SYMONS'S
MONTHLY
METEOROLOGICAL MAGAZINE.

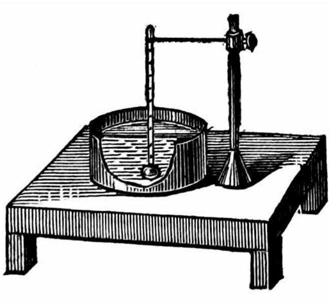
LXX.] NOVEMBER, 1871. [PRICE FOURPENCE, or 5s. per ann. post free

DEW POINT AND OTHER HYGROMETERS.

On further consideration of this subject, and bearing in mind the absence of any comprehensive treatise on meteorology, and of any sequel to Saussure's excellent "Essais sur l'hygrométrie,"* we intend to enlarge the scope of this article, and to give brief descriptions of all the hygrometers which are known to us. Referring our readers to our abstract of Saussure's work for some of the earliest forms of cold water dew point instrument, we add this month two others of the same class. The description and engravings of LeRoy's (A.D. 1752) are copied from Prof. Everett's capital translation of Deschamel's "Natural Philosophy," and of Bache's from Loomis's "Treatise on Meteorology." Next month we hope to describe those in which ether is employed, viz., Connell's, Daniell's, Pouillet's, and Regnault's.

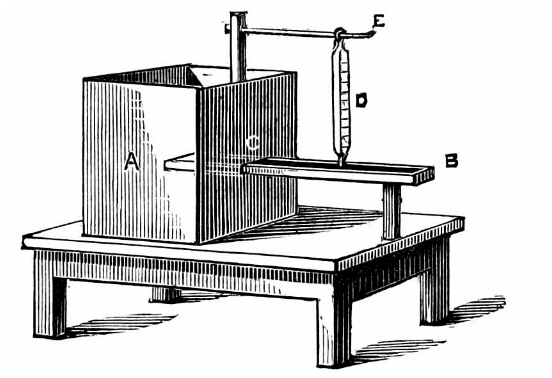
"LE ROY'S HYGROMETER.—The instrument consists of a tin vessel containing water, in which a thermometer is immersed. The temperature of the water and containing vessel is gradually lowered by the introduction of ice, and when it has fallen below the dew-point of the adjacent air, a portion of the vapour will be condensed as dew upon the exterior of the vessel. This is at once recognized by the metallic surface losing its brilliancy.

"We may observe that the deposition of dew does not begin till the point of saturation has been passed, and that the indication of the thermometer is consequently somewhat too low. Le Roy proposed an empirical correction of half a degree. There are, however, other defects in the instrument; the use of ice does not afford a speedy and regular diminution of temperature, and it is especially objectionable to place an open vessel containing water in the very place where the humidity of the air is to be determined."



* *Met. Mag.*, Vol. II., pp. 66-68, 88-90.

"BACHE'S HYGROMETER.—When it is required to determine the dew-point frequently at short intervals, the following apparatus, invented by Professor Bache, is very convenient. A small metallic box, A, is filled with a mixture of salt and snow, by which means its temperature is reduced to about zero. From the side of the box projects a polished metallic bar, B, having on its upper side a groove, C, containing mercury, in which is immersed the bulb of a thermometer, D, which is suspended from a support, E, so that the thermometer is movable along the groove. One end of the bar, B, has a very low temperature, while the other is but little below that of the surrounding air. That portion of the bar whose temperature is below the dew-point will be covered with moisture, while the other part will be dry, and the two portions will be separated by a well-defined bounding line. By placing the bulb of the thermometer, D, opposite to this line, we may immediately determine the temperature of the dew point. When only an occasional observation of the dew-point is desired, this instrument is inconvenient, because it requires considerable time to prepare it for experiment.



ON EVAPORATION OF WATER.

To the Editor of the Meteorological Magazine.

