76	76	80	83	87	90	90	90	86
Llandudno	85	82	79	76	73	75	76	76	79	80	82	83	79
ENGLAND, S.W.													
Carmarthen	90	86	80	72	71	71	75	76	80	84	87	91	80
Weston-super-Mare	90	88	84	80	79	79	78	80	84	85	88	89	84
Ilfracombe	87	86	84	83	86	84	83	84	85	86	87	86	85
Bude	..	..	..	..	..	..	..	..	..	..	..	..	..
Cullompton	90	87	81	76	73	72	74	76	83	86	89	89	81
Brampford Speke ..	92	90	84	79	77	76	78	80	87	89	92	92	85
Sidmouth	91	89	83	81	79	80	82	80	86	88	89	90	85
Teignmouth	89	87	82	79	74	75	76	77	82	85	88	90	82
Babbacombe	89	86	80	78	76	75	76	75	82	82	87	88	81
Ashburton	93	89	82	81	78	78	80	80	85	87	91	91	85
Falmouth	88	86	80	78	77	77	79	79	82	82	85	87	82
IRELAND.													
Londonderry	88	88	84	77	73	73	77	81	84	86	89	89	82
Dublin	86	85	81	76	72	73	74	80	84	85	86	86	81
Killarney	89	88	86	80	79	80	83	83	85	87	88	90	85
CHANNEL ISLANDS.													
Guernsey	89	88	84	82	83	83	83	82	84	84	86	87	85

TABLE VII.—MEAN AMOUNT OF CLOUD (0-10) AT 9 A.M., 1881-1890.

Station.	January.	February.	March.	April.	May.	June.	July.	August.	September.	October.	November.	December.	Year.
ENGLAND, N.E.													
Scarborough	7·0	7·1	6·6	6·7	5·9	6·2	6·3	6·2	6·5	6·5	6·6	6·5	6·5
ENGLAND, E.													
Hillington	7·9	7·8	7·5	7·4	7·2	7·1	7·1	6·8	6·9	7·0	7·6	7·9	7·4
Somerleyton	6·9	6·9	6·8	6·5	6·3	6·5	6·5	6·4	6·2	6·3	7·1	7·3	6·6
Lowestoft	6·9	7·2	6·8	6·8	6·1	6·4	6·6	6·6	6·6	6·5	7·3	7·3	6·8
MIDLAND COUNTIES.													
Wakefield	7·6	7·8	7·2	7·7	6·6	7·2	6·9	6·9	7·3	7·5	7·5	7·3	7·3
Hodsock	7·2	7·4	6·6	7·3	6·6	6·9	7·0	6·9	6·9	6·7	7·0	6·9	7·0
Buxton	7·9	7·8	7·1	7·3	6·8	6·7	7·1	7·2	7·2	7·4	7·9	7·7	7·3
Belper	..	..	..	..	..	..	..	..	..	..	..	..	..
Cheadle	7·5	7·4	6·7	7·0	6·5	6·5	6·9	7·1	6·6	6·5	7·1	7·2	6·9
Churchstoke	7·7	7·9	7·7	7·6	7·1	7·1	7·5	7·2	7·5	7·8	7·8	7·5	7·5
Burghill	7·6	7·4	6·9	7·2	6·7	6·7	6·9	6·5	6·8	7·1	7·2	7·2	7·0
Ross	7·0	6·8	6·1	6·8	6·2	6·0	6·3	5·9	6·3	6·4	6·7	6·8	6·4
Cheltenham	7·5	7·5	6·9	7·0	6·5	6·6	6·8	6·6	6·8	7·1	7·3	7·5	7·0
Kenilworth	8·0	7·8	7·0	7·5	7·0	6·8	7·2	7·0	7·2	7·0	7·3	7·8	7·3
Aspley Guise	7·0	7·5	6·7	7·1	6·9	6·7	6·7	6·6	6·7	6·5	7·0	7·2	6·9
ENGLAND, S.													
Regent's Park	..	..	..	..	..	..	..	..	..	..	..	..	..
Norwood	7·8	7·6	6·7	6·7	6·5	6·7	6·4	6·5	6·7	6·3	7·4	7·6	6·9
Croydon	7·9	8·1	7·3	7·3	6·9	7·1	7·1	6·9	7·4	6·8	7·9	7·8	7·4
Beddington	7·5	7·7	6·6	7·0	6·5	6·5	6·3	6·4	6·9	6·7	7·4	7·3	6·9
Marlborough	7·9	7·8	6·9	7·4	6·9	7·1	6·9	6·4	7·0	6·5	7·5	7·8	7·2
Strathfield Turgiss	7·7	7·7	6·9	7·0	6·6	7·1	6·8	6·3	6·9	6·9	7·1	7·5	7·0
Swarraton	7·6	7·7	6·8	7·1	6·8	7·0	6·8	6·2	6·7	6·8	7·3	7·6	7·0
Harestock	7·7	7·8	6·8	7·3	6·8	6·9	7·0	6·6	6·9	6·8	7·4	7·6	7·1
Southampton	7·3	7·5	6·5	6·8	6·4	6·7	6·9	6·3	6·7	6·3	7·3	7·2	6·8
Margate	7·6	7·5	6·7	6·5	6·2	6·7	6·8	6·3	6·4	6·9	7·5	7·6	6·9
Ramsgate	7·5	7·4	6·7	6·3	6·0	6·4	6·4	6·0	6·4	6·6	7·3	7·6	6·7
Brighton	..	..	..	..	..	..	..	..	..	..	..	..	..
Worthing	6·6	6·4	5·8	5·9	5·5	5·7	6·1	5·2	5·4	5·5	6·6	6·4	5·9
Portsmouth	7·1	6·7	5·5	5·6	5·3	5·4	5·7	5·0	5·5	5·7	6·8	7·1	6·0
Ventnor	6·8	6·6	5·9	5·8	5·5	5·7	6·1	5·4	5·8	6·0	6·7	6·7	6·1
Southbourne	7·0	6·8	5·9	6·0	5·5	5·7	6·0	5·5	5·8	5·8	6·8	6·9	6·1
Weymouth	6·8	6·1	5·2	5·3	4·7	4·4	4·7	4·3	4·7	5·3	6·7	6·3	5·4
SCOTLAND, W.													
Scaleby	7·8	7·5	7·1	6·9	6·5	6·5	7·5	7·3	6·9	7·0	7·4	7·5	7·2
ENGLAND, N.W.													
Seathwaite	8·3	7·8	7·5	6·9	7·0	6·9	8·0	7·9	7·6	8·0	8·3	7·8	7·7
Blackpool	7·5	6·7	6·3	6·0	5·7	5·7	6·1	6·4	6·2	6·9	7·2	7·5	6·5
Macclesfield	6·5	6·5	6·7	6·8	6·3	6·2	6·6	6·8	5·9	6·6	7·0	7·1	6·6
Llandudno	7·2	7·3	7·0	6·5	6·1	6·1	7·2	7·3	6·9	7·1	7·5	7·2	7·0
ENGLAND, S.W.													
Carmarthen	7·5	7·2	6·7	6·4	6·7	6·4	7·4	6·2	6·4	6·9	7·3	7·2	6·9
Weston-super-Mare	8·0	7·6	6·9	6·7	6·5	6·4	6·7	6·3	6·9	6·9	7·8	7·7	7·0
Ilfracombe	7·8	7·0	6·4	6·2	6·0	5·9	6·5	6·1	6·5	7·1	8·0	7·5	6·8
Bude	7·6	6·7	6·1	5·9	6·0	6·0	6·6	6·1	6·1	6·7	7·5	7·4	6·6
Cullompton	8·0	7·2	6·4	6·9	6·4	6·6	6·7	6·2	6·7	6·9	7·3	7·6	6·9
Brampford Speke ..	8·0	7·5	6·9	7·2	6·8	6·5	7·0	6·7	6·9	7·0	7·6	7·5	7·1
Sidmouth	8·1	7·9	7·1	7·2	6·7	6·6	7·3	6·8	6·6	7·1	7·8	7·7	7·2
Teignmouth	7·7	7·5	6·5	6·9	6·4	6·3	6·6	6·4	6·3	6·7	7·1	7·2	6·8
Babbacombe	7·9	7·8	6·7	7·0	6·7	6·4	6·6	6·3	6·5	6·9	7·3	7·4	7·0
Ashburton	7·2	7·1	6·2	6·4	6·1	5·9	6·0	5·7	6·2	6·3	6·8	6·9	6·4
Falmouth	7·9	7·2	6·8	6·8	6·3	6·4	6·9	6·6	6·7	6·9	7·2	7·4	6·9
IRELAND.													
Londonderry	7·7	7·9	7·7	7·2	7·4	7·8	8·2	8·4	7·8	7·8	7·6	8·1	7·8
Dublin	6·6	7·2	6·5	6·3	6·1	6·4	7·0	6·5	6·2	6·2	6·2	6·4	6·5
Killarney	7·5	7·7	7·0	7·1	7·3	6·8	7·8	7·5	7·4	7·4	7·4	7·2	7·3
CHANNEL ISLANDS.													
Guernsey	7·3	7·3	6·6	6·3	5·7	6·0	6·2	5·5	6·3	6·6	7·5	7·5	6·6

TABLE VIII.—MEAN RAINFALL, 1881-1890.

Station.	January.	February.	March.	April.	May.	June.	July.	August.	September.	October.	November.	December.	Year.
ENGLAND, N E.	In.	In.	In.	In.	In.	In.	In.	In.	In.	In.	In.	In.	In.
Scarborough ..	2·02	1·77	2·09	2·03	1·85	1·66	2·81	2·86	2·32	3·33	2·59	2·17	27·50
ENGLAND, E.													
Hillington	1·98	1·66	1·89	1·54	1·75	2·18	3·03	2·79	2·73	3·03	2·69	2·13	27·40
Somerleyton ..	1·60	1·58	1·60	1·59	1·85	1·42	2·70	1·96	2·74	3·53	2·76	2·12	25·45
Lowestoft	1·44	1·37	1·49	1·51	1·64	1·51	2·74	1·83	2·75	3·25	2·61	2·02	24·16
MID. COUNTIES													
Wakefield	2·18	1·74	2·16	2·06	2·15	1·91	2·82	2·11	2·04	2·90	2·41	2·04	26·52
Hodsock.....	2·00	1·56	1·91	1·70	2·38	1·76	2·36	2·28	1·78	2·66	2·05	1·85	24·29
Buxton	4·66	3·51	3·96	2·48	3·24	3·22	4·43	4·26	3·84	5·23	5·70	4·78	49·31
Belper........	2·70	2·27	2·44	2·04	2·42	2·24	2·73	2·76	2·53	3·58	3·18	2·67	31·56
Cheadle......	2·46	2·03	2·37	1·95	2·30	2·73	2·89	3·04	2·77	3·27	3·39	2·63	31·83
Churchstoke..	2·88	2·49	2·06	2·18	2·61	2·16	2·57	2·67	2·32	3·16	3·68	2·69	31·47
Burghill......	2·06	1·96	1·67	1·86	2·16	2·21	2·47	2·04	1·82	2·34	2·87	1·92	25·38
Ross	2·81	2·24	2·06	2·15	2·36	2·37	2·99	2·28	2·30	2·82	3·27	2·23	29·88
Cheltenham ..	2·13	2·11	1·95	1·95	2·12	2·32	2·82	2·04	2·27	2·58	3·02	2·19	27·50
Kenilworth ...	2·22	1·84	1·91	1·74	2·16	2·01	2·71	2·47	2·33	2·67	2·89	2·01	26·96
Aspley Guise..	1·69	1·47	1·56	1·69	2·18	1·75	2·27	1·84	2·11	2·40	2·60	1·88	23·44
ENGLAND, S.													
Regent's Park .	1·91	1·78	1·73	1·78	2·05	2·05	2·68	2·03	2·25	2·60	2·50	1·81	25·17
Norwood......	1·75	1·68	1·53	1·69	1·86	1·89	2·83	1·88	2·06	2·42	2·51	1·73	23·83
Croydon......	1·94	1·86	1·73	1·80	1·86	1·66	2·68	1·87	2·12	2·54	2·86	1·88	24·80
Beddington ...	1·81	1·68	1·61	1·65	1·93	1·60	2·80	1·72	2·04	2·43	2·60	1·74	23·61
Marlborough.	2·75	2·55	2·25	2·00	2·10	2·38	2·97	2·26	2·42	2·86	3·51	2·65	30·70
Strathfield T. .	2·14	1·86	1·55	1·65	1·97	1·86	2·35	1·99	2·10	2·53	2·75	1·86	24·61
Swarraton...	2·61	2·28	2·12	1·89	2·23	1·95	2·75	2·46	2·42	2·82	3·24	2·47	29·24
Harestock	2·92	2·15	2·19	1·98	2·13	2·11	2·46	2·32	2·40	2·96	3·40	2·72	29·74
Southampton..	2·67	2·09	2·03	1·96	2·22	1·82	2·64	2·19	2·44	3·04	3·45	2·67	29·22
Margate	1·72	1·41	1·44	1·51	1·56	1·38	2·12	1·76	2·48	3·11	2·65	2·17	23·31
Ramsgate	1·62	1·43	1·66	1·52	1·60	1·44	2·49	1·87	2·58	3·11	2·71	2·20	24·23
Brighton......	2·67	2·04	1·92	1·70	1·76	1·70	2·60	2·12	2·70	3·74	3·37	2·43	28·75
Worthing	2·30	1·92	1·76	1·55	1·74	1·69	2·32	1·99	2·50	3·29	3·22	2·26	26·54
Portsmouth ...	2·33	1·92	1·69	1·63	1·90	1·74	2·34	1·94	2·33	2·90	3·19	2·12	26·03
Ventnor......	2·60	2·00	1·78	1·71	1·83	1·66	2·41	1·72	2·58	3·56	3·48	2·80	28·13
Southbourne..	2·28	1·91	1·75	1·71	2·02	1·91	2·04	1·77	2·37	2·96	3·20	2·41	26·33
Weymouth	2·33	1·96	1·79	1·81	1·75	2·24	1·92	1·90	2·19	3·01	3·52	2·59	27·01
SCOTLAND, W.													
Scaleby	2·59	1·74	2·37	1·73	2·05	2·29	3·98	3·44	3·08	2·89	3·47	2·58	32·21
ENGLAND, NW.													
Seathwaite....	13·58	11·14	10·97	6·43	8·57	6·81	11·44	8·81	12·10	11·24	14·75	13·20	129·04
Blackpool	2·96	2·10	2·65	1·80	2·47	1·96	3·62	3·22	3·35	3·37	3·98	2·75	34·23
Macclesfield ..	2·81	1·94	2·59	1·79	2·39	2·92	3·67	3·49	2·99	3·41	3·50	3·10	34·60
Llandudno....	2·58	1·86	2·04	1·79	2·00	1·76	2·50	2·58	2·17	3·06	3·24	2·54	28·12
ENGLAND, SW.													
Carmarthen ..	4·65	3·64	3·68	2·52	2·91	2·86	4·61	3·78	4·20	5·21	5·84	4·75	48·65
Weston-s-Mare	2·23	1·57	1·85	1·95	2·04	2·15	2·90	2·91	2·59	3·02	3·23	2·43	28·87
Ilfracombe ...	2·62	1·90	2·16	1·64	2·07	1·90	2·55	2·70	2·71	3·22	3·85	3·31	30·63
Bude	3·13	2·24	2·15	1·85	1·91	1·90	2·54	2·32	2·97	3·69	4·06	4·09	32·85
Cullompton...	3·07	2·77	2·47	2·52	2·24	2·13	3·19	2·78	2·73	3·71	3·94	3·41	34·96
Brampford Sp.	2·78	2·94	2·37	2·35	2·04	1·96	2·93	2·43	2·61	3·88	3·78	3·18	33·25
Sidmouth	2·86	2·60	2·27	2·47	1·96	2·24	2·93	2·49	2·68	3·38	3·59	2·97	32·44
Teignmouth ..	2·92	2·73	2·68	2·28	2·02	1·78	2·78	1·93	2·24	3·51	3·56	3·14	31·57
Babbacombe ..	3·26	2·75	2·79	2·37	2·22	1·87	2·92	2·26	2·36	3·65	4·03	3·41	33·89
Ashburton....	5·15	4·68	4·26	3·20	2·60	2·39	3·79	3·25	3·59	5·45	6·54	5·67	50·57
Falmouth.....	4·09	3·61	3·21	2·55	2·41	2·25	3·48	2·92	3·77	4·72	5·60	4·95	43·56
IRELAND.													
Londonderry..	3·87	3·01	2·84	1·93	2·55	2·44	3·56	4·01	3·86	3·94	4·62	3·92	40·55
Dublin........	2·10	2·17	2·06	2·10	2·08	1·64	2·28	2·66	20·2	2·71	2·93	2·02	26·77
Killarney	7·38	5·99	4·58	3·22	3·49	2·80	3·42	4·17	4·08	5·34	6·22	6·41	57·10
CHANNEL IS.													
Guernsey......	2·99	2·50	2·04	1·96	1·98	1·88	2·12	2·17	2·67	4·06	4·82	3·34	32·53

TABLE IX.—No. of Rainy Days (0·01 in. and upwards), 1881–1890.

Station.	January.	February.	March.	April.	May.	June.	July.	August.	September.	October.	November.	December.	Year.
England, N.E.													
Scarborough	16	16	17	16	15	13	16	15	16	19	19	19	197
England, E.													
Hillington	17	15	14	15	14	12	16	14	13	18	18	17	183
Somerleyton	15	15	14	15	11	10	15	12	15	18	19	16	175
Lowestoft	15	14	14	14	11	11	15	13	15	17	18	16	173
Midland Counties.													
Wakefield	17	15	14	15	12	11	16	14	15	17	18	16	180
Hodsock	17	15	13	15	14	12	16	14	16	17	17	16	182
Buxton	17	17	17	14	14	13	16	16	16	19	20	17	196
Belper	16	14	13	14	14	11	16	14	15	17	19	15	178
Cheadle	18	15	17	14	15	12	18	15	16	18	20	17	195
Churchstoke	16	14	14	13	15	13	17	14	14	18	19	14	181
Burghill	17	13	13	13	13	12	16	13	13	16	18	17	174
Ross	17	15	14	15	16	14	18	15	17	18	20	15	194
Cheltenham	17	15	14	15	14	13	18	14	14	19	20	17	190
Kenilworth	17	13	13	14	13	13	16	14	13	17	18	16	177
Aspley Guise	16	13	11	14	13	11	15	13	13	16	16	15	166
England, S.													
Regent's Park	15	13	12	14	13	12	15	13	12	15	16	15	165
Norwood	15	14	13	14	13	11	16	13	14	16	18	16	173
Croydon	15	13	13	14	13	11	16	13	14	16	18	16	172
Beddington	15	12	13	13	13	10	14	13	13	16	17	15	164
Marlborough	17	14	14	15	14	14	17	14	14	17	19	18	187
Strathfield Turgiss	16	12	13	13	13	11	15	13	13	16	17	14	166
Swarraton	15	11	11	12	12	11	14	13	12	15	15	15	156
Harestock	16	13	13	13	14	11	15	14	12	16	17	16	170
Southampton	18	14	15	14	13	12	17	15	15	17	19	18	187
Margate	16	14	13	14	12	9	14	14	14	16	17	16	169
Ramsgate	15	13	13	14	11	9	13	12	14	16	17	16	163
Brighton	16	13	13	12	11	10	12	12	12	16	17	15	159
Worthing	16	13	11	12	11	11	12	12	13	14	17	15	157
Portsmouth	17	13	13	14	12	11	15	14	14	15	18	17	173
Ventnor	16	13	13	12	12	10	14	13	13	15	18	15	164
Southbourne	16	12	12	11	12	11	14	12	12	15	17	16	160
Weymouth	16	11	12	12	11	11	13	12	12	14	18	15	157
Scotland, W.													
Scaleby	19	15	17	14	15	13	19	17	18	18	20	16	201
England, N.W.													
Seathwaite	20	17	19	14	16	15	21	19	18	19	20	21	219
Blackpool	19	16	15	15	14	12	17	15	17	17	19	18	194
Macclesfield	17	16	15	13	15	12	19	16	16	18	18	17	192
Llandudno	17	14	14	13	11	12	14	14	16	17	18	16	176
England, S.W.													
Carmarthen	20	16	16	14	15	14	18	17	17	20	23	20	210
Weston-super Mare	17	13	13	13	15	12	17	15	14	16	18	15	178
Ilfracombe	17	13	16	14	15	12	18	15	15	18	19	17	189
Bude	16	11	10	10	11	9	12	12	11	15	18	15	150
Cullompton	19	15	14	15	13	12	17	16	16	20	21	19	197
Brampford Speke	19	16	15	14	14	12	17	15	15	19	21	20	197
Sidmouth	18	16	16	15	14	14	18	17	17	19	21	19	204
Teignmouth	16	14	14	13	12	11	14	11	12	16	19	17	169
Babbacombe	17	14	16	14	13	13	16	14	15	18	21	18	189
Ashburton	18	14	15	14	13	12	17	14	16	17	21	18	189
Falmouth	21	15	17	14	14	12	17	15	16	20	22	21	204
Ireland.													
Londonderry	22	20	21	16	17	16	23	21	19	21	22	22	240
Dublin	18	16	16	14	16	15	18	16	15	17	19	16	196
Killarney	22	18	18	16	17	14	20	19	18	20	23	20	225
Channel Islands.													
Guernsey	17	16	14	13	11	10	13	12	14	19	22	18	176

The rainfall is now rather irregular, as a rule it diminishes in August and September, but there are notable exceptions, particularly in our south-west and south districts, and also in Ireland and Guernsey; and it then rises again in October. Before dealing with this month, I should like to remark that in *October* our sea coast stations have a larger amount of rain than our inland stations. No station has under 2 inches; between 2 and 3 inches are all the stations between longitude 0° and 3° W. (except Brighton, Worthing, Southampton, Ventnor, Weymouth, Weston-super-Mare, Belper, Cheadle, Macclesfield, Buxton, and Guernsey), and also Dublin; between 3 and 4 inches are Scarborough, Hillington, Somerleyton, Lowestoft, Margate, Ramsgate, Brighton, Worthing, Southampton, Ventnor, Weymouth, Sidmouth, Brampford Speke, Cullompton, Teignmouth, Babbacombe, Bude, Ilfracombe, Weston-super-Mare, Churchstoke, Belper, Cheadle, Macclesfield, Llandudno, Blackpool, and Londonderry; between 4 and 5 inches are Falmouth, and Guernsey; between 5 and 6 inches are Ashburton, Carmarthen, Buxton, and Killarney; and over 6 inches is Seathwaite (11·24 ins.).

November seems to be a wetter month than October except in our North-eastern, Eastern, and South-eastern Counties, but I do not propose to go into this at length, as the distribution is very similar to that of October, December has a rainfall smaller than November and rather greater than January, with a distribution similar to this latter month.

The mean yearly rainfall is under 25 inches at Hodsock, Lowestoft, Margate, Ramsgate, Aspley Guise, Norwood, Croydon, Strathfield Turgiss, and Beddington; it is between 25 and 30 inches at Scarborough, Wakefield, Llandudno, Dublin, Burghill, Ross, Cheltenham, Kenilworth, Hillington, Somerleyton, Regent's Park, Brighton, Worthing, Ventnor, Portsmouth, Southampton, Harestock, Swarraton, Southbourne, Weymouth, and Weston-super-Mare; between 30 and 35 inches at Scaleby, Blackpool, Macclesfield, Cheadle, Belper, Churchstoke, Marlborough, Cullompton, Brampford Speke, Sidmouth, Teignmouth, Babbacombe, Bude, Ilfracombe, and Guernsey; between 35 and 40 inches at no station; between 40 and 45 inches at Falmouth, and Londonderry; between 45 and 50 inches at Carmarthen, and Buxton; and over 50 inches at Ashburton (50·57 ins.), Killarney (57·10 ins.), and Seathwaite (129·04 ins.) Practically less rain falls in the east than in the west, and the rate of fall increases as we travel west.

As to the number of rainy days, I do not propose to deal with this much at length, for the number of rainy days is very uniform, and at no station is the difference between the months of greatest and least number more than nine days. On looking at Table IX. it will at once be seen that the smallest number of rainy days occurs in June and the largest in November in all districts. With reference to the mean yearly number of rainy days I shall treat more at length, as it shows some very interesting features. Bude, Weymouth, Swarraton, Worthing, and Brighton, have between 150 and 159 rainy days; Aspley Guise, Regent's Park, Beddington, Strathfield Turgiss, Margate, Ramsgate, Ventnor, Southbourne, and Teignmouth, have between 160 and 169 days; Llandudno, Belper, Burghill, Kenilworth, Somerleyton, Lowestoft, Norwood, Croydon, Harestock, Portsmouth, Weston-super-Mare, and Guernsey have between 170 and 179 days; Wakefield, Hodsock, Hillington, Churchstoke, Marlborough, Southampton, Babbacombe, Ashburton, and Ilfracombe, have between 180 and 189 days; Scarborough, Blackpool, Dublin, Macclesfield, Buxton, Cheadle, Ross, Cheltenham, Cullompton, and Brampford Speke, have between 190 and 199 days; Scaleby, Sidmouth, and Falmouth, have between 200 and 209 days; Carmarthen and Seathwaite have between 210 and 219 days; Killarney has 225 days and Londonderry 240 days.

The general conclusions to be drawn from this paper may be shortly summarised as follows:—

(1.) With respect to mean temperature the sea coast stations are warm in winter and cool in summer, whilst the inland stations are cold in winter and hot in summer.

(2.) The mean maximum temperature occurs at all stations in July or August, while the mean minimum takes place mostly in December or January, except at Llandudno and the south-western sea coast stations, where it is later, taking place in February or March.

(3.) Relative Humidity is lowest at the sea coast stations and highest at the inland ones.

(4.) The south-western district seems the most cloudy in winter, spring, and autumn, and the southern district the least cloudy in the summer months, and the sea coast stations are, as a rule, less cloudy than the inland ones.

(5.) Rainfall is smallest in April and, as a rule, greatest in November, and it increases as we travel from east to west.

DISCUSSION.

Mr. Symons said that in the process of preparing the two diagrams of mean temperature and of lowest mean minimum temperature, which had been placed before the meeting, he had been obliged to carefully go through the figures contained in this paper, and had not succeeded in discovering any erroneous values, a result which spoke well both for the compiler and the printer of the paper. His object in constructing the maps shown was to ascertain where the warmest winter temperature prevailed, and also where the warmest yearly temperature was experienced. He did not quite understand how it was that Dublin was so warm in winter; possibly it was due to the influence of the sea, or to the position of the instruments in the heart of the city. The distribution of the lowest minimum temperatures was just what one would have expected, stations adjacent to the sea being warmer than those inland, and the west coast being warmer than the east. In the case of the mean temperature the distribution was a little different. One very noticeable anomaly was that of Ilfracombe. He did not understand why this place should be so warm, and could not help thinking that the method of exposure (of which he did not at all approve) was largely responsible for these apparently favourable climatic conditions. The form of screen used—really a large summer house,—the position of the rain gauge on the roof of this erection, and the general surroundings of the instruments, were, he thought, calculated to give results which would make Ilfracombe appear in a much more favourable light as regarded temperature and rainfall than was actually the case. It would be for the Council to consider whether a station so equipped ought to have been accepted or to be retained on the list. Attention had been drawn to the low percentage of relative humidity at Seathwaite, which, as was well known, was by far the wettest of all the stations compared in Mr. Bayard's paper. He had no reason to doubt the correctness of this result, and he believed it was usually the case that at places with a large rainfall, the air was as dry as, or drier than, at places where the rainfall was comparatively small. He thought this was due to the fact that it was the stations at considerable elevation which registered the largest rainfall, and the high ground being frequently of a rocky nature, very little rain penetrated the soil, so that the amount of moisture evaporated from the ground was exceedingly small, and quite insufficient to cause any appreciable increase in the relative humidity of the air. The neighbourhood of Buxton had been pointed out as one of the districts where the percentage of humidity was highest, but he believed it would be found, if observations were available, that at the neighbouring town of Matlock, where the rainfall was considerably less than at Buxton, the air was much damper. He was surprised to see the observations of amount of cloud (Table VII.) agree so very closely, and thought the very uniform results spoke well for the efficiency of the observers. He did not think that the table of number of "rainy days" afforded much material for discussion, as the records of days of rainfall depended so much on the disposition of individual observers, some of whom ignored very small amounts, while others duly measured them and entered them in their registers. He had endeavoured to ascertain the mildest places during the winter months, chiefly as indicated by the mean minimum temperatures, and had found that the stations ranged themselves in the following order:—Guernsey, Ilfracombe, Falmouth, Ventnor, Teignmouth, Weymouth, Llandudno, and Babbacombe. The smallness of the amount of daily range of temperature was an important factor in the determination of the climatic conditions of any place, and giving weight to this consideration, as well as to the average degree of cold experienced, the following order was obtained:—Ilfracombe, Guernsey, Falmouth, Ventnor, Llandudno, Weymouth, Teignmouth, and Babbacombe. It would be noticed that the extreme difference between the mean temperature of the stations on the south coast did not amount to more than 1°·0 or 1°·5; but he ventured to think that the same amount of difference could be obtained between records from two streets in any of these towns. The fact was that it was desirable to have, if possible, several stations in each seaside resort, at gradually increasing elevations and distances from the sea. It was important, too, that the exposure in each of the seaside towns should be, as nearly as possible, at a similar distance from the sea and at a similar elevation, so that the observations could be more strictly comparable. He had not much doubt that if the instruments at Brighton were placed on what was known as the Madeira Drive, instead of, as at present, located in the Old Steyne Gardens, the results would probably equal the Ventnor records; and if the Ventnor instruments were at a lower elevation and nearer the beach than they are now, the effect would probably be that still more favourable results would be obtained than those given in this paper.

The PRESIDENT (Dr. WILLIAMS) said that in speaking of Buxton and Cheadle as the coldest stations, it must be remembered that both these places were at a considerable height above the level of the sea, Buxton being at an elevation of 987 feet, and Cheadle 646 feet. Respecting the warmth of the sea coast stations in winter compared with those inland, it was interesting to observe the effect of the warm water in the south-west upon the temperature of the air on the neighbouring coast, the higher temperature of the air in the west as compared with that in the east being due to the warming influence of the waters of the Atlantic. The following figures of average sea and air temperatures in the month of February at five stations clearly showed this effect:—

	Sea Temperature.	Air Temperature.
	°	°
Scilly Islands	49	47
Falmouth	48	46
Torquay	46	45
Dover	43½	42
Yarmouth	39	40

It would be noticed that in the case of estuaries like the Bristol Channel, Southampton Water, and the Wash, the influence of the sea upon air temperature was considerably diminished, and this was probably to be accounted for by the fact that these inlets were comparatively shallow, so that a good deal of wet sand bank would be exposed at low water, giving rise to a considerable amount of evaporation, which would tend to lower the air temperature. Then too the water in such estuaries would not be entirely sea water, and the fresh water mixed with it would have the effect of making the temperature lower than that of the adjacent sea. It would be noticed that, generally speaking, there was a decrease in warmth along the course of the English Channel from Land's End to Dover, or the farther places were removed from the influence of the Gulf Stream the less mild their winter climate became. He had not succeeded in discovering why Ilfracombe was so much warmer in winter than Bude, as both were under the influence of the Gulf Stream. The difference might, of course, be due to the exposure of the instruments at Ilfracombe, or might arise from the naturally sheltered position of Ilfracombe; Bude being very exposed and unprotected. Carmarthen appeared to be cold, as from its proximity to the west coast he would have expected it to have been warmer. On the whole the results of these ten years observations confirmed what Dr. Tripe, Dr. Buchan, and he himself had previously shown, viz. the great influence of the Gulf Stream in equalising the climate of sea coast stations in the west, and especially in giving them a mild winter climate. Concerning Mr. Symons's remarks upon the differences of climate to be found in a single sea-side health resort, there was no doubt that to obtain the warmest situation it was necessary that the observations should be made as near to the sea as possible. Any elevation above sea level caused reduction of temperature.

Admiral Maclear said that he could confirm the statement that a large rainfall had but little, if any, effect upon the humidity of the air, for when he was stationed in the Straits of Magellan, where it rained on an average five days a week, wet clothes hung out under an awning dried very speedily. The natives of the neighbouring land of Tierra del Fuego were accustomed to go about without any clothing, and appeared to suffer no inconvenience. They could not have so exposed themseves if the air had been damp.

Mr. Gaster said that twenty-two years ago he visited Ilfracombe, and his opinion as to the exposure of the thermometers compelled him to use the observations with very great caution. With regard to Mr. Bayard's paper, he confessed that he was rather disappointed with the manner in which the material had been handled. The conclusions arrived at were not very new, where correct; it was hardly necessary, for instance, to say that the inland stations are colder in winter than those on the coast, because that was a fact which was already well known. He considered the results needed rather to be discussed in a manner which had regard to the situation of the stations in relation to the surrounding country, their distance from, and height above, the sea, whether they were on hills or in valleys, the direction in which the valleys ran, &c. If reference was made to any good collection of mean temperatures over the British Islands it would be noticed that, after allowing for altitude, a band of warm air stretched across Scotland from the Firth of Clyde to the Firth of Forth in winter, and a band of cool air in summer, the explanation being that in winter the warm sea air rushed through the valley, meeting little impediment, and thus retained more of its heat than the air which collided with, and was stopped by, the hills to the northward and southward of the valley referred to. The present observations, if combined with those from other authorities, would doubtless show other positions where similar phenomena would be observed; and there were many other ways in which better use might be made of such excellent materials.

Mr. Ellis said that Mr. Bayard's paper was excellent so far as it went. He thought it was important to have the original values when dealing with figures, and these Mr. Bayard had given, it being open to any person to apply any corrections for altitude or otherwise, and discuss the observations in any manner he thought fit. He (Mr. Ellis) had compared some averages of the four stations, Norwood, Regent's Park, Croydon and Beddington (the altitudes of which did not differ very much from that of Greenwich) with those for the Royal Observatory for the same period of years. The averages of the four places for the ten years were: mean maximum, 56°·0; mean minimum, 41°·8; mean temperature, 48°·9; the mean temperature at Greenwich, deduced from the hourly readings from the photographs reduced to the thermometer of the revolving stand, being also 48°·9. The mean result of amount of cloud also agreed very closely, the mean of the four stations being 6·9 and the mean at Greenwich 7·0. The average number of rainy days at the four stations was 168, and at Greenwich 162. The agreement is thus very satisfactory. He had not had opportunity to make further comparison. A mean from ten years observations, while the best that could be obtained from the Society's published results, was of course not founded on a sufficiently long period to be accepted as an absolutely reliable average. In fact he had shown in a paper read before the Society in 1891, that the monthly averages of temperature for different periods of ten years differ as much as 2° or 3°. Fifty years, although a lengthy period, was perhaps hardly sufficient to obtain a satisfactory mean, and it was doubtful if a hundred years was any too long for the purpose of obtaining a reliable average.

Mr. STRACHAN thought that some reference should have been made to the work which others had done in this branch of meteorology. He drew attention to the fact that two, and, in the case of second order stations, three different mean temperatures were published in the *Meteorological Record*, viz. mean temperature at 9 a.m., the mean of maximum and minimum, and, in the second order tables, the mean of the averages at 9 a.m. and 9 p m. These three values often differed considerably, especially in the summer months, and having regard to this difference he considered that it was desirable that a definite decision should be come to as to which of these three values was to be accepted as representing the true mean temperature. The Society might devise and adopt a definite method for deducing mean monthly temperatures.

Mr. M. JACKSON said that there was a popular belief that seaside places were much colder than places situated inland; and he had known parents who had seriously considered this popular notion when selecting a school for their children. The results given in Mr. Bayard's paper entirely dissipated such an idea. It would be noticed from a glance at the tables that so far as temperature was concerned Croydon and Ramsgate agreed very well together on the mean, but the mean was not the only item which had to be considered in determining the value of any place as a health resort, the extreme temperatures being of very great importance, as invalids and weakly people were very susceptible to extremes of heat and cold. He had been much surprised, in looking through the figures, to find that Buxton was so cold and wet, and that the climate of Ilfracombe was of so favourable a character, but he thought it desirable that these results should be confirmed or modified by observations made at other stations differently situated in these two towns.

Mr. LATHAM said that there was no doubt that many of the stations showed a higher temperature than was due to them owing to their sheltered situation. Llandudno, for instance, was a place to which such a remark applied, its natural formation securing for it a greater degree of warmth than its geographical position would lead one to expect. The town was situated on low ground and had a southerly aspect, being sheltered on the north by the promontory of the Great Orme, which really acted as a great reflector of the sun's rays, as well as a protection against winds from a cold quarter. Ilfracombe, too, was greatly sheltered by the high grounds in the immediate neighbourhood, and probably the favourable climatic conditions which appeared to prevail at this health resort were assignable to its protected situation. With respect to the observations of amount of cloud, it was desirable to bear in mind that the expanse of sky visible varied greatly at different places, and the wonder was that there were not greater discrepancies between the observations.

Mr. WALLIS said that the ten years quoted in the paper was far too short a period for obtaining true averages of rainfall, if not of temperature also, and it would be interesting if Mr. Bayard could add the twenty years mean for two or three of the stations, so as to exhibit the relation of the averages given to those obtained from a longer period.

Mr. MARRIOTT said that the stations organised by the Society were started on an uniform system, and everything possible was done to render the observations reliable. Each station was regularly inspected, the thermometers in use being tested and the manner of exposure and methods of observation inquired into at every visit of inspection. The alterations in the corrections for the index errors of the thermometers were ascertained and allowed for. At the first inspection these alterations were found to be in many cases considerable. As regarded the exposure and situation of the instruments, the albums of photographs of the stations afforded a ready means of judging of the method of exposure, the local peculiarities of any station, and other conditions which might exercise an effect upon the observations. Mr. Strachan had stated that some confusion seemed likely to arise concerning what should be regarded as the "mean temperature," three various means being given in the *Meteorological Record*, but he (Mr. Marriott) thought that if the headings of the columns containing the means of the temperature observations were read, no one could fail to understand what the several values represented. He had taken the mean temperature, the mean maximum temperature, and the mean minimum temperature for the year and for January and July at each station and plotted them on maps, having first reduced all the figures to their equivalent sea-level values, and had found that most of the apparent anomalies to which the previous speakers had drawn attention almost entirely disappeared. The results from Ilfracombe had been particularly questioned, and the manner of the exposure of the instruments there greatly objected to; but taking the sea-level temperatures as given in the maps which he had prepared, the Ilfracombe figures agreed very well with neighbouring stations. The mean maximum was lower in summer and higher in winter than at other stations in the district, and the mean minimum was higher, a condition of things which appeared to be plainly due to the influence of the sea, which was in close proximity to the screen. At any rate he did not see how such a result could be in any way due to the method of exposure, as, in his opinion, the large summer house sort of erection, with its pyramidal roof, which was used as a shelter for the thermometers at Ilfracombe,[1] if it had any effect at all, would be more likely to affect the maximum thermometer, and thus cause higher temperatures to be recorded. The minimum temperatures which were registered there could not be affected by the form of screen in use, but were no doubt greatly influenced by the sea. It was hardly fair to compare Bude with Ilfracombe, as, although on the same coast and not a great many miles apart, their situation as regards exposure was widely different, Ilfracombe being greatly sheltered, while Bude was very bleak and open.

The mean minimum and maximum temperatures at Weston-super-Mare, Ilfracombe and Bude were as follows:—

		Weston-s.-Mare.	Ilfracombe.	Bude.
		°	°	°
Mean Minimum	Year	44·3	46·9	43·7
	January	36·1	39·4	36·4
	July	55·1	55·7	53·5
Mean Maximum	Year	55·5	55·3	55·6
	January	44·9	47·2	46·4
	July	66·9	64·9	65·3

Proximity to streams seemed to have the effect of lowering the air temperature. This was particularly noticeable in the case of Beddington, in Surrey, the instruments there being close to the River Wandle. The influence of the sea upon air temperature in the south-west was indicated by the fact of the lowest mean minimum temperature at the sea coast stations in that district taking place in March, as the minimum temperature of the sea occurred in that month.

One speaker had suggested that a twenty years' average should be given for those stations where the records were of sufficient extent; he had made a comparison between the averages for twenty years, 1871-90, recently published by the Meteorological Office as a supplement to the *Weekly Weather Report*, and those for the ten years 1881-90, worked up by Mr. Bayard for as many of the stations as appeared in both sets of averages, and had found the average temperature for the years 1881-90 was about 0°·4 lower than the average of the twenty years 1871-90. He had also made a comparison between the mean monthly amounts of cloud and the percentages of possible duration of bright sunshine at nine stations for the period 1881-90, and had found that there was a very close agreement between the cloud and sunshine observations, as would be seen by the figures given in the Table on the next page.

If the average of the rainfall at all the stations within each degree of longitude was calculated, beginning with the eastern stations and working westwards, the gradual increase in the amount of rainfall from east to west was very clearly marked. There was not such a marked variation in the rainfall if the stations were arranged according to latitude. (See figures on the next page.)

[1] NOTE.—A new set of thermometers mounted in a Stevenson screen over grass, together with a Snowdon rain gauge, will shortly be added to the equipment of the Station at Ilfracombe.—*October 19th.*

TABLE IV.—MEAN MAXIMUM TEMPERATURE, 1881–1890.