SIR,—The following propositions appear to me to embrace and explain the phenomena of evaporation observed by Mr. Dines :—

1. When air is saturated with moisture at temperature of atmosphere neither evaporation nor condensation can take place.

2. When air is saturated, but the water of a *higher* temperature, evaporation must take place (for the air, which is warmed by contact with the water), being no longer *saturated* is capable of receiving and carrying away additional moisture ; hence the water must lose weight and also be cooled by the abstraction of the latent heat of the vapour thus eliminated.

3. When air is saturated, but the water of a *lower* temperature, condensation of vapour must take place on the surface of the water, for the air (chilled by its contact) can no longer retain the same amount of moisture, consequently the weight of the water will be increased, and its temperature also must rise from the influence of the warmer air.

The above three propositions may be verified, experimentally, whenever the wet and dry bulb thermometers are precisely at the same temperature.

4. Let us suppose both the air and the water to be several degrees *above* the temperature of the wet bulb; the air in contact with the water will obviously carry off vapour from it. Hence the weight of the water will diminish and its temperature must fall (as in the case of the wet bulb) until the latent heat of the vapour so abstracted is exactly compensated for by the heat (from all sources) which the water-vessel receives; after this occurs, evaporation will still go on, and consequently the water will lose weight although the temperature of the water may remain stationary.

5. Let us suppose the water to be several degrees *below* the dew-point temperature, while the air is several degrees above it; the air now in contact with the water is *capable of abstracting* vapour until it reaches its "temperature of saturation." But, being chilled further by the contact with the water, it is compelled, as I may say, to surrender its previous spoils again, so that when the water is a certain number of degrees *below the dew-point,* the weight of moisture which the air could vaporize (in falling to the temperature of the wet bulb) will be exactly balanced by the quantity of vapour which the colder water could abstract from the air, after it had attained the condition of saturation; so soon, however, as the temperature of the water rises above this point (although still perhaps *some degrees* below the dew-point) the evaporative influence will prevail, contrary to the first proposition laid down by Mr. Dines, in his paper (Nov. 1870), viz., "That no evaporation takes place from water unless the temperature of the water is greater than that of the dew-point."

At the close of his 2nd Table (p. 201), he gives an experiment totally opposed to such a conclusion. In the last line of this Table, his dry bulb is at 59° and the wet bulb at 53°·8, his calculated dew-point being 49°·2 and temperature of water 38°·6. After about a quarter of an hour "condensation ceased," temperature of water being 44°, and two minutes afterwards "evaporation commenced" with water at 45°.

He has not stated the temperatures of the wet and dry thermometers at these precise points, but I cannot believe that the *dew-point* had fallen (in the time specified) below 45°. In fact, in the previous quarter of an hour, the temperature of the dry bulb had *risen* from 58°·1 to 59°, and of the wet bulb from 53°·1 to 53°·8, (his calculated *dew-point* having also risen). Now, assuming the temperatures of dry and wet bulbs to remain at 59° and 53°·8, respectively, my views lead to the following results:—

I find the weight of water which (1000 cubic inches of) dry air could vaporize in falling from 59° to 53°·8, to be 0·35836 grain, and the maximum weight of 1000 cubic inches of vapour at 53°·8, is 2·70631 grains. Hence (deducting the former from the latter) we have 2·34795 grains, which is the maximum weight of 1000 cubic inches of vapour at 49°·69, (and this, by my calculation, is the dew-point, instead of 49°·2).

Now, if we *again deduct* 0·35836 from 2·34795 grains, (in order to find out at what temperature, below the dew-point, the *condensation* of vapour is equal to the previous evaporation during the fall from 59° to 53°·8), we get 1·98959 grains, which is the maximum weight of vapour in 1000 cubic inches at temp. 45°. Hence, according to my views, this is the temperature at which evaporation ought to begin to preponderate over the tendency to condensation, and it is evident that this agrees perfectly with what Mr. Dines has recorded as the result of his experiment.