Station.	January.	February.	March.	April.	May.	June.	July.	August.	September.	October.	November.	December.	Year.
ENGLAND, N.E.	°	°	°	°	°	°	°	°	°	°	°	°	°
Scarborough	42·2	43·2	45·6	49·1	55·7	61·2	65·6	64·2	60·4	52·8	47·5	42·1	52·5
ENGLAND, E.													
Hillington	41·5	43·8	47·7	53·2	61·2	67·1	70·5	69·0	63·9	54·8	47·8	41·3	55·2
Somerleyton	42·7	43·6	47·1	51·2	59·0	64·1	68·8	67·6	63·5	55·3	48·9	42·7	54·5
Lowestoft	42·6	43·3	46·0	49·8	57·0	62·9	67·4	66·8	63·3	55·3	49·2	42·7	53·9
MIDLAND COUNTIES.													
Wakefield	43·2	44·1	46·4	51·7	59·9	65·1	67·7	66·6	62·2	53·8	48·7	42·7	54·3
Hodsock	42·7	44·5	47·7	52·8	60·5	66·0	69·0	67·6	63·3	54·5	48·4	42·3	54·9
Buxton	40·1	41·3	43·6	49·6	57·1	63·0	65·1	63·9	59·8	50·6	45·4	39·8	51·6
Belper	41·5	42·9	46·1	51·7	59·1	64·7	67·2	65·6	61·2	52·5	47·1	41·3	53·4
Cheadle	40·9	42·3	45·1	51·0	58·1	63·3	65·5	64·4	60·6	51·8	46·5	40·5	52·5
Churchstoke	42·7	43·9	46·3	52·1	59·0	64·8	66·9	66·2	61·9	53·3	48·2	42·5	54·0
Burghill	43·7	45·4	48·9	54·6	62·3	67·9	70·4	69·4	64·4	55·3	49·4	43·4	56·3
Ross	43·6	45·5	49·2	55·1	62·7	68·6	70·8	69·9	64·6	55·2	49·5	43·3	56·5
Cheltenham	42·8	44·5	47·5	53·6	61·1	66·9	69·2	68·4	63·7	54·4	49·1	42·7	55·3
Kenilworth	41·8	43·4	46·9	52·4	59·9	65·8	68·5	67·2	62·9	53·8	47·7	41·5	54·3
Aspley Guise	41·4	43·0	47·1	53·1	60·7	66·6	69·9	68·6	63·6	54·0	47·5	41·0	54·7
ENGLAND, S.													
Regent's Park	42·9	44·1	48·1	54·3	62·1	68·1	71·0	70·0	64·9	55·2	49·2	42·9	56·1
Norwood	42·8	44·3	48·3	54·3	62·5	68·1	71·2	70·1	65·1	55·6	49·2	42·7	56·2
Croydon	42·9	44·0	47·9	53·9	61·6	67·0	70·0	69·3	64·4	55·2	49·2	42·8	55·7
Beddington	42·8	43·9	48·1	54·1	62·2	67·9	71·1	70·1	64·7	55·2	49·2	42·4	56·0
Marlborough	42·3	43·7	47·2	53·0	60·4	66·1	68·6	68·0	63·3	54·4	48·1	42·0	54·8
Strathfield Turgiss	43·2	45·1	49·3	55·6	63·4	69·0	72·1	70·8	65·7	56·3	49·6	43·0	56·9
Swarraton	42·5	43·8	47·2	53·3	60·5	65·7	68·3	67·8	63·2	54·6	48·7	42·4	54·8
Harestock	42·6	44·1	47·6	53·5	60·3	66·0	68·5	68·1	63·7	55·1	49·1	42·8	55·1
Southampton	43·9	45·4	49·0	55·2	62·2	67·9	69·9	69·5	65·1	56·5	50·2	43·8	56·6
Margate	43·1	43·6	46·7	51·2	58·6	64·0	68·5	67·8	63·6	55·2	49·7	43·5	54·6
Ramsgate	43·5	44·0	47·2	52·6	59·7	65·1	69·0	68·4	64·4	55·6	50·1	43·5	55·3
Brighton	44·8	44·9	47·6	52·3	60·4	65·4	67·9	66·9	64·0	56·8	51·8	45·8	55·7
Worthing	43·5	44·4	47·3	52·6	59·5	64·6	67·0	67·4	64·6	56·4	50·3	44·0	55·1
Portsmouth	44·4	45·4	48·8	54·6	62·2	68·0	70·7	70·4	66·1	57·6	51·1	44·6	57·0
Ventnor	45·7	46·1	48·6	53·4	59·6	64·8	67·0	67·9	64·6	57·2	51·9	46·4	56·1
Southbourne	44·2	45·1	47·9	53·1	59·3	64·7	67·5	68·0	64·1	56·3	50·5	44·7	55·5
Weymouth	45·7	45·3	47·5	51·9	58·3	63·8	66·8	66·9	63·4	56·2	51·2	45·9	55·2
SCOTLAND, W.													
Scaleby	42·6	43·9	46·3	51·8	59·2	64·9	66·2	65·0	62·0	53·3	47·5	41·8	53·7
ENGLAND, N.W.													
Seathwaite	42·2	43·0	44·6	50·9	58·1	63·8	63·8	63·3	60·0	52·3	46·5	42·0	52·5
Blackpool	42·5	43·3	45·0	50·9	57·5	62·5	64·3	63·7	60·9	53·4	48·1	42·7	52·9
Macclesfield	41·6	42·5	45·1	51·1	58·7	64·3	65·8	64·8	61·0	52·2	47·0	41·1	52·9
Llandudno	45·6	45·6	46·8	51·1	57·5	62·7	64·8	64·2	61·5	54·5	50·4	45·5	54·2
ENGLAND, S.W.													
Carmarthen	44·9	46·4	48·6	54·1	59·9	65·3	66·6	66·7	63·6	56·0	50·8	45·2	55·7
Weston-super-Mare	44·9	45·8	48·0	53·1	59·5	64·8	66·9	67·0	63·8	56·0	50·7	45·0	55·5
Ilfracombe	47·2	46·8	47·9	51·9	58·0	62·5	64·9	65·2	62·5	56·4	52·4	47·6	55·3
Bude	46·4	46·8	48·4	53·3	58·8	63·8	65·3	65·9	63·5	56·7	51·7	46·8	55·6
Cullompton	45·0	45·9	48·9	54·3	61·4	66·9	68·9	68·3	64·3	56·2	50·5	44·8	56·3
Brampford Speke	44·8	45·8	49·0	55·0	62·1	67·1	68·9	67·3	62·9	55·0	50·3	44·4	56·1
Sidmouth	45·5	45·5	47·5	52·1	58·1	63·3	65·7	66·0	62·6	55·7	51·0	45·8	54·9
Teignmouth	46·3	46·4	49·4	54·2	60·3	65·7	67·6	67·9	64·5	56·7	51·6	46·5	56·4
Babbacombe	46·0	46·2	48·3	52·7	58·8	65·0	67·4	67·4	63·3	56·4	51·4	46·4	55·8
Ashburton	45·6	46·1	48·7	53·3	59·8	65·6	67·8	67·3	63·6	56·5	51·4	46·0	56·0
Falmouth	47·3	46·9	48·4	51·8	57·5	63·2	65·4	65·3	62·1	56·1	52·1	47·7	55·3
IRELAND.													
Londonderry	45·5	46·6	48·7	54·1	60·4	65·3	65·9	64·7	61·8	54·5	49·4	45·0	55·2
Dublin	46·0	46·5	48·1	52·2	58·8	64·2	66·1	64·9	61·1	54·2	50·1	45·3	54·8
Killarney	47·8	48·2	49·4	53·3	58·6	64·1	65·1	64·9	61·7	55·7	51·6	47·3	55·6
CHANNEL ISLANDS.													
Guernsey	47·0	46·6	48·9	52·8	59·1	63·2	66·5	67·1	64·4	57·3	52·8	47·7	56·1

TABLE V.—MEAN TEMPERATURE, 1881–1890.

Station.	January.	February.	March.	April.	May.	June.	July.	August.	September.	October.	November.	December.	Year.
ENGLAND, N.E.	°	°	°	°	°	°	°	°	°	°	°	°	°
Scarborough	38.4	39.2	40.4	43.9	49.7	55.3	59.1	58.2	55.1	48.3	43.5	38.4	47.5
ENGLAND, E.													
Hillington	36.6	38.2	40.1	45.0	51.7	57.3	60.8	59.4	55.6	47.9	42.5	36.6	47.6
Somerleyton	37.5	38.4	40.3	44.5	51.2	56.4	60.4	59.6	56.8	49.1	43.8	37.7	48.0
Lowestoft	38.2	38.8	40.3	44.2	50.5	56.1	59.9	59.6	57.0	49.4	44.3	38.3	48.1
MIDLAND COUNTIES.													
Wakefield	38.5	39.0	40.2	44.5	51.2	56.5	59.7	58.5	54.7	47.7	43.2	38.1	47.7
Hodsock	37.1	38.9	40.2	44.5	51.1	56.7	59.9	58.6	54.9	47.5	42.7	37.0	47.4
Buxton	35.1	35.9	36.8	41.9	48.3	53.9	56.8	55.5	52.0	44.7	40.2	34.7	44.7
Belper	36.7	38.1	39.5	44.4	50.9	56.5	59.3	58.0	54.3	46.5	42.2	36.6	46.9
Cheadle	36.4	37.4	39.0	43.6	50.0	55.3	58.0	56.9	53.9	46.2	41.2	36.1	46.2
Churchstoke	37.3	38.3	39.2	43.7	49.9	55.5	58.1	57.3	53.8	46.5	42.6	37.2	46.6
Burghill	38.1	39.6	41.3	46.1	52.7	58.2	60.7	59.7	55.7	47.9	43.8	37.9	48.5
Ross	38.4	39.6	41.7	46.5	53.0	58.7	61.4	60.3	56.1	48.1	44.2	38.2	48.9
Cheltenham	37.6	38.7	40.3	45.2	51.8	57.4	60.3	59.0	55.3	47.1	43.4	37.7	47.8
Kenilworth	36.8	38.2	40.0	44.6	51.0	56.9	59.9	58.6	55.0	47.0	42.5	36.7	47.3
Aspley Guise	36.7	37.8	40.0	44.8	51.4	57.3	60.6	59.6	55.6	47.5	42.4	36.3	47.5
ENGLAND, S.													
Regent's Park	38.4	39.3	41.4	46.6	53.5	59.3	62.4	61.4	57.3	48.7	44.3	38.3	49.2
Norwood	38.4	39.5	41.4	46.4	53.3	59.1	62.2	61.2	57.2	48.9	44.1	38.2	49.2
Croydon	38.2	39.1	41.1	46.0	52.7	58.3	61.5	60.7	56.7	48.4	44.0	38.0	48.7
Beddington	37.6	38.8	40.8	45.7	52.5	58.1	61.3	60.3	56.2	47.9	43.3	37.4	48.3
Marlborough	37.2	38.4	39.9	44.7	51.2	56.7	59.5	58.5	54.7	46.8	42.5	36.8	47.2
Strathfield Turgiss	37.5	39.2	41.2	46.1	53.0	58.6	61.6	60.9	56.4	48.2	43.4	37.4	48.6
Swarraton	37.3	38.5	40.0	44.9	51.1	56.7	59.6	58.8	55.2	47.2	43.0	37.3	47.5
Harestock	37.7	38.8	40.3	45.2	51.4	57.1	59.9	59.4	55.8	48.0	43.5	37.9	47.9
Southampton	38.3	39.7	41.2	46.2	52.6	58.2	60.7	60.1	56.6	48.7	44.1	38.4	48.7
Margate	38.9	39.6	41.2	45.7	52.1	57.5	61.3	61.0	58.0	50.1	45.1	39.4	49.2
Ramsgate	39.0	39.5	41.5	46.3	52.6	57.9	61.3	61.0	58.2	50.0	45.2	39.1	49.3
Brighton	39.9	40.5	41.6	46.3	53.3	58.5	61.5	60.9	58.1	50.8	47.0	41.0	50.0
Worthing	39.0	40.0	41.3	46.2	52.8	57.7	60.6	60.7	58.1	50.1	45.6	39.6	49.3
Portsmouth	39.1	40.2	41.9	46.7	53.7	59.3	62.2	62.1	58.4	50.6	45.9	39.9	50.0
Ventnor	41.6	41.9	43.1	47.4	53.3	58.3	61.2	61.8	59.1	52.1	47.8	42.3	50.8
Southbourne	39.9	40.4	41.6	46.0	52.1	57.5	60.5	60.4	57.0	49.8	45.6	40.2	49.3
Weymouth	41.4	41.3	42.3	46.2	52.3	57.7	60.7	60.9	57.9	51.2	47.1	41.8	50.1
SCOTLAND, W.													
Scaleby	37.6	38.5	39.5	44.0	50.3	55.7	58.1	57.1	54.1	46.8	41.9	36.7	46.7
ENGLAND, N.W.													
Seathwaite	38.1	38.4	39.1	44.2	50.5	56.1	57.6	56.8	53.8	46.8	42.2	37.7	46.8
Blackpool	38.0	38.9	39.8	44.3	50.3	55.6	58.6	57.9	55.1	48.2	43.6	38.3	47.4
Macclesfield	36.9	37.8	39.0	44.0	50.5	56.0	58.3	57.5	54.1	46.3	42.2	36.6	46.6
Llandudno	41.3	41.2	41.7	45.5	51.3	56.7	59.2	58.8	56.2	49.9	46.0	41.4	49.1
ENGLAND, S.W.													
Carmarthen	39.7	40.9	41.8	46.2	52.0	57.3	59.2	58.7	56.0	49.2	45.2	39.9	48.8
Weston-super-Mare	40.5	41.1	42.3	46.7	52.9	58.2	61.1	60.7	57.5	50.6	46.3	40.6	49.9
Ilfracombe	43.3	43.1	43.8	47.3	52.9	57.8	60.3	60.8	58.3	52.5	48.8	43.9	51.1
Bude	41.4	41.6	42.4	46.4	52.0	57.0	59.4	59.4	56.8	50.7	47.2	41.8	49.7
Cullompton	39.5	40.2	41.6	46.0	52.2	57.6	60.0	59.1	55.8	48.7	44.8	39.1	48.7
Brampford Speke	39.4	40.3	41.9	46.6	53.2	58.5	60.7	59.4	55.4	48.5	44.7	39.1	49.0
Sidmouth	40.8	41.0	41.9	45.8	51.5	56.7	59.4	59.3	56.5	50.1	46.3	41.3	49.2
Teignmouth	41.9	41.8	43.3	47.6	53.3	58.7	61.1	60.9	57.9	50.9	47.0	41.9	50.5
Babbacombe	41.6	41.6	42.5	46.3	52.1	57.7	60.4	60.1	56.9	50.5	46.6	41.8	49.9
Ashburton	40.9	41.1	42.4	46.3	52.4	57.9	60.4	60.0	56.9	50.5	46.5	41.2	49.7
Falmouth	43.6	43.0	43.7	46.9	52.1	57.5	59.9	59.9	57.2	51.7	48.2	43.8	50.6
IRELAND.													
Londonderry	40.4	41.1	42.2	46.1	51.7	56.7	58.2	57.4	54.5	48.3	44.0	39.8	48.4
Dublin	41.7	42.0	42.7	46.3	52.2	57.6	59.9	58.8	55.5	49.2	45.7	40.9	49.4
Killarney	42.4	42.3	42.8	45.8	50.9	56.3	58.1	57.9	51.8	49.0	45.9	41.3	49.0
CHANNEL ISLANDS.													
Guernsey	43.4	43.2	44.6	47.9	53.4	57.6	60.8	61.4	59.4	53.0	49.3	44.2	51.5

TABLE VI.—MEAN RELATIVE HUMIDITY AT 9 A.M., 1881–1890.

Station.	January.	February.	March.	April.	May.	June.	July.	August.	September.	October.	November.	December.	Year.
ENGLAND, N.E.	%	%	%	%	%	%	%	%	%	%	%	%	%
Scarborough	91	87	86	82	77	77	76	76	84	86	88	89	83
ENGLAND, E.													
Hillington	92	90	85	81	76	75	75	78	85	89	91	92	84
Somerleyton	89	88	84	79	75	76	74	76	83	85	88	89	82
Lowestoft	91	89	86	81	79	78	75	75	82	84	90	90	83
MIDLAND COUNTIES.													
Wakefield	91	90	87	82	77	78	78	79	84	86	89	90	84
Hodsock	90	88	82	77	72	73	72	75	83	84	89	90	81
Buxton	92	92	87	84	78	75	78	80	84	88	91	91	85
Belper	91	90	86	81	79	79	80	83	88	89	91	91	86
Cheadle	92	91	85	81	77	80	82	82	87	89	93	92	86
Churchstoke	89	89	83	78	75	77	77	80	83	86	88	89	83
Burghill	92	89	83	78	75	73	74	75	84	88	91	92	83
Ross	90	87	81	77	74	74	74	76	83	85	89	89	82
Cheltenham	90	88	83	78	76	77	77	78	85	88	89	90	83
Kenilworth	90	88	84	79	74	76	75	78	85	88	91	89	83
Aspley Guise	94	91	84	78	73	73	73	74	83	86	92	93	83
ENGLAND, S.													
Regent's Park	89	87	83	76	71	73	73	76	82	86	88	87	81
Norwood	90	87	81	75	69	70	70	73	80	85	90	89	80
Croydon	90	88	82	75	70	71	71	73	81	85	89	89	80
Beddington	91	87	82	76	71	72	70	75	82	86	89	90	81
Marlborough	93	91	86	79	75	77	75	76	84	88	92	92	84
Strathfield Turgiss	91	90	84	77	74	76	74	76	83	88	90	92	83
Swarraton	..	..	..	..	..	..	..	..	..	..	..	..	..
Haiestock	90	88	81	76	72	72	73	73	81	85	88	89	81
Southampton	92	88	82	75	72	72	73	74	82	85	90	90	81
Margate	90	87	84	79	77	77	74	77	80	84	88	88	82
Ramsgate	90	87	84	79	76	75	74	77	80	86	88	90	82
Brighton	87	85	82	74	71	74	77	70	80	80	86	85	80
Worthing	90	89	84	80	76	76	78	77	82	85	90	90	83
Portsmouth	91	89	84	78	75	75	75	77	82	86	90	90	83
Ventnor	88	86	81	79	77	78	79	76	80	80	85	86	81
Southbourne	89	88	82	76	75	75	77	74	82	85	89	89	82
Weymouth	87	85	82	78	77	76	77	75	79	80	84	85	80
SCOTLAND, W.													
Scaleby	89	89	87	80	79	79	80	83	85	89	91	92	85
ENGLAND, N.W.													
Seathwaite	85	87	86	77	73	75	77	79	83	83	85	86	81
Blackpool	90	91	87	80	77	75	78	78	83	84	89	90	84
Macclesfield	93	90	88	83	76	76	80	83	87	90	90	90	86
Llandudno	85	82	79	76	73	75	76	76	79	80	82	83	79
ENGLAND, S.W.													
Carmarthen	90	86	80	72	71	71	75	76	80	84	87	91	80
Weston-super-Mare	90	88	84	80	79	79	78	80	84	85	88	89	84
Ilfracombe	87	86	84	83	86	84	83	84	85	86	87	86	85
Bude	..	..	..	..	..	..	..	..	..	..	..	..	..
Cullompton	90	87	81	76	73	72	74	76	83	86	89	89	81
Brampford Speke	92	90	84	79	77	76	78	80	87	89	92	92	85
Sidmouth	91	89	83	81	79	80	82	80	86	88	89	90	85
Teignmouth	89	87	82	79	74	75	76	77	82	85	88	90	82
Babbacombe	89	86	80	78	76	75	76	75	82	82	87	88	81
Ashburton	93	89	82	81	78	78	80	80	85	87	91	91	85
Falmouth	88	86	80	78	77	77	79	79	82	82	85	87	82
IRELAND.													
Londonderry	88	88	84	77	73	73	77	81	84	86	89	89	82
Dublin	86	85	81	76	72	73	74	80	84	85	86	86	81
Killarney	89	88	86	80	79	80	83	83	85	87	88	90	85
CHANNEL ISLANDS.													
Guernsey	89	88	84	82	83	83	83	82	84	84	86	87	85

TABLE VII.—MEAN AMOUNT OF CLOUD (0-10) AT 9 A.M., 1881-1890.

Station.	January.	February.	March.	April.	May.	June.	July.	August.	September.	October.	November.	December.	Year.
ENGLAND, N.E.													
Scarborough	7·0	7·1	6·6	6·7	5·9	6·2	6·3	6·2	6·5	6·5	6·6	6·5	6·5
ENGLAND, E.													
Hillington	7·9	7·8	7·5	7·4	7·2	7·1	7·1	6·8	6·9	7·0	7·6	7·9	7·4
Somerleyton	6·9	6·9	6·8	6·5	6·3	6·5	6·5	6·4	6·2	6·3	7·1	7·3	6·6
Lowestoft	6·9	7·2	6·8	6·8	6·1	6·4	6·6	6·6	6·6	6·5	7·3	7·3	6·8
MIDLAND COUNTIES.													
Wakefield	7·6	7·8	7·2	7·7	6·6	7·2	6·9	6·9	7·3	7·5	7·5	7·3	7·3
Hodsock	7·2	7·4	6·6	7·3	6·6	6·9	7·0	6·9	6·9	6·7	7·0	6·9	7·0
Buxton	7·9	7·8	7·1	7·3	6·8	6·7	7·1	7·2	7·2	7·4	7·9	7·7	7·3
Belper	..	..	..	..	..	..	..	..	..	..	..	..	..
Cheadle	7·5	7·4	6·7	7·0	6·5	6·5	6·9	7·1	6·6	6·5	7·1	7·2	6·9
Churchstoke	7·7	7·9	7·7	7·6	7·1	7·1	7·5	7·2	7·5	7·8	7·8	7·5	7·5
Burghill	7·6	7·4	6·9	7·2	6·7	6·7	6·9	6·5	6·8	7·1	7·2	7·2	7·0
Ross	7·0	6·8	6·1	6·8	6·2	6·0	6·3	5·9	6·3	6·4	6·7	6·8	6·4
Cheltenham	7·5	7·5	6·9	7·0	6·5	6·6	6·8	6·6	6·8	7·1	7·3	7·5	7·0
Kenilworth	8·0	7·8	7·0	7·5	7·0	6·8	7·2	7·0	7·2	7·0	7·3	7·8	7·3
Aspley Guise	7·0	7·5	6·7	7·1	6·9	6·7	6·7	6·6	6·7	6·5	7·0	7·2	6·9
ENGLAND, S.													
Regent's Park	..	..	..	..	..	..	..	..	..	..	..	..	..
Norwood	7·8	7·6	6·7	6·7	6·5	6·7	6·4	6·5	6·7	6·3	7·4	7·6	6·9
Croydon	7·9	8·1	7·3	7·3	6·9	7·1	7·1	6·9	7·4	6·8	7·9	7·8	7·4
Beddington	7·5	7·7	6·6	7·0	6·5	6·5	6·3	6·4	6·9	6·7	7·4	7·3	6·9
Marlborough	7·9	7·8	6·9	7·4	6·9	7·1	6·9	6·4	7·0	6·5	7·5	7·8	7·2
Strathfield Turgiss	7·7	7·7	6·9	7·0	6·6	7·1	6·8	6·3	6·9	6·9	7·1	7·5	7·0
Swarraton	7·6	7·7	6·8	7·1	6·8	7·0	6·8	6·2	6·7	6·8	7·3	7·6	7.0
Harestock	7·7	7·8	6·8	7·3	6·8	6·9	7·0	6·6	6·9	6·8	7·4	7·6	7·1
Southampton	7·3	7·5	6·5	6·8	6·4	6·7	6·9	6·3	6·7	6·3	7·3	7·2	6·8
Margate	7·6	7·5	6·7	6·5	6·2	6·7	6·8	6·3	6·4	6·9	7·5	7·6	6·9
Ramsgate	7·5	7·4	6·7	6·3	6·0	6·4	6·4	6·0	6·4	6·6	7·3	7·6	6·7
Brighton	..	..	..	..	..	..	..	..	..	..	..	..	..
Worthing	6·6	6·4	5·8	5·9	5·5	5·7	6·1	5·2	5·4	5·5	6·6	6·4	5·9
Portsmouth	7·1	6·7	5·5	5·6	5·3	5·4	5·7	5·0	5·5	5·7	6·8	7·1	6·0
Ventnor	6·8	6·6	5·9	5·8	5·5	5·7	6·1	5·4	5·8	6·0	6·7	6·7	6·1
Southbourne	7·0	6·8	5·9	6·0	5·5	5·7	6·0	5·5	5·8	5·8	6·8	6·9	6·1
Weymouth	6·8	6·1	5·2	5·3	4·7	4·4	4·7	4·3	4·7	5·3	6·7	6·3	5·4
SCOTLAND, W.													
Scaleby	7·8	7·5	7·1	6·9	6·5	6·5	7·5	7·3	6·9	7·0	7·4	7·5	7·2
ENGLAND, N.W.													
Seathwaite	8·3	7·8	7·5	6·9	7·0	6·9	8·0	7·9	7·6	8·0	8·3	7·8	7·7
Blackpool	7·5	6·7	6·3	6·0	5·7	5·7	6·1	6·4	6·2	6·9	7·2	7·5	6·5
Macclesfield	6·5	6·5	6·7	6·8	6·3	6·2	6·6	6·8	5·9	6·6	7·0	7·1	6·6
Llandudno	7·2	7·3	7·0	6·5	6·1	6·1	7·2	7·3	6·9	7·1	7·5	7·2	7·0
ENGLAND, S.W.													
Carmarthen	7·5	7·2	6·7	6·4	6·7	6·4	7·4	6·2	6·4	6·9	7·3	7·2	6·9
Weston-super-Mare	8·0	7·6	6·9	6·7	6·5	6·4	6·7	6·3	6·9	6·9	7·8	7·7	7·0
Ilfracombe	7·8	7·0	6·4	6·2	6·0	5·9	6·5	6·1	6·5	7·1	8·0	7·5	6·8
Bude	7·6	6·7	6·1	5·9	6·0	6·0	6·6	6·1	6·1	6·7	7·5	7·4	6·6
Cullompton	8·0	7·2	6·4	6·9	6·4	6·6	6·7	6·2	6·7	6·9	7·3	7·6	6·9
Brampford Speke..	8·0	7·5	6·9	7·2	6·8	6·5	7·0	6·7	6·9	7·0	7·6	7·5	7·1
Sidmouth	8·1	7·9	7·1	7·2	6·7	6·6	7·3	6·8	6·6	7·1	7·8	7·7	7·2
Teignmouth	7·7	7·5	6·5	6·9	6·4	6·3	6·6	6·4	6·3	6·7	7·1	7·2	6·8
Babbacombe	7·9	7·8	6·7	7·0	6·7	6·4	6·6	6·3	6·5	6·9	7·3	7·4	7·0
Ashburton	7·2	7·1	6·2	6·4	6·1	5·9	6·0	5·7	6·2	6·3	6·8	6·9	6·4
Falmouth	7·9	7·2	6·8	6·8	6·3	6·4	6·9	6·6	6·7	6·9	7·2	7·4	6·9
IRELAND.													
Londonderry	7·7	7·9	7·7	7·2	7·4	7·8	8·2	8·4	7·8	7·8	7·6	8·1	7·8
Dublin	6·6	7·2	6·5	6·3	6·1	6·4	7·0	6·5	6·2	6·2	6·2	6·4	6·5
Killarney	7·5	7·7	7·0	7·1	7·3	6·8	7·8	7·5	7·4	7·4	7·4	7·2	7·3
CHANNEL ISLANDS.													
Guernsey	7·3	7·3	6·6	6·3	5·7	6·0	6·2	5·5	6·3	6·6	7·5	7·5	6·6

TABLE II.—Excess or Deficiency of the MEAN TEMPERATURE of the AIR on each day of the year above or below the general mean for the year, as deduced from the observations made at the ROYAL OBSERVATORY, GREENWICH, during the FIFTY YEARS 1841–1890.

Day.	January.	February.	March.	April.	May.	June.	July.	August.	September.	October.	November.	December.
	°	°	°	°	°	°	°	°	°	°	°	°
1	−11·23	− 9·82	−9·68	−4·21	−0·19	+ 7·45	+10·78	+12·73	+ 9·81	+4·87	−2·68	− 9·35
2	−11·35	−10·00	−8·91	−3·56	−0·01	+ 8·76	+11·67	+12·48	+10·37	+3·85	−3·25	− 9·76
3	−10·98	−10·10	−8·85	−3·40	+0·21	+ 9·29	+12·51	+12·09	+10·54	+4·16	−3·65	− 8·71
4	−10·49	−10·02	−9·25	−2·98	+0·02	+ 9·10	+12·85	+12·51	+10·05	+3·72	−3·47	− 8·35
5	−10·52	− 9·37	−8·34	−3·13	+0·81	+ 8·80	+13·31	+12·90	+ 9·96	+3·31	−2·79	− 7·35
6	−11·86	− 8·88	−7·82	−2·98	+1·72	+ 9·00	+12·96	+12·89	+ 9·48	+2·86	−3·63	− 7·16
7	−11·53	− 9·59	−8·00	−2·91	+1·72	+ 8·78	+12·76	+13·33	+ 9·41	+4·08	−4·18	− 8·08
8	−11·41	− 9·91	−8·04	−3·17	+1·24	+ 8·79	+12·06	+13·44	+ 9·10	+2·81	−4·62	− 8·80
9	−11·72	−11·34	−8·92	−4·49	+1·42	+ 8·46	+12·27	+13·01	+ 9·34	+1·55	−5·82	− 9·40
10	−11·52	−11·42	−9·44	−4·49	+1·84	+ 8·20	+12·56	+12·70	+ 8·85	+1·87	−6·14	−10·15
11	−11·60	−12·28	−9·23	−4·54	+2·15	+ 8·60	+12·29	+12·87	+ 8·25	+1·89	−6·49	−10·72
12	−12·26	−11·72	−8·88	−3·72	+2·86	+ 9·33	+13·28	+13·19	+ 8·80	+0·78	−7·14	− 9·99
13	−11·24	−11·21	−8·65	−3·81	+3·09	+ 9·50	+13·80	+13·66	+ 8·34	+0·46	−6·92	− 8·91
14	−10·93	− 9·37	−8·19	−3·07	+2·94	+ 9·81	+13·99	+12·76	+ 8·22	+0·75	−6·24	− 9·07
15	−11·18	− 8·99	−8·02	−2·25	+3·24	+ 9·66	+14·35	+12·52	+ 8·20	+0·30	−6·84	− 8·43
16	−11·27	− 9·46	−7·30	−1·96	+4·18	+ 9·76	+13·71	+12·64	+ 8·46	+0·30	−6·72	− 8·70
17	−10·80	− 9·31	−7·93	−1·77	+3·55	+ 9·15	+13·48	+12·13	+ 8·59	+0·35	−7·92	− 9·31
18	−10·52	− 9·61	−7·80	−1·51	+3·83	+ 9·00	+13·51	+12·03	+ 7·55	−0·22	−7·55	− 9·86
19	−10·24	−10·14	−7·65	−0·95	+4·21	+ 9·76	+13·08	+12·05	+ 6·72	+0·48	−6·93	−10·36
20	−11·28	−10·69	−8·00	−0·26	+4·75	+10·30	+13·31	+11·99	+ 6·60	−0·56	−7·28	−10·96
21	−11·89	− 9·99	−8·66	−0·57	+5·26	+11·37	+13·81	+11·74	+ 5·87	−1·09	−7·68	−10·51
22	−11·49	− 9·57	−8·76	−0·98	+5·67	+11·70	+14·20	+11·46	+ 6·08	−0·82	−6·90	−10·61
23	−10·75	− 9·86	−7·64	−1·31	+5·98	+11·68	+13·58	+11·03	+ 5·48	−1·06	−7·32	−11·30
24	−11·13	− 9·75	−6·96	−1·62	+6·41	+11·85	+12·55	+11·06	+ 5·72	−1·43	−7·65	−11·34
25	−10·76	− 9·12	−7·10	−0·98	+6·21	+11·55	+12·63	+11·30	+ 5·24	−1·93	−7·42	−11·80
26	−10·47	− 8·79	−6·75	−0·93	+6·47	+11·83	+12·74	+11·57	+ 5·06	−2·49	−6·93	−10·96
27	−10·00	− 9·68	−6·43	−0·73	+6·68	+12·57	+12·83	+11·75	+ 5·59	−2·30	−7·58	−11·15
28	−10·23	− 9·42	−5·73	−0·81	+6·60	+12·17	+12·72	+11·58	+ 5·98	−2·13	−8·06	−10·84
29	− 9·44	− 7·73	−5·20	−1·35	+6·22	+11·89	+12·80	+10·73	+ 5·40	−2·89	−8·55	−10·39
30	− 9·46		−4·85	−0·37	+6·93	+11·32	+13·09	+10·53	+ 4·98	−2·25	−9·18	−10·56
31	− 9·19		−4·22		+6·72		+13·21	+10·09		−2·04		−10·97
Means	−10·93	− 9·96	−7·78	−2·29	+3·64	+9·98	+12·99	+12·15	+ 7·73	+0·55	−6·25	− 9·80

TABLE IX.—No. of Rainy Days (0·01 in. and upwards), 1881–1890.

Station.	January.	February.	March.	April.	May.	June.	July.	August.	September.	October.	November.	December.	Year.
England, N.E.													
Scarborough......	16	16	17	16	15	13	16	15	16	19	19	19	197
England, E.													
Hillington........	17	15	14	15	14	12	16	14	13	18	18	17	183
Somerleyton......	15	15	14	15	11	10	15	12	15	18	19	16	175
Lowestoft	15	14	14	14	11	11	15	13	15	17	18	16	173
Midland Counties.													
Wakefield	17	15	14	15	12	11	16	14	15	17	18	16	180
Hodsock	17	15	13	15	14	12	16	14	16	17	17	16	182
Buxton	17	17	17	14	14	13	16	16	16	19	20	17	196
Belper............	16	14	13	14	14	11	16	14	15	17	19	15	178
Cheadle..........	18	15	17	14	15	12	18	15	16	18	20	17	195
Churchstoke	16	14	14	13	15	13	17	14	14	18	19	14	181
Burghill..........	17	13	13	13	13	12	16	13	13	16	18	17	174
Ross	17	15	14	15	16	14	18	15	17	18	20	15	194
Cheltenham	17	15	14	15	14	13	18	14	14	19	20	17	190
Kenilworth........	17	13	13	14	13	13	16	14	13	17	18	16	177
Aspley Guise......	16	13	11	14	13	11	15	13	13	16	16	15	166
England, S.													
Regent's Park.....	15	13	12	14	13	12	15	13	12	15	16	15	165
Norwood..........	15	14	13	14	13	11	16	13	14	16	18	16	173
Croydon	15	13	13	14	13	11	16	13	14	16	18	16	172
Beddington........	15	12	13	13	13	10	14	13	13	16	17	15	164
Marlborough	17	14	14	15	14	14	17	14	14	17	19	18	187
Strathfield Turgiss	16	12	13	13	13	11	15	13	13	16	17	14	166
Swarraton	15	11	11	12	12	11	14	13	12	15	15	15	156
Harestock	16	13	13	13	14	11	15	14	12	16	17	16	170
Southampton......	18	14	15	14	13	12	17	15	15	17	19	18	187
Margate..........	16	14	13	14	12	9	14	14	14	16	17	16	169
Ramsgate	15	13	13	14	11	9	13	12	14	16	17	16	163
Brighton	16	13	13	12	11	10	12	12	12	16	17	15	159
Worthing	16	13	11	12	11	11	12	12	13	14	17	15	157
Portsmouth	17	13	13	14	12	11	15	14	14	15	18	17	173
Ventnor..........	16	13	13	12	12	10	14	13	13	15	18	15	164
Southbourne	16	12	12	11	12	11	14	12	12	15	17	16	160
Weymouth........	16	11	12	12	11	11	13	12	12	14	18	15	157
Scotland, W.													
Scaleby	19	15	17	14	15	13	19	17	18	18	20	16	201
England, N.W.													
Seathwaite	20	17	19	14	16	15	21	19	18	19	20	21	219
Blackpool	19	16	15	15	14	12	17	15	17	17	19	18	194
Macclesfield	17	16	15	13	15	12	19	16	16	18	18	17	192
Llandudno	17	14	14	13	11	12	14	14	16	17	18	16	176
England, S.W.													
Carmarthen	20	16	16	14	15	14	18	17	17	20	23	20	210
Weston-super Mare	17	13	13	13	15	12	17	15	14	16	18	15	178
Ilfracombe	17	13	16	14	15	12	18	15	15	18	19	17	189
Bude	16	11	10	10	11	9	12	12	11	15	18	15	150
Cullompton	19	15	14	15	13	12	17	16	16	20	21	19	197
Brampford Speke..	19	16	15	14	14	12	17	15	15	19	21	20	197
Sidmouth	18	16	16	15	14	14	18	17	17	19	21	19	204
Teignmouth	16	14	14	13	12	11	14	11	12	16	19	17	169
Babbacombe......	17	14	16	14	13	13	16	14	15	18	21	18	189
Ashburton........	18	14	15	14	13	12	17	14	16	17	21	18	189
Falmouth	21	15	17	14	14	12	17	15	16	20	22	21	204
Ireland.													
Londonderry	22	20	21	16	17	16	23	21	19	21	22	22	240
Dublin	18	16	16	14	16	15	18	16	15	17	19	16	196
Killarney	22	18	18	16	17	14	20	19	18	20	23	20	225
Channel Islands.													
Guernsey	17	16	14	13	11	10	13	12	14	19	22	18	176

RAIN DROPS.

By E. J. LOWE, F.R.S., F.R.Met.Soc.

(Plate X.)

[Received March 15th.—Read May 18th, 1892.]

During the past twelve months rain drops have been sketched at Shirenewton Hall, near Chepstow, at a height of 530 feet above the sea.

Sheets of slate in a book form, that could be instantly closed, were adopted. These were ruled in inch squares, and after exposure the drops were copied on sheets of paper ruled like the slates.

Whether at our height above the sea the drops differ from those falling near the sea level has yet to be tested.

These diagrams (more than 300) have disclosed a number of interesting facts as regards the variation in size, form and distribution; and a few of the more interesting have been selected in illustration (Plate X.).

Some drops produce a wet circular spot; whilst others, falling with greater force, have splashes around the drops.

The same sized drop varies considerably in the amount of water it contains, some of the drops on the slate are nearly flat, and others more or less spherical; the former cannot be shaken out of form, whilst the latter would scatter the water over the slate.

The size of the drop ranges from almost an invisible point, to that of a patch at least 2 inches in diameter, and this increase in size does not always depend upon increased heat.

A shower mostly contains drops of two or three very different sizes.

The distribution is extremely irregular, though sometimes there is method in this irregularity.

Occasionally large drops fall that must be more or less hollow, as they fail to wet the whole surface enclosed within the drop.

Incidental drops are notched on the edge.

The manner of grouping is extremely varied.

The ordinary shower is very irregular in distribution.

The feel of the falling drop is deceptive, as a greater force of small drops gives the sensation of being much larger.

Besides the ordinary rain drops, the diagrams show the drops produced by a mist floating along the ground, and also the manner in which snow flakes wet the slates on melting.

I may mention that we have no dense mist, though clouds are often close to the ground.

Description of the Diagrams (Plate X.).

Figure 1. 1891, May 14, exposure 10 seconds. Singular grouping and an absence of small drops. Barometer (uncorrected) 29·6 inches. Temperature 52°, but rapidly lowered to 37°.

Figure 2. 1891, December 14, exposure 5 seconds. Very varied in size and distribution, but not uncommon. Barometer (uncorrected) 29·0 inches. Temperature 40°.

Figure 3. 1891, May 29, exposure 10 seconds. This was the commencement of a thunderstorm. The largest drops measured 2 inches in diameter and were from 6 to 8 inches apart, the smallest were 1 inch in diameter and 2 to 3 inches apart; a portion splashed. Barometer (uncorrected) 29·2 inches. Temperature 68°.

Figure 4. 1891, August 27, exposure 5 seconds. In a thunderstorm, some very large drops, clustering; scarcely any splashing. Amongst the drops were some with marginal notches. Drops fell at different angles and directions, producing long narrow lines on the slate.

Figure 5. 1891, August 31, exposure 1 second. Wind rough, clouds on ground. A groundwork of minute drops, with clusters of larger drops, and a few still larger single drops, or in pairs. Temperature 60°, wet bulb 59°·1.

Figure 6. 1891, September 21, exposure 15 seconds. Rough North-west wind. Singular grouping of small drops.

Figure 7. 1891, October 15, exposure 1 second. During a violent thunderstorm with rough wind, driving the drops almost horizontally. Some hail. A network of moderately large drops, and groups of very large drops. The long drops in Fig. 7 were deposited upon a flat surface. The drops in this position were much fewer in number than on a slate held vertically. Barometer (uncorrected) 29·0 inches. Temperature 52°.

Figure 8. 1891, December 15. Very varied in size, the larger drops only partially wetting the slate. Temperature 47°.

DISCUSSION.

Mr. Bayard said that the natural result of rain drops falling upon a hard substance like slate would be that they would spread out and so appear to be larger than they actually were. It was hardly correct to say that a rain drop was a certain size from measurements of the area wetted by the drop when falling.

Mr. Symons said that Mr. Lowe was not quite accurate in saying that rain drops two inches in diameter fell; what he really meant was that the drops were that size when spread out upon the slate.

Mr. Latham considered that the paper should not be too severely criticised, as it was by means of papers of this description that matters of common observation were placed upon permanent record.

Mr. Marriott said that he agreed with the remarks which had fallen from Mr. Latham concerning the value attaching to this paper. He thought that it would have been very interesting if the temperature of the falling rain had been observed. The late Mr. George Dines was, he believed, one of the few persons who had made such observations, and he had found that the temperature of rain was rather high. By means of the hail gauge, devised by Prof. Colladon of

Geneva, which was shown in the Society's Exhibition in March 1888, and subsequently presented to the Society by Dr. Marcet, he (Mr. Marriott) had secured three observations of the temperature of falling hail, and had been much surprised at the results obtained. These observations were made at Norwood, and were as follows:—

May	15, 1891	... ...	31°0
„	17, „	... ...	33·2
April	27, 1892	... ...	27·9

There were two interesting features about the hail on the last named day—one was that several stones picked up were composed of seven smaller stones, six being frozen round a central nucleus, much resembling a snow crystal; the other feature was that some of the stones were of a pyramidal shape, the apex portion being clear ice, and the base portion being opaque. The question of the formation of hail was a very interesting problem; hail certainly was not formed at any very great altitude above the earth's surface, as thunderstorms often did not extend to a greater elevation than 3,000 or 4,000 feet above the ground. The usual rate of decrease in air temperature was considered to be 1° for each 300 feet above sea level; it therefore followed that when hail was formed the temperature in the thunderstorm cloud must be reduced very considerably below the normal temperature of the air at the elevations mentioned. The alternate layers of clear and opaque ice which were frequently found in hail stones were probably due to the manner in which the stones were whirled about in the course of formation.

Mr. Tripp thought that the paper was a very suggestive one, although the method adopted was simple. There appeared to be more water in the drops at one time than at another. It was known that electricity played an important part in the coalescence of drops, and that soap bubbles could be caused to coalesce by means of very slight electrical influence. Mr. Shelford Bidwell's experiment showing the electrification of a steam jet was another instance of the effect of electricity on the coalescence of the water particles in a cloud. The relation of electricity to the subject upon which Mr. Lowe had written was worthy of investigation.

Mr. Whipple thought that the method adopted by Mr. Lowe was a very rough one. Chemically prepared paper might have been used with much more satisfactory results.

Mr. Scott said that a plan for recording the size of rain drops suggested by Mr. Whipple had been proposed some years ago. It consisted of an apparatus in which a strip of chemically prepared paper was moved by clockwork past a wide opening in such a way that the rain should fall upon the paper and the stains left by the drops could be afterwards measured. He did not know whether such an arrangement was ever really carried out. The form of hailstone described by Mr. Marriott did not appear to be very uncommon, as stones somewhat similar had been figured in books, especially by Padre Sanna Solaro, S.J., in the *Annuaire de la Soc. Mét., Paris*, for 1863. He was not disposed to think that thunderstorms usually occurred at so low an elevation above the earth's surface as from 3,000 to 4,000 feet; in fact the late Professor Dove had maintained that thunderstorms frequently crossed the Alps. The average rate of decrease of temperature with altitude—1° for every 300 feet—was only considered to apply to a calm condition of atmosphere. When the atmosphere was in a disturbed condition, as was the case in a thunderstorm, the difference in temperature between the upper and lower edge of a cloud was often considerable. MM. Barral and Bixio, in their famous balloon ascent from Paris in 1850, had experienced a wonderful difference in temperature when passing through a thick cloud bank at an elevation of 18,000 feet, the temperature of its upper edge was —40°F., corresponding to the freezing point of mercury.

Mr. Symons said that an arrangement similar to Prof. Colladon's was described in *British Rainfall* for 1868, pages 10 to 12; there were also papers on the subject by Mr. G. Dines and Mr. T. Stevenson (with engraving) in the *Meteorological Magazine*, Vol. XII. (1877), pages 77 and 86. As regarded the use of chemically prepared paper for recording the drops of rain, he believed it was suggested by M. Hervé-Mangon.

Mr. DINES said that he did not believe in hollow drops of rain, neither did he think that such a drop would form a ring of water on the slate. A tennis ball, when flattened out, still had a fair amount of material left in the central parts, although not so much as there was near the edge.