After this (in about eleven minutes), he states, the temperature of the water to have risen to 49°·8, and that 0·4 grain of water had been vaporized in that interval, so that *after* this amount of evaporation the water was probably very little (if at all) above the dew-point temperature. HENRY HUDSON, M.D., M.R.I.A.

Glenville.

EUROPEAN RAINFALL IN SEPTEMBER, 1871.

(*From the "Zeitschrift der Österreichischen Gesallschaft für Meteorologie," November 1st*, 1871.

"The month of September began with very fine summer weather and great drought, which lasted until the last week of the month, wherein a general deterioration of the weather took place. The rainfall of this month is specially remarkable.

"In Vienna, from August 26th to September 26th, not one millimetre of rain, but from noon on September 26th to the next morning, 51·2 mm. (2·02 in.) fell in the Botanic Gardens, (and 56·4 mm. (2·22 in.) in that of the Central Meteorological Office,) and the rainfall for the whole month amounted to 55·3 mm. (2·18 in.,) whereas the average is 41·7 mm. (1·64 in.) The rain of the 26th was general and evenly distributed throughout the country, and fell with a gentle north wind and a very low barometer, the minimum of the month. According to the tracings of the self-recording rain gauge, the duration of the heaviest fall was from 0.53 p.m. to 3.19 p.m., during which time 40·9 mm. (1·61 in.) fell; which gives for the hourly fall 16·8 mm. (0·66 in.), being one of the heaviest falls of which we have record in Vienna since the 10th June, 1853, when 7·9‴ (3·50 in.) fell in one hour during a thunderstorm.

"In England also similar characteristics prevailed during September, as we learn from *Symons's Monthly Meteorologieal Magazine* for October, that the rainfall was one of the largest on record for that month, and almost the whole fell in the last eight days of the month. At Cobham, for instance, where the record begins with 1825, the rainfall of September amounted to 120 mm. (4·72 in.,) although during 46 years, only the Septembers of 1826 and 1839 had heavier falls. At York 168 mm. (6·60 in.) fell, which was 2·8 times more than the mean,"

EXTRAORDINARY STILLNESS OF THE ATMOSPHERE.

To the Editor of the Meteorological Magazine.

SIR,—It may be note-worthy to put on record a remarkable evidence of stillness of the air. On the 15th instant I sent up two ordinary fire balloons, 10 ft. in circumference, at this place, which is, by Ordnance survey, 1200 ft. above the sea, open moor-land at the head of Wharfedale. The night of the 15th was quiet, slight haze, stars visible. The balloons were observed to veer slightly eastward at first, then very slowly to the N.W., but ascending *almost* perpendicularly till out of sight, or the spirit was burned out. The following morning, about 9.45, some workmen observed a balloon, as they thought just sent up, but as they watched it they saw it slowly descend upon the moor; they went up to it, and found it just alighted uninjured, and certainly not half a mile from the spot whence it first ascended, having been suspended in the still air nearly 13 hours! by what power I know not. It was not a gas balloon. Strange to say, the other balloon was found not 50 yards from the same spot, having pursued almost a similar course; this was not seen to descend.—Yours truly,

CHARLES H. L. WOODD.

Outershaw Hall, Langstrothdale Chase,
Skipton-in-Craven, Aug. 31, 1871.

RAINFALL RULES.

To the Editor of the Meteorological Magazine.

SIR,— I would suggest that those observers who prefer to use a third decimal in their rainfall registers should nevertheless send in their returns only to the nearest hundredth. The use of the third figure does not always imply that the level of the water can be read off to 1-1000th of an inch, but that it can be read to less than 1-100th, which is generally the case.

The existence of sources of error, which exceed a proposed unit of measurement, is not held as yet to be an objection to reading thermometers to a tenth of a degree, although the nature and position of the stand or screen used affects the reading to an extent 20, 30, or even 50 times as great.

I expected that the strong language I used about Section 3 of Rule XII. would be challenged. The instance I referred to was that of Dec. 1st, 1869, when the depth of snow was 3½ inches, and equivalent in water ·29. But the quantity caught in a common tin 5-inch gauge was ·85; a 12-inch at 5 ft. in my garden caught ·95, and a 5-inch cylinder on ground 1·00. On the 27th October, 1869, these gauges caught ·62, ·80, ·85 respectively; the snow was 5 inches deep, and the equivalent therefore ·41. In both cases the ground was frozen before the fall commenced. I could give other instances if necessary.

In these cases an ordinary gauge is much more accurate, and one with a high rim, which can very easily be added to any gauge, would be the best means I know of measuring the depth. For snow, I would place such a gauge in a moderately sheltered position, 3 feet above the ground, to prevent any from drifting in.

I do not speak without some experience of snow. It snowed on 47 days last winter, and on 55 the previous winter.

I am, Sir, your obedient servant,
FENWICK W. STOW.

P.S. If Sec. 3 is to stand, would not a caution that it is applicable only when the temperature is below 32° be desirable?

REVIEWS.

Contributions to our Knowledge of the Meteorology of Cape Horn and the West Coast of South America. Published by the authority of the Meteorological Committee. 4to., 36 pages, 12 plates. Stanford.

A VERY useful monograph which we would notice fully were not its price such as to place it within the reach of all, and were not our own space considerably less than our requirements. It is mainly compiled from Ships Logs, but in an Appendix are given abstracts of observations at Punta Arenas, Puerto Montt, Valdivia, Santiago, Copiapo, and Coquimbo, whence we have compiled the following Table :—

STATION	Punta Arenas.	Puerto Montt.	Valdivia.	Santiago.	Copiapo.	Coquimbo
Latitude	53°12'S.	41°30'S.	39°49'S.	33°26'S.	27°22'S.	29°55'S.
Longitude	70°56'W.	72°52'W.	73°13'W.	70°37'W.	70°23'W.	71°17'W.
Altitude	...	33 ft.	...	1782 ft.	1296 ft.	59 ft.
Mean annual pressure..	...	29·99 in.	...	28·23 in.	28·68 in.	29·93 in.
,, ,, temp......	43°·0	51°·8	53°·6	55°·6	61°·8	59°·7
,, max. ,, ...	57°·2	66°·7	71°·2	74°·7	75°·3	68°·7
,, min. ,, ...	34°·1	41°·1	37°·0	42°·6	52°·9	52°·3
Absolute max. ,, ...	74°·3	...	...	87°·8	86°·0	...
,, min. ,, ...	17°·6	...	...	31°·6	38°·3	...
Mean annual rainfall...	21·70 in.	102·06in.	108·98in.	16·79 in.	...	...

Quarterly Weather Report of the Meteorological Office. Vol. 2, Part II., April—June, 1870. London, Stanford.

Being in all respects similar to previous numbers, requires simply notice for increasing promptitude of publication.

Results of Meteorological Observations made at the Radcliffe Observatory, Oxford, in the year 1868, under the superintendence of the Rev. R. MAIN, M.A., Radcliffe Observer. 8vo., 71 pages. Parker.

THE tower of the Radcliffe Observatory is upwards of 100 ft. high, and on the summit Mr. Main has placed a max., a min., a dry and a wet bulb thermometer, all of which were read daily throughout the year 1868. The result is to show a higher temperature on the top during the summer and nearly identical ones during the rest of the year. Nothing definite is stated as to the mounting of the upper thermometers, and no engraving represents their position, but both are desirable to show whether or not it is probable that this summer excess arises from heat reflected from the leads of the roof, or other proximate substances.

The entry for September 5th, 1868, at 10 a.m., is very remarkable; it is as follows :—

At 105 ft.		At 5 ft.	
DRY.	WET.	DRY.	WET.
80·5	70·2	70·5	65·8

From other parts of the volume, we learn that the minimum temperature of the 5th had been 49°·1 on the tower, and 51°·8 at 5 ft. above ground, and that fog was prevalent. The fact which strikes us as remarkable is *not* that the upper thermometer was above the fog, and therefore 10° higher than the lower one, but that the upper one should have risen more than 30° above its own minimum by 10 o'clock on a foggy morning in September.