Mr. INWARDS said he found it difficult to understand how a ring of water could be made on the slate by the fall of a spherical drop. He suggested that the incomplete spots might have been caused by the fall of a partially melted hailstone, which the observer had failed to notice, and which had shaken off the moisture adhering to it on coming into contact with the slate.

Mr. GREATHEED suggested that the explanation of the rings and imperfect spots made by the rain on the slate was, perhaps, that the slate had in some way become greasy. It seemed, however, possible that a rain drop, in its passage through a foggy atmosphere, might acquire a coating which would render adhesion irregular.

LEVELS OF THE RIVER VAAL AT KIMBERLEY, SOUTH AFRICA,

With Remarks on the Rainfall over the Drainage Area.

BY WILLIAM B. TRIPP, M.Inst.C.E., F.R.Met.Soc.

[Received March 3rd.—Read May 18th, 1892.]

RIVER and rainfall observations are now fortunately extending, and it may be hoped that the time will arrive when we shall not be so ignorant as we now are as to the extent of the resources available from these supplies for reservoirs and fountains of water, which are so valuable in many parts of the world.

The subject of this paper is a diagram of the comparative levels of the River Vaal, South Africa, taken at the intake of the Kimberley Waterworks from July 4th, 1885, to April 25th, 1891, with a record of a high flood occurring in 1880, contributed by Mr. R. H Twigg, M.Inst.C.E., F.R.Met.Soc., the consulting engineer to that undertaking. From this diagram the heights given in the present paper have been tabulated.

In connection with the above the tables of rainfall for the same period, so far as they exist, down to the end of 1890, have been extracted by me from the *Reports of the Cape of Good Hope Meteorological Commission*, the monthly rainfall only being given. The stations at which records have been kept are by no means so numerous, nor are the records so complete, as could be desired.

The greatest length of the drainage area of the River Vaal, above the intake of the Kimberley Waterworks to the Klipstad, is nearly 400 miles, while the greatest width, at the Mont aux Sources, is over 200 miles, and the drainage area included within the line of watershed must be some 43,000 to 44,000 square miles.

Such data are very interesting and important, and the engineer and meteorologist are mutually indebted to each other for their collection. In the present case, however, they are not sufficiently complete to enable us to arrive at an accurate comparison of the volume of water flowing down the river to the amount of the rainfall, as they are deficient in some important particulars. In the case of the observations of this river, what is further required is —1. An accurate cross-section at the point at which the gaugings were taken, from which the areas at different heights could be calculated: and 2. The velocities of flow at various levels, or such sections and data as might enable these to be deduced. Until these are furnished we can only obtain a general idea of the flow of the river. The information obtained is, however, interesting and important as a record, and the further river observations required could be subsequently obtained and the total flow calculated with such accuracy as attainable from the weekly observations. It may be remarked, however, that considerable fluctuation may have taken place within the weekly intervals which are not given in the tables.

It is otherwise with the rainfall, the blanks in which cannot now be supplied, if not already in existence; the daily records of such stations as exist would give additional information of importance as to the fall in relation to time, &c., which is an important factor in determining the proportion of flow off the ground, and as giving the rate of propagation of the floods down the valley.

I remember hearing, when I was in South Africa, that the engineers engaged on the Kimberley Waterworks could obtain intelligence of advancing floods, in some cases as much as a fortnight before their arrival, and could consequently take precautions beforehand. (See *Phil. Soc. of Cape Town*, November 29th, 1882, my paper on the river Buffalo.)

The records of some 14 rainfall stations, which appeared to be those most important both as regards their perfection and as being those most widely distributed in the neighbourhood of the drainage area, have been extracted, and these constitute the most important information available; some of them, however, are only fragmentary.

The geological and physical features of the drainage area are also of importance in determining the relation between the rainfall and its flow off the ground, and any information on these would be interesting. The persistently level character of the strata in many parts of South Africa has been often observed as giving rise to lacustrine formation. Having examined the longitudinal declivity of the valley of the River Vaal, by the aid of the tables of altitudes of places in South Africa collected by the late Mr. J. G. Gamble, F.R.Met.Soc., I find that the rise of the River Vaal must be very slight for a long distance, some hundreds of miles in fact above its junction with the Orange River; and from information now given by Mr. Twigg it appears that near Kimberley the river forms a series of lagoons and rapids, and Mr.

Twigg considers that from this circumstance an estimate of the discharge would be exceedingly difficult to obtain, and the flood levels must not be assumed to indicate its volume by any usual formula.

An inspection of Table I. shows that the floods rise and subside rapidly like great flood waves ; the suddenness of the occurrence of these floods, in my opinion, also corresponds with the general experience on other rivers in South Africa, and arises from the rapidity with which the waters flow off the lands owing to denudation of forests, &c., and the large areas contained within the watersheds.

The rainfalls, it will be found, do not in all cases account for the fluctuations shown on the Table diagram, and it will be seen that there is at present a complete absence of records of the meteorological events occurring in the Drakenberg range ; and it is suggested that the attention of the various governments in South Africa should be called to this deficiency, not only as affecting a scientific question, but as being one of which the discussion may prove of material benefit.

The River Vaal forms one of the principal feeders of the Orange River, of which the whole drainage area may be estimated at over 400,000 square miles, about a quarter of which lies above the junction between the Orange and Vaal, the greater part of this latter portion being over 4,000 feet above the sea-level, the Mont aux Sources reaching 10,000 feet, and the Cathkin 10,360 feet, these being two points in the Drakenberg range forming the main watershed of South Africa. This upper portion must be by far the most important section for keeping up the flow of the Orange River, as over the remainder of the drainage area the rainfall is very inconsiderable, immense tracts being practically rainless, and exceeding 10 inches in only a narrow strip of the eastern part, while over those portions lying above the previously mentioned junction, the annual fall may average over 20 inches, the amount increasing towards the head waters of the river. The fall is still greater on the eastern side of the Drakenberg range, a fact which doubtless deprives the western drainage areas of a large portion of the moisture which would otherwise reach them.

The division immediately under consideration forms, of course, the upper part of the drainage area of the River Vaal, the main artery of which takes its rise in the Klipstad Mountains, which attain an elevation of 6,020 feet above the sea. The general distribution of the rainfall throughout the year in these parts is such that the principal fall takes place in the summer from January to March, and in the spring from October to December ; there is ordinarily a drought from about April to September, although these conditions are often more or less departed from, and winter rains when they occur are much prized.

This distribution of rain is to be noticed both in the rainfall tables, and as a consequence in a very marked degree in the river table, there being a marked period of floods and fluctuations at a comparatively high level from about the end of October to the latter part of April, lasting about 5⅝ months; and a period of quiescence, during which the river steadily falls, with very

TABLE I.—Rise and Fall of the River Vaal at Kimberley, July 1885 to April 1891.

Level of the Engine Room floor 56 feet 6 inches above Intake.

Year.	January.			February.			March.			April.			May.			June.		
	Date.	Height.		Date.	Height.		Date.	Height.		Date.	Height.		Date.	Height.		Date.	Height.	
		Ft.	In.		Ft.	In.		Ft.	In.		Ft.	In.		Ft.	In.		Ft.	In.
1885	..	..		..	..		..	..		..	..		..	..		..	..	
	..	..		..	..		..	..		..	..		..	..		..	..	
	..	..		..	..		..	..		..	..		..	..		..	..	
	..	..		..	..		..	..		..	..		..	..		..	..	
	..	..		..	..		..	..		..	..		..	..		..	..	
1886	2	11	0	6	8	6	6	9	0	3	7	0	1	6	6	5	6	0
	9	14	0	13	8	6	13	19	9	10	6	0	8	8	6	12	6	0
	16	10	0	20	9	6	20	12	0	17	6	0	15	7	6	19	6	0
	23	14	0	27	14	0	27	10	6	24	5	6	22	6	6	26	6	0
	30	8	6	..	..		..	..		..	..		29	6	4	..	..	
1887	1	11	6	5	5	1	5	7	6	2	9	7	7	10	0	4	6	4
	8	7	10	12	5	0	12	11	7	9	8	0	14	10	7	11	6	2
	15	7	7	19	5	0	19	8	10	16	7	1	21	8	6	18	6	2
	22	6	0	26	5	0	26	9	3	23	6	9	28	7	6	25	6	0
	29	5	7	..	..		..	..		30	6	6	..	..		..	..	
1888	7	7	0	4	15	0	3	17	0	7	22	0	5	27	0	2	6	9
	14	6	9	11	13	9	10	13	0	14	26	9	12	12	0	9	6	6
	21	7	6	18	35	0	17	10	0	21	12	0	19	8	2	16	6	5
	28	22	3	25	44	6	24	8	7	28	18	0	26	8	1	23	6	4
	..	..		..	..		31	12	0	..	..		..	..		30	6	0
1889	5	6	7	2	6	9	2	6	5	6	5	3	4	5	0	1	4	10
	12	7	2	9	6	5	9	5	9	13	5	2	11	4	11	8	4	9
	19	9	9	16	6	5	16	5	7	20	5	1	18	4	10	15	4	8
	26	7	10	23	6	5	23	5	5	27	5	0	25	4	10	22	4	7
	..	..		..	..		30	5	4	..	..		..	..		29	4	7
1890	4	5	4	1	6	0	1	8	9	5	5	9	3	4	7	7	4	6
	11	5	0	8	6	5	8	7	1	12	5	6	10	4	7	14	4	6
	18	4	6	15	9	5	15	6	8	19	5	1	17	4	6	21	4	6
	25	5	6	22	9	4	22	8	7	26	4	9	24	4	6	28	4	6
	..	..		..	..		29	6	9	..	..		31	4	6	..	..	
1891	3	8	0	7	13	0	7	8	0	4	13	0	..	..		..	..	
	10	24	0	14	9	0	14	7	5	11	13	0	..	..		..	..	
	17	10	0	21	11	0	21	11	10	18	6	8	..	..		..	..	
	24	50	3	28	20	3	28	9	8	25	8	0	..	..		..	..	
	31	40	0	..	..		..	..		..	..		..	..		..	..	

slight fluctuations from about April 19th to October 31st; or about 6 months 12 days, on an average of the dates assumed in the present observations, as being those of transition between the dry and flood seasons.

There is a note on the diagram that in 1880 there occurred the highest flood of which any mention is made, rising to within 4 feet of the engine room floor, or to 52·50 feet above the zero of the gauge. The highest levels subsequently recorded were 44·75 feet on February 25th, 1881, and 50 feet on January 24th, 1891 the lowest being 3·25 feet on November 14th,

TABLE I.—Rise and Fall of the River Vaal at Kimberley, July 1885 to April, 1891 (*Continued*).

Level of the Engine Room floor 56 feet 6 inches above Intake.

Year.	July.		August.		September.		October.		November.		December.	
	Date.	Height.	Date.	Height.	Date.	Height.	Date.	Height.	Date.	Height.	Date.	Height.
		Ft. In.		Ft. In.		Ft. In.		Ft. In.		Ft. In.		Ft. In.
1885	4	6 0	1	5 6	5	5 6	3	7 6	7	7 8	5	10 6
	11	5 10	8	5 6	12	7 0	10	6 6	14	7 8	12	10 0
	18	5 6	15	5 6	19	14 0	17	6 0	21	6 0	19	8 6
	25	5 6	22	5 6	26	9 6	24	10 6	28	10 0	26	10 0
	..	..	29	5 6	..	..	31	10 0	..	..	..	..
1886	3	5 11	7	5 10	4	5 7	2	5 5	6	4 7	4	4 0
	10	5 10	14	5 9	11	5 7	9	5 4	13	4 6	11	13 0
	17	5 10	21	5 8	18	5 6	16	5 3	20	4 6	16	7 8
	24	5 10	28	5 8	25	5 6	23	5 2	27	4 0	25	8 6
	31	5 10	..	..	..	..	30	5 0	..	..	..	..
1887	2	5 11	6	5 3	3	5 6	1	4 10	5	4 3	3	7 9
	9	5 10	13	5 3	10	5 6	8	4 9	12	4 2	10	8 6
	16	5 9	20	5 0	17	5 1	15	4 5	19	4 0	17	6 4
	23	5 6	27	5 9	24	5 0	22	4 5	26	4 0	24	6 9
	30	5 6	..	..	..	..	29	4 5	..	..	31	7 3
1888	7	5 3	4	6 2	1	4 5	6	5 3	3	8 6	1	6 6
	14	5 3	11	5 0	8	4 4	13	4 8	10	7 6	8	6 2
	21	5 0	18	4 1	15	7 0	20	14 9	17	7 0	15	5 11
	28	5 0	25	4 7	22	6 3	27	10 8	24	6 9	22	5 6
	..	..	..	..	29	5 5	..	..	..	..	29	5 3
1889	6	4 7	3	4 7	7	4 7	5	4 7	2	10 8	7	5 9
	13	4 7	10	4 7	14	4 6	12	4 7	9	10 8	14	5 8
	20	4 7	17	4 7	21	4 6	19	4 7	16	5 9	21	5 7
	27	4 7	24	4 7	28	4 6	26	4 7	23	6 3	28	5 6
	..	..	31	4 7	..	..	..	..	30	5 9	..	..
1890	5	4 5	2	4 2	6	3 11	4	3 7	1	3 4	6	7 8
	12	4 5	9	4 1	13	3 10	11	3 6	8	3 4	13	7 5
	19	4 4	16	4 0	20	3 9	18	3 5	15	3 4	20	9 11
	26	4 3	23	4 0	27	3 8	25	3 5	22	8 1	27	10 4
	..	..	30	4 0	..	..	..	..	29	6 10	..	..
1891	..	..	..	..	..	..	..	..	..	..	..	..
	..	..	..	..	..	..	..	..	..	..	..	..
	..	..	..	..	..	..	..	..	..	..	..	..
	..	..	..	..	..	..	..	..	..	..	..	..
	..	..	..	..	..	..	..	..	..	..	..	..

Note.—The figures given above are the actual heights of the river as taken, the heights referred to in the text are approximate only, being taken by scale from a diagram.

1890; the recorded range being therefore (52·50 − 3·25 = 49·25 or) nearly 50 feet.

The two longest rainfall records are those kept at Kimberley, of which 1875 is the first complete year, and at Bloemfontein begun in 1879. The wettest recorded year at each of these stations was 1881, when 34·34 ins. were recorded at Bloemfontein and 30·30 ins. at Kimberley.

TABLE II.

Monthly Rainfall at some of the Stations within or on the border of the Drainage Area of the River Vaal above the intake of the Kimberley Waterworks, as given in the Reports of the Cape of Good Hope Meteorological Commission, from which the following are the most complete records, and those most widely distributed over the Drainage Area.

Name of Station.	Griqualand West.			Orange Free State.								British Bechuana-land.	Transvaal.	
	Newlands, Backley West.	Backley West.	Kimberley Gaol.	Jacobsdal.	Boshop.	Bloemfontein.	Winberg.	Lady Brand.	Harrismith.	Kroonstadt.	Hoopstadt.	Vryburg.	Rietfontein.	8 miles East of Johannesberg.
Height above Sea	..	Ft. 3,800	Ft. 4,042	..	Ft. 1,885	Ft. 4,535	..	Ft. 5,000	Ft. 5,200	Ft. 5,200	..	Ft. 4,200	..	..
1885.	Ins.	Ins.	Ins.	Ins.	Ins.	Ins.	Ins.	Ins.	Ins.	Ins.	Ins.	Ins.	Ins.	Ins.
January..	0·43	0·34	0·34	..	0·63	0·72		1·16	1·82	2·62				
February	1·80	2·23	1·78	2·10	2·78	3·48		4·23	1·58	4·22				
March ..	1·07	1·89	1·36	3·26	2·64	1·73		2·04	2·04	1·19				
April	0·52	0·84	0·73	..	0·69	0·79		1·97	0·83	1·48				
May	0·31	0·69	0·40	1·60	1·00	1·13	No record.	0·97	1·00	0·66	No record.	No record.	No record.	No record.
June	0·02	0·10	0·12	..	0·04	0·08		0·26	0·81	..				
July	..	..	..	..	..	0·45		0·13	0·17	..				
August ..	0·42	1·05	0·77	1·50	0·68	1·03		1·68	0·63	0·80				
September	0·45	1·21	1·35	3·16	3·09	2·38		6·24	4·00	4·61				
October	0·98	1·64	0·41	0·80	1·46	0·29		1·52	2·15	1·42				
November	2·31	1·73	0·47	0·62	1·88	1·47		1·78	1·27	2·77				
December	1·53	1·59	0·52	1·13	1·16	2·74		5·00	7·93	3·56				
Totals..	10·22	13·31	8·25	..	16·05	16·29	..	26·98	24·23	23·33	..	..	..	..
1886.	Ins.	Ins.	Ins.	Ins.	Ins.	Ins.	Ins.	Ins.	Ins.	Ins.	Ins.	Ins.	Ins.	Ins.
January..	1·47	1·74	1·24	0·28		3·05				6·26	..	..		
February	3·01	0·60	1·04	2·20		0·97				3·46	2·16	..		
March ..	4·79	4·21	3·52	4·16		5·24				6·10	3·40	2·42		
April	2·31	1·15	0·94	1·04		1·88				2·88	0·87	0·93		
May	0	0·02	0	..	No record.	0	No record.	No record.	No record.	0	..	0	No record.	No record.
June	0·02	0·05	0	..		0·05				0	..	0		
July	0·03	0·11	0·28	0·27		0·55				0·38	0·04	0·09		
August ..	0·07	0·25	0·19	0·24		0·43				0·11	..	0		
September	0·03	0·10	0·09	0·05		0				0·32	..	0		
October ..	0·64	0·48	0·42	0·53		0·58				2·55	0·32	0·66		
November	0·24	0·62	0·41	0·10		0·91				4·52	2·51	0·92		
December	5·4[illegible]	6·57	4·94	4·63		3·81				3·36	4·14	3·56		
Totals..	18·10	15·90	13·07	..	..	17·47	..	..	..	29·94	..	..	..	..
1887.	Ins.	Ins.	Ins.	Ins.	Ins.	Ins.	Ins.	Ins.	Ins.	Ins.	Ins.	Ins.	Ins.	Ins.
January..	1·41	1·10	1·33	1·71		1·05	1·88	1·23	0·37	1·24	1·54	2·22		
February	3·50	4·71	2·95	4·66		4·65	4·62	3·99	4·58	4·97	1·75	4·09		
March ..	1·48	2·53	1·74	2·19		2·95	3·36	7·24	6·05	8·47	4·21	4·73		
April	2·17	1·51	1·25	1·22		4·17	3·11	2·89	2·56	1·94	1·65	1·72		
May	2·15	2·36	1·79	2·24	No record.	1·57	0·98	2·31	0·73	1·85	0·42	1·13	No record.	No record.
June	1·52	1·25	1·08	0·39		0·02	0	0·18	0·65	0·65	0·45	1·46		
July	0·70	1·22	0·64	1·59		1·02	0·95	1·60	0	0	0·37	0·17		
August ..	0·04	0·26	0·60	1·10		1·11	1·01	1·29	0·61	0·83	0·77	0·70		
September	0	0·07	0·02	0		0·46	0	0·26	0·25	0·15	..	0·05		
October..	1·67	1·15	0·98	1·05		1·39	1·69	1·41	0·47	0·98	0·62	1·14		
November	1·59	1·57	0·86	1·28		0·58	1·40	2·75	3·15	3·64	2·90	3·41		
December	4·74	6·80	4·09	2·30		2·47	4·74	4·10	4·97	1·71	3·20	2·98		
Totals..	20·97	24·53	17·33	19·73	..	21·44	23·74	29·25	24·39	26·43	17·88	23·80	..	..

TABLE II.