Report of the Sanitary Committee of the Borough of Nottingham, for the year 1870. Nottingham: Shepherd Brothers, 8vo., 19 pages.

SIMILAR in most respects to those for previous years, the time has now come to point out that it would add to the value of the excellent Meteorological Table, if the yearly averages were taken of all the elements, and if the corresponding values for previous years were also appended. We also think it a mistake to give the "rainfall gauged at three stations within the Borough," the fall at each should be given separately, and then the average taken, if desired—but mean results of that class are not very serviceable.

The Committee close their report with the following words, which we commend to the attention of other corporations, who would consult their own interest in following the good example which Nottingham sets before them :—

"The importance of local observations is now becoming much appreciated throughout the country, and as the science of meteorology is so directly connected with the great question of water supply and sewerage as well as those affecting public health, it is desirable that careful and continued registrations should be made and preserved in this as in other populous places."

Fifth Annual Report on the Sanitary Condition of Merthyr Tydfil, being for the year 1869. By T. J. DYKE, F.R.C.S., &c. Merthyr: M. W. White and Sons. 8vo, 28 pages.

WE have in previous years indicated the general features of this report; on the present occasion, therefore, we confine ourselves to noting its efficient continuance, and to quoting the following practical remarks :—

"The influence of atmospheric changes upon the health of the inhabitants of a district may be easily traced in such a parish as Merthyr Tydfil; situated in an upland valley formed by a mountain river—the Taff, which springs from the most elevated spot in South Wales, the Brecon Beacon, the deep and narrow gorge, through which it runs rapidly to the sea, is bounded by precipitous sides rising to ridges, ranging from twelve to sixteen hendred feet in height above the sea level; a place so situated is peculiarly liable to those vicissitudes of cold and wet by which the human frame is detrimentally affected. West winds bring with them clouds whose moisture is quickly condensed by the high points of the hills which encompass the valley, north and east winds blow cold over elevated bog lands saturated with moisture. These influences, acting upon a population whose industry was ill rewarded owing to the depression in the Iron Trade, were in 1869 very painfully manifested.

"1st Quarter: In January rain fell on sixteen out of thirty-one days to a depth of 10·8 inches, the mean night temperature was but 35°, while in the day it averaged 45°. The fall of the barometer to 29·15 on the 3rd was indicative of the thunderstorms which came on in the evening of that day, and again in the evening of the 5th. During the three last days in January, the rainfall amounted to five inches; of which 2½ inches fell on the 31st. Wet weather continued throughout February, the amount of rain collected—8·95 inches, fell on nineteen out of twenty-eight days, a great storm of wind from the west, and of rain, prevailed from the 7th to the 9th,—the water collected measured 3¼ inches. The night temperature was 35°, in the day it averaged 46°. The month of March was fine and cold, it rained on eight days to a depth of 2·89 inches; the night temperature averaged 30°, that in the day 42°.

"During the Quarter it rained on forty-three days out of ninety. The measured fall of rain amounted to 22·64 inches. In the last quarter of 1868, rain fell on fifty-three days to a depth of 22·94 inches. Thus during the six months of winter, it rained on ninety-six out of one hundred and eighty-two days, the total rainfall amounting to 45½ inches.

"This long continuance of wet weather acted most perniciously; for remembering that the houses in the parish are mostly built of a porous sandstone, on foundations of unmortared stone, with floors of paving-stone laid on the soil after the removal only of the sod the result was to saturate the foundations of the abodes of our poorer brethren with water—that water moreover charged with the excrementitious deposits freely scattered in backyards and gardens; the cold winds required that the doors and windows should be kept closed, and thus that thorough ventilation which houses so damp imperatively needed was prevented; lastly food was dear, and labour ill remunerated; these various causes combined to raise the average rate of mortality to twenty-eight in the thousand."