MONTHLY RAINFALL AT SOME OF THE STATIONS WITHIN OR ON THE BORDER OT THE DRAINAGE AREA OF THE RIVER VAAL ABOVE THE INTAKE OF THE KIMBERLEY WATER WORKS, AS GIVEN IN THE REPORTS OF THE CAPE OF GOOD HOPE METEOROLOGICAL COMMISSION, FROM WHICH THE FOLLOWING ARE THE MOST COMPLETE RECORDS, AND THOSE MOST WIDELY DISTRIBUTED OVER THE DRAINAGE AREA—*Continued.*

Name of Station.	Griqualand.			Orange Free State.								British Bechuanaland.	Transvaal.	
	Newlands, Backley West.	Backley West.	Kimberley Gaol.	Jacobsdal.	Boshop.	Bloemfontein.	Winberg.	Lady Brand.	Harrismith.	Kroonstadt.	Hoopstadt.	Vryberg.	Rietfontein.	8 miles East of Johannesberg.
Height above Sea	..	Ft. 3,800	Ft. 4,042	..	Ft. 1,885	Ft. 4.535	..	Ft. 5,000	Ft. 5,200	Ft. 4,500	..	Ft. 4,300	..	..
1888.	Ins.	Ins.	Ins.	Ins.	Ins.	Ins.	Ins.	Ins.	Ins.	Ins.	Ins.	Ins.	Ins.	Ins.
January	2·05	2·14	2·05	1·37	5·40	2·42	6·40	6·41	5·98	2·47	3·03	2·41		
February	4·13	2·83	3·60	3·13	..	2·21	3·84	4·34	7·96	4·17	3·77	4·27		
March ..	6·29	6·02	3·96	3·77	5·69	5·87	6·44	6·61	4·67	6·88	5·68	3·95		
April	1·60	2·40	1·59	2·00	1·98	4·22	4·16	6·21	5·02	6·08	5·41	2·70		
May	2·12	2·28	1·77	3·04	1·94	3·10	0·41	1·51	0·15	1·03	0·55	1·11	No record.	No record.
June	0	0·01	0·08	0·32	0·09	0·02	..	0·38	0·20	0·06	0·02?	0·02		
July	0	0	0	0	0	0·10	..	1·08	0·87	0·33	..	0		
August ..	0·01	0·07	0·23	0·69	0·22	2·23	0·55	1·05	2·39	0·87	0·46	1·27		
September	0·91	1·18	1·74	1·25	1·15	1·22	0·51	0·93	1·36	0	0·91	0·84		
October ..	0·40	0·54	2·81	1·18	1·39	4·15	2·80	3·60	3·56	4·86	2·34	0·12		
November	0·40	0 25	0	0	0·65	0·32	1·34	1·58	2·45	1·60	0·40	0·31		
December	1·70	1·13	0·42	0·42	0·60	2·06	0·33	4·04	1·00	3·16?	1·93	4·45		
Totals ..	19·61	18·85	18·25	..	..	27·92	..	37·74	35·61	31·51?	24·50?	21·45	..	..
1889.	Ins.	Ins.	Ins.	Ins.	Ins.	Ins.	Ins.	Ins.	Ins.	Ins.	Ins.	Ins.	Ins.	Ins.
January	1·88	1·38	2·28	1·37	2·78	4·86	2·58	3·96	4·08	1·86	4·24	3·31	4·50	
February	3·90	2·55	1·76	5·28	1·37	6·00	2·67	5·06	1·88	1·27	2·68	4·82	6·91	
March ..	1·57	1·92	1·79	0·61	0·88	3·15	0·62	1·06	1·58	1·61	1·04	3·39	4·35	
April	2·06	2·69	1·56	2·00	3·52	3·15	1·60	4·03	0·67	2·37	2·32	5 57	4·19	
May	0·11	0·34	0	0·29	0·82	0·72	..	0·80	0·16	0·31	..	0·42	0·32	
June	0	0	0	0	0	0·06	..	0·13	0	0	..	0	0	No record.
July ...	0	0	0	0	0	0	..	0	0	0	..	0	1·45	
August ..	0·18	0·10	0·08	0·14	0·61	1·71	1·15	1·79	0·33	0·37	1·40	0·41	0·89	
September	0	0	0·22	0·18	0	1·39	..	1·75	0·17	0	..	0	0·34	
October ..	1·54	3·40	5·06	3·83	5·36	5·81	2·16	2·48	4·85	1·35	1·88	0·35	3·59	
November	3·49	3·36	1·76	2·80	4·37	2·49	3·70	4·05	6 20	4·46	6·22	1·37	2·29	
December	2·92	3·29	1·46	1·67	1·61	3·71	1·44	2·43	2·47	1·90	2·48	1·20	4·42	
Totals..	17·65	19·03	15·97	18·17	21·32	33·05	..	27·54	22·39	15·50	22·26	20·84	33·25	..
1890.	Ins.	Ins.	Ins.	Ins.	Ins.	Ins.	Ins.	Ins.	Ins.	Ins.	Ins.	Ins.	Ins.	Ins.
January	0·91	1·71	1·30	2·19	2·80	1·67		3·02	3·32	2·99			6·14	4·59
February	4·61	6·40	5·74	5·09	7·15	5·69		8·08	6·45	3·74			3·15	3·09
March ..	3·26	2·42	1·42	2·18	3·68	4·04		3·95	0·36	2·99			1·24	2·17
April	2 78	4·51	2·87	2·69	2·43	3·61		1·94	0·93	1·50			1·04	3·09
May	0·54	0·75	0·75	1·08	0·34	1·82		1 53	0·80	2·69			0	1·29
June	0·74	1·18	1·03	1·67	0·95	1·37	No record.	1·33	0·31	0·68	No record.	No record.	0	0·46
July	0·46	0·81	0·52	0·83	0·15	0·44		1·21	0·71	0·68			0	0
August ..	0·06	0·03	0	0·11	0·06	0·13		1·52	0·13	0			0	0
September	0	0	0	0·05	..	0		0	0	0·05			0·82	0·08
October .	1·50	1·80	1·33	1·31	0·96	1·94		3·73	0·87	2·38			0·19	5·77
November	1·76	1·74	2·45	1·75	1·17	3·49		5·03	4·22	4·82			4·52	5·14
December	3·16	3·80	3·59	3·66	..	4·44		3·99	..	6·23			2·80	5·76
Totals ..	19·78	25·15	21·00	22·61	..	28·64	..	35·33	..	28·75	..	..	19·90	31·44

TABLE IV.—ANALYSIS OF RISES AND FALLS OF THE RIVER VAAL, COMPARED WITH THE RAINFALL.

Autumn and Winter Droughts.			
Begun.	Ended.	Duration.	Remarks, Principal Fluctuations, Rainfall, &c.
1885 Not given	1885 Sept. 6, 249th day	Record not complete	Steady fall. Height 6·0 ft. to 5·40 ft. In June 1 and July 5 stations were without rain
1886 April 3, 93rd day	1886 Dec. 4, 338th day	8 months 1 day	Steady fall from 7·0 ft. on April 3 to 4·10 ft. Dec. 4. In May 6, June 4, Aug. 2 and Sept. 3 stations were without any rain recorded
1887 June 4, 155th day	1887 Nov. 26, 330th day	5 months 22 days	Nearly steady fall from 6·80 ft. to 3·75 ft. Slight rise in Aug., corresponding with rainfall, 1·29 in. at Lady Brand. June 1, July 1 and Sept. 4 stations were without rain
1888 May 19, 139th day	1888 Oct. 14, 287th day	4 months 26 days	Fall from 8·30 ft. to 4·70 ft., with slight rises in beginning of Aug., corresponding to rainfall of July and Aug. and rise in Sept. Good rainfall in many parts of the Drainage Area, but in June 1, July 7, Sept. 1 and Nov. 1 stations were without rain, those of July being in the lower parts of the area within the Watershed
1889 Mar. 10, 69th day	1889 Oct. 26, 299th day	7 months 16 days	Long and steady fall from 5·60 ft. to 4·60 ft. In May, June and July 2, 10 to 11 stations respectively without any rain, and Sept. 6 stations
1890 Mar. 29, 88th day	1890 Nov. 14, 318th day	7 months 16 days	Long and steady fall, from 6·50 ft. to 3·25 ft., the lowest point reached. In Aug. and Sept. 4 and 6 stations respectively with no rain.

The year 1874 was remarkably wet in the eastern part of the Cape Colony and Natal. The Kimberley record is not complete for this year, which was, however, very wet, the fall for 5 months, January, February, March, April,

TABLE IV.—ANALYSIS OF RISES AND FALLS OF THE RIVER VAAL, COMPARED WITH THE RAINFALL.—*Continued*.

Spring and Summer Floods.			
Began.	Ended.	Duration.	Remarks, Principal Fluctuations, Rainfall, &c.
1885 Sept. 6	1886 April 3	Really ended Apr. 3, after which very slight fluctuations 6 months 27 days	Sept. 20. Height 14·0 ft.; considerable rainfall during Sept. in Upper and East part of Drainage Area. Lady Brand 6·24 ins. in Dec. and Jan. Heavy fall in same parts. Dec. 7·93 ins. at Harrismith. Jan. 6, 26 ins. at Kroonstadt
1886 Dec. 4	1887 June 4	6 months	Slight fluctuations only. Floods on Dec. 13, 13·0 ft. and Jan. 1, 11·60 ft. Heaviest fall occurred below the intake at Barkley in Dec., and at Vryburg 2·22 ins. only in Jan. River higher also in March, April and May, corresponding with rainfall, 8·47 ins. Kroonstadt in May, 4·17 ins. Bloemfontein in April, and in lower parts of Drainage Area in May
1887 Nov. 26	1888 May 19	5 months 23 days	1888 wettest year in upper part. March '88 wettest month. Very high flood on Feb. 25, 44·75 ft., corresponding with high rainfall in Jan. and Feb. in East and North of Drainage Area. Floods of 26·5 ins., 26·8 ins. in April and May respectively, probably both due to rainfall of April in upper part of Drainage Area
1888 Oct. 14	1889 Mar. 10	4 months 24 days	Very slight floods in Oct. and Jan. Rainfall only 4·86 ins. at highest in Oct. and Jan., and not so high in intervening months.
1889 Oct. 26	1890 Mar. 9	5 months 3 days	Very slight floods in Nov. Feb. and March. See remarks on Rainfall
1890 Nov. 14	1891 Record not complete after April 25	Record not complete	Highest flood recorded, except that in 1880, on Jan. 24, 50·0 ft. The rainfall for 1891 not available.

and July having amounted to 20·53 ins., or nearly double the average. Tremendous floods were experienced in nearly all the eastern rivers, and it is very possible that the River Vaal may have then risen to a higher level than any here recorded.

The following connected account of the principal features of the river diagram, compared as far as practicable with the rainfall, may be interesting :—

1885. The first height is taken July 4th, 1885, 6 feet above zero in the middle of the usual winter droughts. In June one, and in July five of the stations had no rain recorded. The river falls steadily to 5·40 feet on September 6th, when a sudden rise takes place in a flood of 14 feet on September 20th. September was a very wet month, at five stations the fall being 3 ins. and over, and at three stations over 4 ins, and being greatest at the eastern and upper part of the drainage area.

1886. Floods again occurred in January 1886, corresponding to rainfall in December 1885; three stations having over 3 ins., two over 5 ins., and Harrismith 8 ins. in the eastern part. The highest flood of the season occurred on March 15th, 1886, height 19·70 feet. March had seven stations with 3 ins. and over, five over 4 ins., two over 5 ins., and one over 6 ins. of rain, out of eight stations of which records are given. The flood season may be said to conclude on April 3rd, having lasted 6 months 27 days.

The droughts commenced on April 3rd, 1886, at a height of 7 feet; then occurred a slight fluctuation in May. After May 23rd there was a steady fall to 4·10 feet on December 4th, the total duration of drought being 8 months 1 day. In May, six, in June, four, in August, two, and in September, three stations had no rain registered.

The flood season commencing December 4th has recorded very slight floods only, the highest being on December 13th of 13·0 feet. In December there were eight stations with 3 ins. of rain or over, and five stations with over 4 ins.; but these occurred at the lower stations chiefly.

1887. Small floods also occurred in March, April, and May, corresponding with rainfall at Kronstadt 8·47 ins. in March, Bloemfontein 4·17 ins. in April. That of May was chiefly in the lower part of the drainage area. The flood season terminated on June 4th, 1887, having lasted 6 months.

The drought of 1887 lasted 5 months 22 days, with a nearly steady fall from 6·80 feet to 3·75 feet on November 26th. There was a slight rise in August corresponding with 1·29 in. rain at Lady Brand. In June one, in July one, and in September, four stations were without rain.

The floods of 1887 lasted for 5 months 23 days, and ended May 19th, 1888.

1888 was the wettest year in the accompanying record, in the upper part of the drainage area, Lady Brand, Harrismith, Kroonstadt, and Hoopstadt. March 1888 was the wettest month at the eleven stations with records, the mean fall amounting to 5·49 ins., and over 3 ins. fell at each station, nine having over 4 ins., eight over 5 ins., and five over 6 ins. January and February were also wet months; in the latter month at nine stations the fall was 3 ins. and over, at five 4 ins. and over, and at one over 6 ins.

A very high flood occurred on February 25th, 1888, height 44·75 feet, being the highest but two recorded. April was also a wet month, and floods of 26·5 feet and 26·8 feet occurred in April and May respectively, perhaps both due to the heavy fall of April in the upper part of the drainage area.

The drought of 1888 lasted only 4 months 26 days, from March 19th to October 14th, during which the river fell from 8·30 feet to 4·70 feet, with slight rises in August and September, which is accounted for by good rains nearly all over the drainage area. These are the least severe droughts recorded in the present data, but June, July, September, and November had respectively one, seven, one, and one stations without rain, those of July being in the lower part of the drainage area.

The flood season of 1888 commenced with a sudden rise to 14·75 feet on October 21st, this being the highest flood for the season, during which the river exhibited very few and slight fluctuations, even falling at the end of December to 5·20 feet, and the highest rise, except that given, was 9·50 feet on January 19th. This again is accounted for by the rainfall having been so slight in November and December 1888, and the fall in January was not by any means great for that season. The date assumed for the termination of the flood season is March 10th.

It may here be remarked, however, that there is much less difficulty in fixing the commencement of the flood season than its termination. As is common in rainfall observations, an excess comes on with violence and gradually dies out with a drought, which is of longer continuance and less marked character. I have, however, assumed such a date each year for the transition from flood to drought as seemed to him most likely from an inspection of the diagram to be the true one, but it is possible that others might in some cases fix a slightly different date. About the commencement of the flood season there can be, he considers, no doubt.

The year 1889 was one of the driest herein recorded, particularly in the upper part of the watershed. In May, June, July, and September, there were respectively two, ten, eleven, and six stations respectively out of thirteen with no rain, and as a consequence the river exhibited a long and steady fall from 5·60 to 4·60 feet on October 26th, when the dry season ended, having lasted 7 months 16 days.

The floods were very slight in the 1889 season, the highest being 10·70 feet on November 3rd and 10th. Slight rises of 9·40 feet and 8·40 feet occurred also in February and March, while on January 18th the river sunk to 4·40 feet, or a lower point than that at the end of the preceding dry season.

In 1890 it is, however, somewhat surprising that the floods of February and March were not more conspicuous, as February was one of the wettest months recorded, the mean at the eleven stations with records being 5·38 ins. and all the stations had 3 ins. or over, eight had 4 ins. or over, seven 5 ins., four 6 ins. or over, and one, Lady Brand, over 8 ins. It is true that at the uppermost stations, Kroonstadt, Rietfontein and Johanesburg, the fall was only 3 ins. and over, and many of the higher falls occurred at the central and lower stations, and we do not know how the falls occurred; if in gentle showers, much of it may have been absorbed. Still this is the portion of the observations which appears most to require explanation.

It is quite possible that the lagoons above alluded to may have been much depleted by the droughts of 1889, &c., and much of the summer fall of 1890 may have been absorbed in refilling them, thus accounting for the slight elevation of the floods registered at Kimberley.

The date assumed for the termination of the flood season is March 29th, this being fairly well defined; duration 7 months 16 days, same as last year.

After the droughts of the latter part of 1888, the whole of 1889, and the very slight floods of 1889, it is not surprising that the droughts of 1890, lasting 7 months 16 days until November 14th, were the lowest recorded, exhibiting a long and steady fall from 6·50 feet to 8·25 feet, which is the lowest point reached on the diagram.

Out of eleven stations with records there was no rain at one station in May, at one in June, at one in July, at four in August, and at six in September.

1891. The flood season 1890-91 is incomplete, the record terminating on April 25th. The report of 1891 of the Cape Commission is not yet to hand, consequently the amount of the rainfall is not at present available.

N.B.—The figures quoted above as being the heights of the river are those scaled from a plotted diagram and are approximate only, whereas the figures given in Table I. are the actual heights taken weekly.

The highest flood recorded, except that of 1880, was measured at 50·25 feet on January 24th, 1891.

The river fluctuations may be summarised as follows:—

Moderate floods 1885 to 1886.

Slight floods 1886 to 1887, 1888 to 1889, and 1889 to 1890.

High floods 1887 to 1888, 1890 to 1891.

Lowest drought 1890.

Shortest drought 1888.

TABLE III.—RAINFALL AT DURBAN OBSERVATORY, NATAL.

Months.	1885.	1886.	1887.	1888.	1889.	1890.
	Ins.	Ins.	Ins.	Ins.	Ins.	Ins.
January	4·77	3·04	4·28	5·59	8·36	1·93
February	2·32	6·55	3·54	5·05	4·97	4·79
March	2·91	3·05	3·55	5·45	2·01	2·01
April	2·22	4·00	3·41	2·18	1·49	8·00
May	1·00	2·18	4·26	3·91	2·42	0·51
June	0·26	0	0·74	0·50	0·23	0·30
July	0·03	3·13	0·80	0·85	0·17	0·10
August	0·61	0·50	3·76	1·15	1·26	0·64
September	10·43	0·86	1·35	4·45	1·10	1·09
October	2·75	0·55	1·41	4·10	4·06	5·31
November	3·15	4·79	3·05	1·34	1·95	3·55
December	4·03	3·14	1·72	3·62	1·52	4·68
				W.	D.	
Total	34·48	31·79	31·87	38·19	29·54	32·91

It has been considered interesting to include the rainfall at Durban, Table III., from which it will be seen that 1888 was the wettest, and 1889 the driest year during the period under discussion, thus so far agreeing with the records nearer the drainage area. It is to be regretted that no records are available of the rainfall of Natal, in the vicinity of the Drakenberg range, though it would appear probable that such may exist.

DISCUSSION.

Mr. TWIGG said that he had sent the diagram of levels of the River Vaal, upon which the paper was based, to the Society, because he thought that it was well within the province of the Society's work to collect and discuss such information. The rapid rises in the river which the diagram exhibited must not be understood as representing anything wonderful, as it is on record that in Australia a river has risen from zero to 200 feet. The increases in the level of the river Vaal were due to a large, but not phenomenal, rainfall spread over a great area of country. The rainfalls, which so greatly increased the volume of the Vaal, probably little exceeded falls experienced in Cumberland. The difference in the effects produced by such rainfall in this country and those produced in South Africa was entirely due to the vast difference in the area over which the rain fell, the great length of the flat portion of the river, and the steepness of the small tributaries that collect the rain falling on the Drakenberg range of mountains. As regarded the rainfall records in South Africa, he had, after a careful investigation, come to the conclusion that there was an unmistakable coincidence between the amount of rainfall and the sun spot cycle, and that periods of maxima rainfall in one district coincided with minima periods in other districts.

Mr. CROSSE said that there was a great difference between the annual distribution of rainfall in Cape Town and the Transvaal, the rainy season at one place nearly corresponding with the dry season at the other. The watershed of the River Vaal was very sparsely populated, and consequently the rainfall stations were few in number. There was a great absence of trees throughout the district and altogether very little vegetation to absorb the moisture deposited, so that the rain which fell ran off the surface of the earth pretty rapidly, and swelled the volume of the river.

Mr. SYMONS said that the paper was a very useful one. There was little doubt that more information concerning the meteorological conditions of South Africa was urgently required, but, as was too often the case, the necessary funds were not forthcoming. High Government officials appeared to regard money spent in meteorological investigation as money ill-spent, whereas it frequently happened that such information was worth from ten to one hundred times the outlay involved in obtaining it.

Mr. TRIPP, in reply, said that the effects of the comparatively small rainfall in raising the level of the Vaal were chiefly due to the immense area drained by the river, and also to the fact that the country was almost denuded of vegetation, and the ground being very dry the rain which fell ran off quickly.

Results of a Comparison of Richard's Anemo-Cinemographe with the standard Beckley Anemograph at the Kew Observatory.

BY G. M. WHIPPLE, B.Sc., F.R.Met.Soc., F.R.A.S., Superintendent.

[Received April 19th.—Read May 18th, 1892.]

Two years ago the writer, being in Paris, was much interested in the pattern of Anemometer constructed by MM. Richard, of that city, and used by several Continental observers in preference to the Robinson Cups which are generally adopted by the English and American meteorologists.

The new form of instrument is a modification of the old Whewell fan, or windmill vane, the change being in the shape of each blade of the vane, which is made oval, and fitted at an angle of 45° to the axis. The vanes are said by MM. Richard to have been carefully calibrated, but no particulars of the calibration have been published by those gentlemen beyond the description given in their printed catalogue, which states the construction of the fan to be as follows:—

"It is formed by six little wings or vanes of sheet aluminium, 4 inches in diameter, inclined at 45°, rivetted on very light steel arms, the diameter of which is so calculated that the vane should make exactly one turn for the passage of a metre of wind (Fig. 1). Its running is always verified by means of a whirling frame fitted up in an experimental room where the air is absolutely calm, and, if necessary, a table of corrections is supplied." The recording part of the apparatus differs entirely from any other anemometer, and is called the *Anémo-Cinémographe*, and in principle as follows:—The pen, recording on a moveable sheet of paper, is lowered at a constant rate by means of a conical pendulum acting through a train of wheel work, whilst a second train, driven by the fan, is always tending to force it up from the lower edge of the paper; its position, therefore, is governed by the relative difference in the velocity of the two trains of wheelwork, being at zero of the scale when the air is calm, but at other times it records the rate of the fan in metres per second (Fig. 2).

The instrument was run at Kew continuously from May 22nd to November 12th, 1891, but since that date paper has only been put on in stormy weather. It was fixed with the fan on the same level as the cups of the Kew Anemograph, at about 10 feet distant from them horizontally.

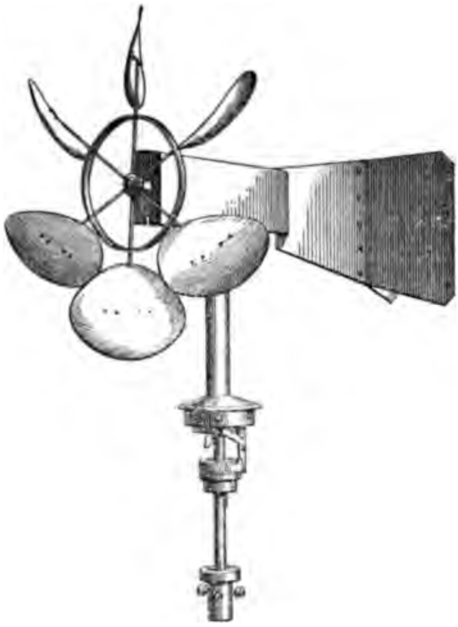


FIG. 1.—Richard's Anémo-Cinémographe.

The vane, which keeps the fan at right angles to the wind, was found to require a wind of 5 miles an hour to maintain it in that position, and it was also found that the fan was less sensitive than the Robinson cups of the Kew instrument, which move with a light breeze of 3 miles an hour. The recording train is worked by means of a Fuller's Bichromate Battery of two cells which did not require attention for two or three months.

The method of comparing the instrument was as follows :—Readings of the dials of the Richard Anemograph were taken at various intervals, and the differences in their readings by calculation were then converted into miles per hour, and percentage of run attained were deduced by comparing them with the corresponding run of the Kew standard as read off by the graduated scale fitted to it.

The following is the result of all the observations :—

Miles per hour Kew Standard (factor 3).	Richard's Anemograph Percentage of Kew Standard Values.	Factor for Richard as deduced from corresponding Kew Readings.
6	88	2·64
8	87	2·61
16	84	2·52

Miles per hour Kew Standard (factor 3).	Richard's Anemograph Percentage of Kew Standard Values.	Factor for Richard as deduced from corresponding Kew Readings.
18	84	2·52
20	84	2·52
22	84	2·52
24	84	2·52
26	83	2·49
28	83	2·49
30	82	2·46
32	81	2·43
34	81	2·43
36	81	2·43
38	80	2·40
40	80	2·40
42	80	2·40

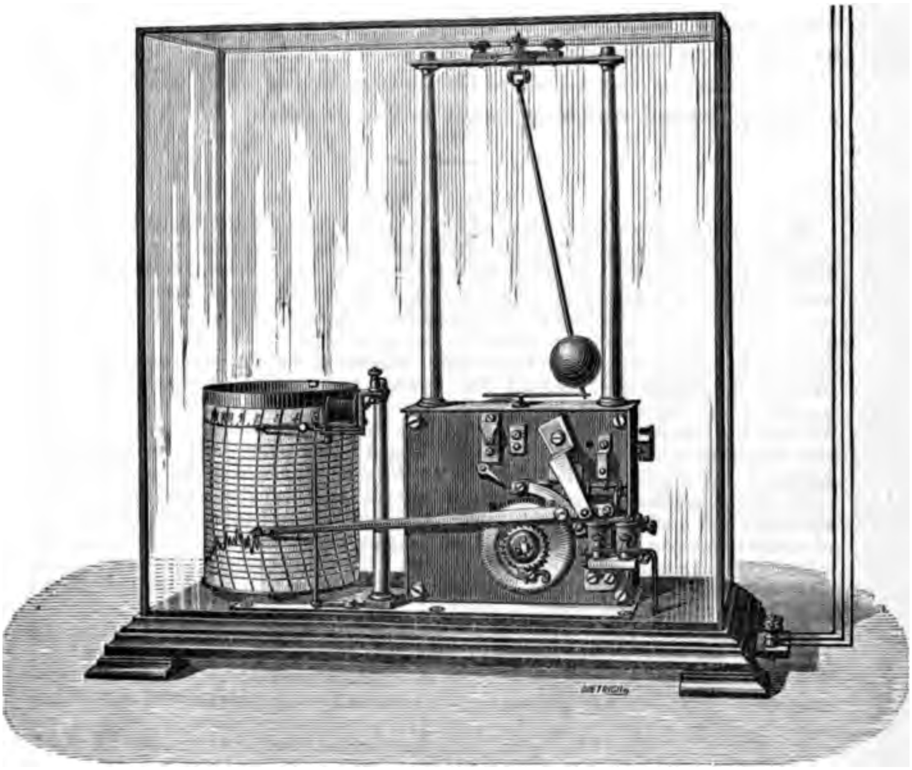


FIG. 2.—Recording part of Richard's Anémo-Cinémographe.

Mean values were also obtained from the curves and compared with the values as obtained from the scale readings, with the following results, both values being converted into miles per hour.

Dial readings in miles.	Mean value from curves in miles run.
9·9	11·0
11·5	11·0
12·0	12·0
13·3	12·0
13·9	13·0
25·0	26·0
25·6	26·0
33·2	28·0
29·7	29·5
49·5	50·0

The curves show that the velocity of the wind can be very readily read off without difficulty, the instrument attaining any velocity in a very few minutes from rest, and so exhibiting the fluctuation in wind force quite clearly, whilst the total run of the wind for any desired interval of time can easily be read off by observation of the wheel work.

The instrument does not record the direction of the wind, MM. Richard having constructed another apparatus for that purpose.

DISCUSSION.

Mr. Whipple, after the reading of the paper, entered into a minute description of the principle and working of the Anémo-Cinémographe constructed by MM. Richard Frères, and illustrated his remarks by references to the instrument itself (the exposed portion, consisting of the fans and vane with their mechanism, being exhibited to the meeting), and also by means of blackboard sketches of portions of the recording apparatus. He said that the Richard instrument gave a different value to that registered by the Robinson cups, and he understood that MM. Richard Frères were prepared to certify that the fans indicated the amount of wind which passed over them. His chief reason for bringing this comparison before the Society was because the ratios between the Robinson Anemometer and the Richard instrument were so divergent. Although the mechanism of the Anémo-Cinémographe was delicate, and in spite of the fact that the recording apparatus was electrically controlled, the instrument had worked uniformly well. If it was desired to record the velocity of every wind movement, the Richard instrument was undoubtedly a distinct advantage over the Robinson Anemograph. The instrument was, however, of such delicate construction that it could only be placed in the hands of skilful observers.

The President (Dr. Williams) said that any apparatus which originated from MM. Richard Frères, of Paris, was sure to be ingenious and interesting. This Anémo-Cinémographe appeared to work uncommonly well, and was of great importance when compared with the various instruments exhibited at the last meeting by Mr. Dines.

Mr. Munro inquired how quickly the instrument took up the velocity of the wind.

Mr. Whipple stated that but a few seconds of time were lost by the instrument in picking up the actual wind velocity.

Mr. Munro said his reason for making that inquiry was because many years ago he had adopted a similar arrangement to that utilised by MM. Richard in some drawings of a proposed anemometer which he had designed. These drawings were shown to Sir George Stokes and to the late Dr. Warren de la Rue, who much admired them, although the opinion was expressed that the instrument would be tardy in taking up the actual velocity of the wind. The drawings of this proposed anemometer, which was designed upon the well-known Morin-screw principle, were also submitted to the Meteorological Council, with the view of an instrument being constructed, but the idea was ultimately abandoned. Some years afterwards Mr. Dines carefully studied these drawings, and gave it as his opinion that such an instrument would be very slow in taking up wind velocities, so that the curve which the instrument would give must always be considerably behind time.

Mr. SYMONS said that an arrangement for registering wind velocity identical with the Anémo-Cinémographe formed part of the Brontometer which had been constructed for him by MM. Richard Frères; he could, therefore, speak from practical experience of the performances of this form of anemometer. He had converted the percentages contained in Mr. Whipple's statement of results into actual indications, and taking the factor for Robinson cups as 2·4 and not 3·0, as had been done in the paper, he had found the agreement between the two anemometers to be wonderfully close, the difference only amounting to tenths of a mile per hour, except at two velocities, when differences of 1 mile were recorded, as shown in the accompanying table. In fact, he did not think any person

RELATIVE VELOCITY OF WIND BY KEW STANDARD ANEMOGRAPH AND RICHARD'S ANÉMO-CINÉMOGRAPHE, REARRANGED FROM MR. WHIPPLE'S PAPER.

Kew Standard.			Velocity indicated by Richard Anémo-Cinémographe.	Excess of Richard.
Velocity Factor 3·0.	Actual Motion of Cups.	Velocity Factor 2·4.		
Miles.	Miles.	Miles.	Miles.	Mile.
6	2·0	4·8	5·3	+ ·5
8	2·7	6·5	6·9	+ ·4
16	5·3	12·7	13·4	+ ·7
18	6·0	14·4	15·1	+ ·7
20	6·7	16·1	16·8	+ ·7
22	7·3	17·5	18·5	+1·0
24	8·0	19·2	20·2	+1·0
26	8·7	20·9	21·6	+ ·7
28	9·3	22·3	23·2	+ ·9
30	10·0	24·0	24·6	+ ·6
32	10·7	25·7	26·0	+ ·3
34	11·3	27·1	27·6	+ ·5
36	12·0	28·8	29·2	+ ·4
38	12·7	30·5	30·4	— ·1
40	13·3	32·0	32·0	0
42	14·0	33·6	33·6	0

would have expected such good results as had been obtained. He did not quite understand the remarks that had been made concerning the time which this instrument, or others of similar construction, required to take up the velocity of the wind they were exposed to. Retardation amounting to minutes had been spoken of, whereas his own experience of the Richard instrument was, that the amount of retardation certainly did not exceed four seconds, its action being almost synchronous with each rush of wind. This anemometer was really much stronger than it looked; there was very little weight in the working parts, and consequently the momentum imparted to the revolving fan was small.

Mr. C. HARDING, after referring to the difficulty he had experienced in interpreting the figures given in the paper, said that the Richard anemometer recorded the actual wind movement, whereas the Kew anemometer cups revolved at a speed which had hitherto been supposed to represent one-third of the natural movement of the wind. The results of Mr. Whipple's comparison really afforded a good confirmation of the results of Mr. Dines's investigation into the question of the correct factor for Robinson cups. The factor 3 was now well known to be too high, and the question arose whether the time had not arrived when the old factor should be modified in accordance with the result of recent research.

Mr. DINES said he was very pleased to see the results of Mr. Whipple's work, as we now had a direct comparison between the Kew instrument and the anemometer which was used in France. It was not very encouraging that Mr. Whipple should have obtained a factor of 2·40 for the Robinson, whereas recent comparisons at Oxshot of a similar character had given 2·10 as the factor. He thought that there were two possible explanations. MM. Richard had given no particulars of their method of calibration beyond stating that it had been done by the use of a whirling machine placed in a closed room. Now he (Mr. Dines) had had some experience in testing anemometers upon a whirling machine, and he had often tried the same air meter, both indoors and out, with the result that the indoor trials always gave a lower value than the outdoor, the difference often amounting to as much as 10 per cent. The fact was that it was impossible indoors to avoid setting up an eddy, and equally impossible to know how much to allow for that eddy. Dr. Robinson, in the account of his very careful experiments, had stated that his results were unreliable on this account. The result was that an instrument calibrated by indoor trials was made to give too high a reading, and he thought it probable, as MM. Richard had given no particulars of how they got over the difficulty of the induced eddy, that they had ignored it, and in consequence calibrated their instrument so that it gave too high a value. The other point was the exposure. He did not know on which side of the Robinson cups the instrument was placed. It was too light to afford shelter to anything behind it, but it would be sheltered by the cups, and possibly by the dome of the observatory, when the wind blew from them to it. Last summer and autumn there had been an overwhelming preponderance of South-westerly winds, and if the Richard instrument were to the north or east of the cups, it must have been more or less sheltered; and this again would make the factor of the Kew pattern too high. This was no imaginary danger, for at a height of 9 feet above his own roof, he had found that the direction of the wind might make a difference of 20 per cent between two instruments placed 10 feet apart. With reference to the recording apparatus, he thought it a very great improvement upon the Beckley Anemograph. Mr. Munro, many years back, had proposed an arrangement similar in principle, but it had not been adopted. Without going into details he might say that the pen was always approaching its proper position; when at a good distance off it moved towards it quickly, but the nearer it got the more slowly it moved. Sir G. G. Stokes had compared the arrangement in a letter to him to a sluggish thermometer, which would give a true mean value, but would always be behind the real value. Whether the lag was much or little depended upon the rate at which the clock turned the wheels, and certainly if an instrument were too sensitive, the result was a large blot upon the paper, instead of a trace, for every gale or strong wind. Mr. Whipple had stated that the cups turned with a lighter breeze than the Richard, and this would account for the decrease of the percentage as the velocity increased, for he had invariably found that the instrument which turned with the lightest wind recorded the highest velocity during light winds.

Mr. WHIPPLE, in reply, said that the purpose of his paper was to show how nearly the factor 2·4 for Robinson cups agreed with the indications of the Richard Anémo-Cinémographe. Another result of the paper was that it was now known how far the velocities recorded by French instruments could be compared with English values. The essential difficulty with velocity instruments was that the mechanism could never be arranged to take up wind movements instantaneously. MM. Richard were certainly right in assuming that a light aluminium fan is more sensitive than the Robinson cups, as it more closely follows varying wind movements.

PROCEEDINGS AT THE MEETINGS OF THE SOCIETY.

May 18th, 1892.

Ordinary Meeting.

C. Theodore Williams, M.A., M.D., President, in the Chair.

Benjamin Ellis Coates Chambers, Grayswood Hill, Haslemere;
Robert Law, F.C.S., Royal Mint, Melbourne;
William Allen Sturge, M.D., F.R.C.P., 29 Boulevard Dubouchage, Nice; and
Edmund Symes Thompson, M.D., F.R.C.P., 33 Cavendish Square, W.,
were balloted for and duly elected Fellows of the Society.

Antoine d'Abbadie, 120 Rue du Bac, Paris;
Dr. Wilhelm von Bezold, Königlisches Preussisches Meteorologisches Institut, Berlin;
Dr. Robert Billwiller, Schweizerische Meteorologische Central-Anstalt, Zürich;
Dr. Nils Ekholm, Meteorologiska Central-Anstalt, Stockholm; and
Prof. Pietro Tacchini, Ufficio Centrale Meteorologico e Geodinamico Italiano, Rome,
were balloted for and duly elected Honorary Members of the Society.

A letter was read from Mrs. Tripe acknowledging the vote of condolence passed at the last Meeting.

The President announced that the Council had that day, under By Law 5, appointed Mr. F. C. Bayard one of the Secretaries in place of the late Dr. Tripe, to hold office until the next General Meeting.

The following letter was read:—

"The London Stereoscopic and Photographic Co., Limited,
"106 and 108 Regent Street, W.

"Dear Sir,

"I am requested by my Directors to acquaint you that at a recent Board meeting they decided to place the dark rooms of the London Stereoscopic Company at the free disposal of those Members of your Society who practise photography (on due appointment being made) for the development of any negatives taken by them.

"Should you be of opinion that the Members would find it convenient to avail themselves of the accommodation proffered by my Directors I shall feel obliged by your causing an announcement to be placed upon the notice-board, or adopting such other means as you may deem proper for bringing the matter before them.

"I am further requested by my Directors to say that strict injunctions will be given to the Company's staff not to solicit orders from any member of your Society who may avail himself of this offer.

"Yours very obediently,
"Albert H. G. Burchatt,
"Manager."

"The Secretary,
"Royal Meteorological Society."

The following Papers were read :—

"RESULTS OF A COMPARISON OF THE RICHARD ANÉMO-CINÉMOGRAPHE WITH THE STANDARD BECKLEY ANEMOGRAPH AT THE KEW OBSERVATORY." By G. M. WHIPPLE, B.Sc., F.R.Met.Soc. (p. 257.)

"RAIN DROPS." By E. J. LOWE, F.R.S., F.R.Met.Soc. (p. 242.)

"LEVELS OF THE RIVER VAAL AT KIMBERLEY, SOUTH AFRICA, WITH REMARKS ON THE RAINFALL OF THE DRAINAGE AREA." By W. B. TRIPP, M.Inst.C.E., F.R.Met.Soc. (p. 245.)

JUNE 15th, 1892.

Ordinary Meeting.

C. THEODORE WILLIAMS, M.A., M.D., President, in the Chair.

THOMAS WILLIAM BACKHOUSE, F.R.A.S., West Hendon House, Sunderland;
Capt. HENRY MANLEY LAMBERT, Ewhurst Lodge, Anerley Park, Anerley, S.E., and
WILLIAM TOPLEY, F.R.S., F.G.S., Assoc.Inst. C.E., 28 Jermyn Street, W.,
were balloted for and duly elected Fellows of the Society.

The following Papers were read :—

"ENGLISH CLIMATOLOGY, 1881-1890." By F. C. BAYARD, LL.M., F.R.Met.Soc. (p. 218.)

"THE MEAN TEMPERATURE OF THE AIR ON EACH DAY OF THE YEAR AT THE ROYAL OBSERVATORY, GREENWICH, ON THE AVERAGE OF THE FIFTY YEARS 1841 TO 1890." By WILLIAM ELLIS, F.R.A.S. (p. 237.)

CORRESPONDENCE AND NOTES.

WHIRLWINDS IN THE SOUTH INDIAN OCEAN.

THE following is an extract from a letter from Captain S. P. Hearn, Ship *Genista*:—

At noon on May 26th, 1892, Lat. 42°0′ S., Long. 99°0′ E., wind fresh from North-west, weather very squally with rain, barometer steady at 29·82 ins., thermometer 49° since midnight, a very heavy black squall with rain began to rise in the west. Barometer suddenly fell 0·1 in. As the squall neared the ship it arched up in the centre, showing a very bright blue sky at the back of it, the ends of the squall on either side were quite black and thick with rain. On its nearer approach to the ship I saw two immense whirlwinds just a little on either side of the centre of the arch and coming direct for the ship, the sea under and near the whirls being carried around and up in great volumes. I thought at first they were two waterspouts forming, but I saw no descending column or clouds from above, as is seen when a waterspout is forming; when these whirls came to within 2 miles of the ship, the squall seemed to part in the centre of the arch, one half passing to the north-east, the other half to the south-east, one whirl following in rear of each part of the squall and not where the clouds were heaviest.

During the time of the separation of the arch we had the wind very unsteady from North-west to South-west. There was only a fresh breeze with thick rain in that part of the squall that neared the ship, yet the squall was travelling along at a great rate, the whirls keeping in the rear till out of sight. I shortened sail to topsails as soon as I saw the squall rising. After it passed the weather looked very fine, bright and clear, but the sky was a windy one, being a very bright blue. By 3 p.m. the wind shifted to West and barometer had fallen to 29·67 ins., thermometer 48°.

At 4 p.m. saw another whirl passing along to windward in the rear of a squall, the clouds above it being twined and twisted in every way.

During the whole night we had very heavy squalls, sometimes following one another very quickly, with little wind between. Direction West-south west. At daylight the weather was much finer. After that to Lat. 40°22′ S., Long. 125° E., I had very peculiar weather. Wind from North-west to South, and back again from a light breeze to a moderate gale. Barometer never rising higher than 29·90 ins., or falling below 29·66 ins.

Climate and Meteorology of Death Valley California.

Prof. Harrington, the Chief of the U.S. Weather Bureau, has recently published in a pamphlet some interesting "Notes on the Climate and Meteorology of Death Valley, California," from which the following extracts have been taken :—

The south-western corner of the arid region of the west is occupied by the Colorado and Mohave deserts, the latter the northern and more extensive of the two. The northern margin of the Mohave Desert reaches out into narrow valleys lying between bold ridges of mountains which run nearly north and south. These valleys are usually shallow, but a few are characterised by great depth. The most remarkable of these is Death Valley, in that its bottom is said to descend below sea-level, while it is about 200 miles from the coast, and between it and the latter intervene the lofty Sierra Nevada Mountains. This valley is said to owe its name to the melancholy fate of a party of immigrants, who, about 1850, perished from thirst within its limits. Death Valley proper lies between latitudes 35°40′ and 36°35′ N. and longitudes 116°15′ and 117°5′ W. from Greenwich. It is about 75 miles long, with an axis running nearly north-north-west and south-south-east.

The principal features of popular interest in Death Valley are its excessive heat and dryness. The temperature rises occasionally in the shade to 122° ; rarely falls at any time in the five hot months below 70° ; and averages 94°. It is not only hot in summer but consistently hot, and the heat is increased by occasional hot blasts from the desert to the south. The air is not stagnant but in unusually active motion. Gales of a few hours' duration are very common, and sometimes they produce sand whirls and sand storms. The heat and movement of the air together make this a very dry—an arid place—and this aridity in summer is almost as consistent as the heat. Rains may fall frequently in the mountains and occasionally in the valley ; clouds are by no means lacking, and water can probably always be found at the depth of a few feet in the soil, yet the heat and wind together keep the surface very dry and the relative humidity low. Animal and plant forms are comparatively few, and the former are usually nocturnal in their habits to avoid the heat.

Both heat and aridity are increased by the character of the valley. It is narrow and deep, apparently the bed of an old sea, enclosed by high and bare mountains. The white and shifting sands become much heated under the noon-day sun ; the rest of the surface is in part salt and alkali, in part pebbly wash from the mountains, in part a loose spongy earth, over which it is difficult to move. With the exception of a few springs, the water is bitter and unwholesome.

The effects of the extreme heat and aridity actually recorded, under conditions which afford full grounds for confidence, must be very serious, but tradition and common report add to these terrors others which are possible enough to deserve quotation. It is said that the thermometer in the shade has sometimes reached 130°, and once touched 137°. Men exposed in the sun's rays in summer are said to be not infrequently driven insane, and the story is told of one man driving in on a load of borax who died suddenly with the water canteen in his hand. Meat slaughtered at night and cooked is spoiled the next morning ; cut thin and dipped in brine it cures in the sun in an hour. A writing desk curled, split, and fell to pieces. Tables warp into curious shapes ; chairs fall apart ; water barrels, incautiously left empty, soon lose their hoops. But the most terrifying aspect of nature in the valley is reported in the cloud bursts—a striking and not infrequent phenomenon over the dry South-west, for which the conditions here are especially favourable. They are small and concentrated storms of the utmost fury, which gather suddenly about the mountains in the hottest weather. An ominous cloud forms with great speed, grows black and full of lightning, sags down to the mountains and releases a flood of water. The tales of the height of the resulting wave of water which comes down the cañon are so marvellous that they border on the mythical and need not be quoted.

The meteorological features of interest lie for the most part in those modifications of diurnal changes which are due to topography. The range of temperature is unusually great ; the hourly progress of the winds show curious changes in speed, in direction, and in temperature. The diurnal change in the barometer is the most characteristic of the form found in continental valleys. It is of the purest single maximum type and has the largest amplitude known. With these features go those sharp thunderstorms limited to certain hours of the day, and daily gales and hot blasts.

It is also noteworthy that the absolute humidity here is fairly constant, and is that belonging to that part of the world. The air in the valley is part of the general aerial ocean, and this shows no sharp contrasts in its moisture contents, except where wind prevails across a mountain ridge. Here the prevailing winds are up and down the valley, and its relative aridity is due to its higher temperature.

A few words may be given to the winter climate, concerning which there are no recorded observations. The physical conditions of the valley, however, supported by the statements of those who have prospected there in the winter, and of those who have resided there in connection with borax works, enables us to reach a fair idea of this season. For five years, beginning in 1883, about 40 men were employed there. The season began with September and ended in June. By them the climate was considered healthy. Ducks and other migrating birds, jack rabbits and cotton-tails were reported as abundant, and the neighbouring Piutes extended their migrations into the valley. Snowfalls occurred on the mountains sometimes to the depth of several feet. Ice forms in, and extreme cold has been reported from, the neighbouring but higher valleys. In fact the relatively clear sky and bare soil make this region a favourable spot for the fall of winter temperatures. At Yuma the lowest temperature often reaches 27°, and once descended to 22°·5.

In short, following the year through, and accepting the guidance of the observations, of the physical conditions, and of the reports of those who have lived there, it is safe to conclude that the winter must be cool and salubrious, with an inch or two of rain. The early spring and late autumn must be of moderate temperature, with clear, delightful air and little rain ; the autumn very dry ; the summer, with May and September, as we know, hot and arid. While the diurnal changes are great, the annual must be very much greater. The winter mean temperature may be between 35° and 40°, and that of the year 58° or 60°.

Nest of a Mason Bee in a Rain Gauge.

I found inside the funnel of a copper rain gauge at the Botanic Gardens in Dublin a lump of clay attached to the side of the gauge. I thought it had been put there by some one ; but on putting my knife to it to scrape it out, I found it harder than hard mortar. I then attacked the bottom, which I found much softer, and to my surprise, dug out some six yellow maggots, very nearly ready to emerge, and of the shape of wasps, or more like drone bees, *i.e.* they were much broader than wasps, but of the same length as large wasps. What were they? I think I have heard of some species of wasps that make clay nests. There were certainly not more than six in the lump of mud, which was about three inches round and half-an-inch in thickness.—Robert H. Scott, Meteorological Office, Victoria Street, S.W., *September 19th*, 1892.

The editor of the Entomological Society's Journal, from which this is extracted, says that the insect was probably a species of *osmia*.

RECENT PUBLICATIONS.

American Meteorological Journal. A monthly review of Meteorology. Vol. IX. Nos. 3-5. July-September, 1892. 8vo.

The principal articles are:—On the appearance and progressive motion of cyclones in the Indian region: by W. L. Dallas (14 pp.). The author is of opinion that cyclones are a production of the upper atmosphere; that they are eddies formed in the current of westerly translation; that they are borne along in this current until they reach its edge, and that they are then thrown out, and in the northern hemisphere are carried first to West-north-west, then to North-west, then to North, and finally to North-east and East, in the massive upper current which flows from the torrid, towards the temperate, zones.—A memoir of the late S. A. Hill: by Miss M. T. Hill (9 pp. and portrait). Mr. Hill, who died on Sept. 23rd, 1890, was professor of physical science at the Muir Central College, Allahabad; and was also meteorological reporter to the Government of the North-west provinces and Oudh.—The Eye of the Storm: by S. M. Ballou (6 pp.).—Recent efforts towards the improvement of Daily Weather Forecasts: by H. H. Clayton (6 pp. and plate).—The sea-breeze at Cohassat, Mass.: by W. C. Appleton (4 pp.).—Temperature Sequences: by Prof. H. A. Hazen (3 pp.).—Synoptical sketch of the progress of Meteorology in the United States: by Lieut. W. A. Glassford (14 pp.).—Note on Winter Thunderstorms: by Prof. W. M. Davis (6 pp.).—Objections to Faye's theory of Cyclones: by W. C. Moore (17 pp.).—Artificial Rain: by E. Powers (6 pp.).—Changes of plane of the Mississippi River: by Prof. T. Russell (5 pp.).—Thunderstorms in New England during the year 1887: by R. de C Ward (4 pp.). The number of days in each month on which thunderstorms were reported were

Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
1	1	0	5	6	18	29	20	6	4	1	1

the total during the year being 92. The hours of maximum frequency were 3.30 to 5.30 p.m. The average rate of movement from all the storms during the year was between 30 and 35 miles an hour. The highest velocity noted was 50 miles, and the lowest 15 miles.—Weather forecasting at the Signal Office, June 30th, 1891: by Prof. H. A. Hazen (6 pp.).—The effect of Topography on Thunderstorms: by R. S. Tarr (3 pp.). The author believes that topography has a decided effect on the path of thunderstorms when they are beginning.

Annuaire de la Société Météorologique de France. 40e Année. 1892. Janvier-Avril. Large 8vo.

The principal Papers are:-Sur la définition de quelques nouveaux termes employés dans les études de météorologie dynamique: par L. Teisserenc de Bort (5 pp.).—Resumés des observations centralisées par le Service hydrométrique du bassin de la Seine pendant l'année 1890: par M. Babinet (40 pp.).—Différences de temperature entre stations voisines: par E. Renou (2 pp.).—Sur la hauteur des nuages: par M. Tardy (3 pp.).—Note sur la tempête du 11 Novembre 1891: par G. Guilbert (3 pp.).

British Rainfall, 1891. On the Distribution of Rain over the British Isles during the year 1891, as observed at nearly 3,000 stations in Great Britain and Ireland, with articles on various branches of Rainfall work. Compiled by G. J. Symons, F.R.S., and H. S. Wallis. 8vo. 1892. 272 pp. and 5 plates.

In addition to the tables giving the rainfall at the individual stations, &c., this contains the following articles:—(1) Recent Annual Rainfall compared with that of the previous 165 consecutive years.—(2) On the exceptional

February of 1891.—(3) On the evaporation from a water surface at Camden Square, London. The rainfall for 1891 was as follows :—

England and Wales	37·36 ins.
Scotland	48·59 ins.
Ireland	39·35 ins.

This shows that, on the whole, the total for the year was not remarkable, the excess averaging less than 10°/₀.

Compte Rendu du V Congrès International des Sciences Geographiques. 8vo.

Contains:—On meteorological observations in tropical countries: by H. F. Blanford (8 pp.). This gives the outcome of the author's long experience in India, and it might be well worth while to have it reprinted, so as to be able to hand a copy to would-be observers going to the tropics. If this paper and Dr. Hann's remarks on the observations to be taken by travellers, contained in the Report of the International Meteorological Committee at Zürich, and which have already been reprinted by the Royal Geographical Society, were taken as instructions by such persons, we should have some prospect of obtaining valuable information from them.

Investigations of the New England Meteorological Society for the year 1890. Reprinted from the Annals of the Astronomical Observavatory of Harvard College. Edward C. Pickering, Director. Vol. XXXI. Part 1. 4to. 1892 (156 pp. and 5 plates).

In addition to the summary of the observations made at the stations of the New England Meteorological Society during 1890, this contains a series of 5 year tables of temperature and precipitation for New England, by J. Warren Smith. There are also three papers on the Tornado at Lawrence, Mass., on July 26th, 1890, viz. (1) The Features of Tornados and their distinction from other storms, by W. M. Davis; (2) The Lawrence Tornado, by H. H. Clayton; and (3) Evidences of Vorticular Motion in the Lawrence Tornado, by H. F. Mills.

Meteorologische Zeitschrift. Redigirt von Dr. J. Hann und Dr. J. Hellmann. April-August 1892. 4to.

The principal articles are:—Die Berechnung wahrer Tagesmittel der Temperatur aus Beobachtungen um $8a$, $2p$, $8p$: von Dr. J. Grossman (8 pp.). This is a discussion of the method given by Köppen and adopted by Prof. Mohn and others for calculating daily means from the observations at 8 a.m., 2 p.m., and 8 p.m. The formula is: $M = n - k\ (n - \text{minimum})\ n - \frac{1}{4}\ (8a + 2p + 8p)$ and k is a constant which depends to a certain extent on the latitude. The author points out that k depends *inter alia* upon the action of land and sea breezes, and that consequently it is not easy to determine it; and he shows by various examples that it is, on the whole, better to revert to the old method of calculation. —Regen und Ueberschwemmungen im September 1890 nördlich der Alpen: von Dr. F. Augustin (7 pp.). This is an account of the floods in the Danube caused by the very heavy rains in the early autumn of 1890. The falls in August were due to thunderstorms, but those in September were not accompanied by any electrical manifestations.—Die Gewitter und der Wettersturz von 25 zum 26 August 1890 in den Ostalpen: von K. Prohaska (13 pp.). This is a second paper on the thunderstorms of the early autumn of 1890. The author describes at length the worst of the thunderstorms of August 25th, which travelled from Sitta die Castello, near Florence, to Vienna in one afternoon, from 6 to 10 p.m. Such a velocity is almost unheard of; between 6¼ and 7¼ it advanced over 106 miles. It wrought an immensity of damage on its way.—Resultate des Regenmess-Versuchfeldes bei Berlin, 1885-1891: von Dr. G. Hellmann (8 pp.). This is an account of the rain gauge experiments carried on for the last seven years. The results are that the gauges within a quarter of a mile of each other agree well in spring and autumn, but not so in summer, owing to thunderstorms, and in winter, owing to snow. The chief disturbing agency is wind, and the author is disposed to approve of Wild's suggestion to surround the gauge—especially for snow—with a close paling. He thinks that he has proved that if a gauge is put on a roof, where it is quite protected from eddies and currents of air, it will give the correct amount.—Bemerkungen über die Beobachtung der Cirren und deren Veröffentlichung: von C. Kassner (4 pp.). The author has discussed the cirrus observations from certain German stations, and finds that owing to difference in the hours of observations, little can be got from them. He urges that the number of stations should be increased, and the hours of observation fixed, but he does not suggest how cirrus clouds are to render themselves visible at the fixed hours when the sky is overcast.—Ueber die Hauptresultate der Untersuchungen, von. Prof. Wolf in Zürich im Gebiete der Sonnenphysik: von. A. Wolfer (19 pp.). This is a reproduction of a paper by the author on the same subject in the *Bibliothèque universelle de Genève* for December 1891. Prof. Wolf has succeeded in discovering certain old records of sun spots, going back to the year 1626 (Scheiner), but the old data only refer to maxima and minima of spots. He makes out an annual record from 1749 to 1890, and in this series the period varies between 16·1 and 7·3 years, so that there is not much certainty as to the probable value of any individual year. Prof. Wolf, however, goes on by an elaborate system of calculations and smoothing, and appears at the end to have found out a sort of a law for the variations; but as he mentions a possible period of 170 years, the outcome of the investigation hardly comes within the limits of practical utility for the present generation.—Die Ursache atmosphärischer Strömungen: von Prof. M. Möller (6 pp.). This is a criticism of Werner von Siemens' Paper "On the Origin of Atmospheric Movements."—Zur Meteorologischen Photogrammetrie: von A. Sprung (10 pp.). The author gives a number of suggestions on the best mode of obtaining correct photographs of halos, parhelia, and of clouds in general.—Ueber die Häufigkeit, Bewegung und Tiefe der barometrischen Minima in Japan: von E. Knipping (7 pp.). This is a reproduction of the author's paper in the Report of the Central Observatory, Tokio.—Sechste allgemeine Versammlung der deutschen Meteorologischen Gesellschaft zu Braunschweig von 6 bis 9 Juni 1892 (13 pp.). The papers read at this annual meeting are reproduced in abstract. The most interesting were those on Atmospheric Electricity and its relation to the sun's rays: by MM. Elster and Geitel. The result is that as the sun's rays discharge the electricity from terrestrial objects, it appears that the difference between the results yielded by different observatories may be related to their different exposures to sunshine. The whole paper deserves careful study by those interested in the subject.

MINUTES OF PROCEEDINGS OF THE INSTITUTION OF CIVIL ENGINEERS. Vol. CIX. Session 1891-92. Part 3. 8vo.

Contains: "On the Mean or Average Annual Rainfall, and the fluctuations to which it is subject:" by A. R. Binnie (48 pp.). After having reviewed the subject of rainfall both from the point of view of the determination of its mean amount at any one station, as well as from that of the fluctuations to which it is liable, the author remarks: "As to the mean or average depth of rain which falls at any station, it may be confidently asserted that the amount in no way depends on mere geographical position as defined by a statement of the latitude and longitude of the station, for great variations exist within very narrow limits. For instance, in England the mean fall varies from about 20 inches in the Eastern Counties up to more than 160 inches in the Lake District; in France from about 19 inches at Marseilles to 43 inches at Lampy-Neuf; in Italy from 28 inches at Palermo to 62 inches at Udine; in India, at Bombay at the sea level, it is about 73 inches, at Mahableshwar in the Western Ghâts, at an elevation of 4,300 feet, it is 254 inches, and at Poonah, less than 70 miles distant, at an altitude of 1,800 feet, it is 19 inches. At Karachi in Sind it is about 7 inches, and on the Khasia Hills, near Calcutta, it amounts to about 450 inches.

"Thus all over the world, both in the tropics and in more temperate climates, the mean amount of rainfall differs often very largely at stations comparatively speaking only a few miles apart; and this difference cannot be ascribed to a high or a low mean temperature, to distance north or south of the equator, to a generally humid climate, such as that of England, or to one in which the year is divided into well marked wet and dry seasons, where all the rain falls in three out of the twelve months. This variation is to be attributed to the position of the station with regard to the prevailing rain bearing winds, as well as to the proximity of ranges of hills or mountains which act as condensers in lowering the temperature until the point of supersaturation is reached.

"The fluctuations of rainfall, with the exception of that of the single wettest year in any record, have been shown to be of nearly equal proportionate amount on both sides of the mean, and do not appear to indicate a few wet years balancing a larger number of dry ones, or the reverse. If any such tendency is shown by this inquiry, it cannot amount to more than 2 or 3 per cent. of the mean amount, which, when the probable error is taken into account, may almost be neglected. Thus in all climates and countries, irrespective of the amount of the mean rainfall, especially if it exceeds 20 inches, the general fluctuations are about equal in amount on both sides of the mean.

"Looking at the results of examination of the fluctuations of rainfall during short periods, there is a great regularity in the quantities when the extreme fluctuations dealt with are considered, especially when falls under 20 inches are excluded; for, irrespective of geographical position and the amount of the mean fall, the average results are almost the same, there being but a slight tendency in the direction of a smaller fluctuation, not so much at stations with a large rainfall, as in countries such as England, which enjoy a humid climate.

"Seeing then that the amount of the mean fall is a purely local circumstance, but that the fluctuations to which it is subject are, within the limits above stated, the same both in their nature and proportionate amount for all places, the amount must evidently be due to locality in each case, while the laws which govern the fluctuations, being apparently of general application, must be sought for in some yet unknown cause common to the whole world.

"The subject is difficult and obscure; its elucidation will need many years of study and research, and will doubtless involve the collection and analysis of a much larger number of records from even a wider area than those under consideration, before a satisfactory result can be arrived at."

Report of the Medical Department of the State of Sungei Ujong for the year 1891. By L. Leonard Braddon, M.R.C.S. Residency Surgeon. Foolscap Folio.

The author has made a collation of the various monthly meteorological returns for the last three years, and has produced charts which show striking coincidences between the fluctuation of the rainfall, and the relative frequency of cases treated for both fever and diarrhœa. Every increase of rainfall above the usual average is followed by an increase in the number of cases of fever treated; but the increase in the latter becomes apparent only in the ensuing month. With less exactness but with as regular frequency, with each increase of rainfall there is a fairly coincident increase in the frequency of beri-beri and diarrhœa. The increase in diarrhœa seeming to precede, rather than follow, the increase of rainfall, or perhaps is coincident rather with diminished fall.

Results of Rain, River and Evaporation Observations made in New South Wales during 1890. H. C. Russell, B.A., C.M.G., F.R.S., Government Astronomer. 8vo. 1892, 174 pp. and 3 plates.

Mr. Russell reports a large increase in the number of rainfall observers, which has risen from 960 in 1889 to 1,088 in 1890. The rainfall for the year 1890 stands as the wettest year upon record so far as the whole Colony is concerned, the average being 35·73 ins. In the autumn the rain was excessive in the northern parts of the Colony, and occasioned heavy floods in the Darling and its tributaries; at Bourke on April 23rd the maximum height of the flood was 42 ft. 7¾ ins.

Scottish Geographical Magazine. Vol. VIII. No. 7. July 1892. 8vo.

Mr. J. P. Thompson in a paper "A Survey of Exploration in British New Guinea," (9 pp.) gives the following account of the climate: "Generally speaking, it may be said that the Possession is healthy, no dangerous epidemics being known, and that Europeans suffer no greater inconveniences than residents of other tropical climes. In the alpine zone of the Owen Stanley Range the climate is apparently dry and bracing, and in the basin of the Upper Fly River the temperature during the night time is invigorating and refreshing, mosquitoes and sand-flies being less troublesome than in the coastal districts. In the neighbourhood of the east end of the territory several of the numerous islands enjoy salubrity of climate and freedom from the drawbacks so frequently experienced in low swampy localities. Essentially a tropical country, British New Guinea possesses a wet and a dry season, the former extending from November to the end of March, during which time heavy thunderstorms, accompanied by drenching rain, prevail. While the dry season lasts, the South-east Trade winds contribute greatly to comfort and to the salubrity of the climate.

Symons's Monthly Meteorological Magazine. July-September 1892. Vol. XXVII. Nos. 318-320. 8vo.

The principal articles are:—Great Rains on June 28th (1 p.).—Thunderstorm and Cloud Burst near Driffield, July 3rd (3 pp.).—The Dry Spring: by B. C. Wainwright, M. L. Evans and R. Littleboy (2 pp.).—Spring Frosts in 1892: by J. Gulson, R. Tyrer, J. Matheson, Rev. H. A. Boys and F. Coventry (5 pp.).—The British Association at Edinburgh (10 pp.).—The Climate of the British Empire during 1891 (3 pp.).—The Welsh Earthquake of August 18th (3 pp.).—Report on the Great Rainfall in East Clare on 2nd July, 1892: by Capt. H. A. Bentley (2 pp.).

INDEX.

THE END.

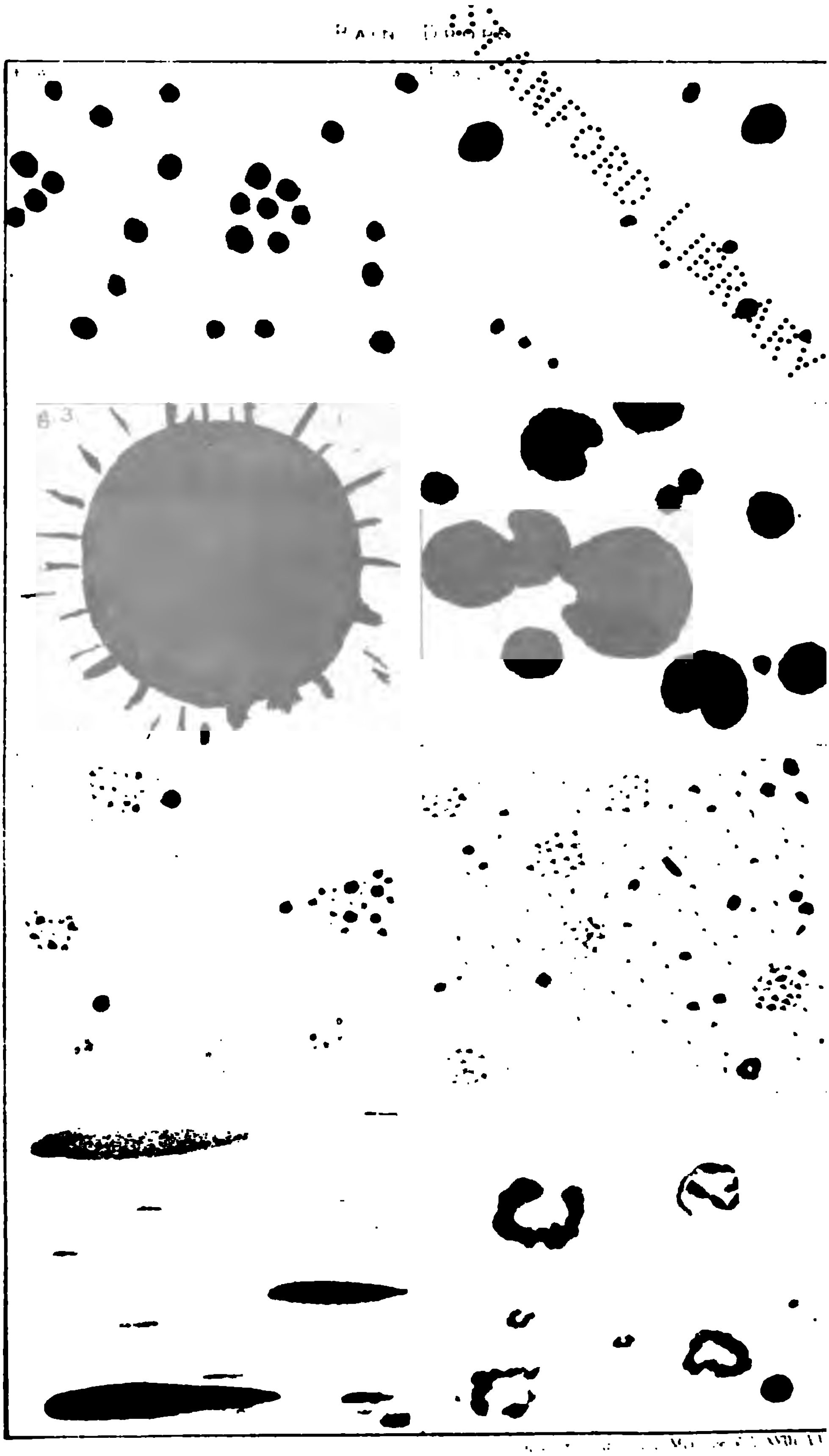
ENGLISH CLIMATOLOGY, 1881-1890.

MAP SHEWING THE

STATIONS OF THE ROYAL METEOROLOGICAL SOCIETY.

George Philip & Son London & Liverpool.

Quart. Journ. Roy. Met. Soc. Vol. XVIII. Pl. 9.




MEZZANINE