Annual Report of the Devonshire Hospital and Buxton Bath Charity for 1870. 8vo, 48 pages. Published at the Hospital.

WE are afraid that the directors of this charity attach more importance to the Buxton waters than to its splendid air, or they would surely take care that, in addition to the useful page or two of letter-press, their observer provided also a tabular abstract of the observations during the year. We do not know any health resort which has probably more to gain from fully publishing the details of its climate, and with so good an observer as Mr. Sykes, a good position for observations, and very fair (though we believe improveable) instruments, they might benefit the charity, the town, the medical profession (and through them their patients), and though last not least, might advance the great work of medico-climatology by developing that which they have ready to their hands.

Twenty-Sixth Annual Report of the Barnstaple Literary and Scientific Institution for 1870. 8vo, 14pp., Barnstaple: Hearson.

THIS little Report contains a tabular Meteorological summary which may serve as a pattern for the Buxton authorities, while, on the other hand, Barnstaple may with advantage copy the Buxton remarks. In the following paragraph we heartily concur, and we think that it would form a fitting subject for prosecution at the hands of the Devonshire Association for the Promotion of Science:—

"It is perhaps desirable that a more extended knowledge than we possess of the climatology of our fair county should be obtained; but neither Exeter nor Plymouth—nor, with one or two exceptions, do any of our inland or coast towns—furnish any contributions to this interesting department of physical science."

Stonyhurst College Observatory. Results of Meteorological and Magnetical Observations, 1870. By Rev. S. J. PERRY. Crown 8vo, 39 pages. Preston: J. Robinson.

THESE excellent tables are as complete as any of their precursors, and the remarks more copious. The promptitude with which the observatory work is attended to is fully indicated by the following remarks upon the Aurora of October 25th, 1870:—

"At 5.50 p.m., on the 25th, a band of red light, forming a perfect arch, was seen, the top slightly N. of the zenith, and resting E. and W. on the horizon. In a few minutes the top of the arch was S. of the zenith, the western extremity fading and the eastern becoming brighter. At 5.55 streamers appeared to radiate from a point near β Cygni to 10° S. of the zenith. In the E. a large patch remained intensely red, the rest faded gradually. At 6.25 it again burst forth with increased splendour, covering almost the whole sky. The colour was red, with the exception of a bright white streamer, which stretched from the radiating point near Cygnus to within 20° of the N.N.W. horizon, where it was obscured by a bank of cloud. At 6.35 p.m., the sky became overcast, heavy rain fell at intervals, and occasional views of the red Auroral light were obtained. At 7.20 p.m., when the sky became clear, the only trace of the Aurora was a greenish light in the N. At 8.1 p.m., there was thunder and lightning. At 8.40 a few white streamers were seen, and the edges of clouds in N.N.E. were tinged with red. At 9.10 p.m., white streamers appeared in all parts of the heavens, having a wavy motion towards α Andromedæ. The bright greenish spectrum line, was very distinct in the white streamers, but could not be detected in the red. At 9.40 the streamers were abruptly terminated by an arch extending E. and W., and passing nearly through α Andromedæ. The wave like motion of the streamers was instantly stopped on reaching this arch, and for a considerable time the rolling streams of light so suddenly checked, presented the appearance of a sea breaking on a level sandy shore.

"The great magnetic storm on the 25th, was first noticed at 3.30 p.m., by the assistant, who found that the point of light from the Horizontal Force Mirror had left the recording cylinder. He then observed both the Vertical Force and Declination points leave their respective cylinders. After this, readings were taken at short intervals up to 10.30 p.m., by means of telescopes carrying scales. The values of these scales in parts of an inch on the cylinders have been very accurately determined by deflections, which enables those variations of the magnets to be determined which are too large to be recorded photographically.

"The following results were thus obtained:

"Range of Declination magnet between 4.35 and 10.15 p.m., was 2°53', and that of the H. F. magnet 0·1426 in British units, between 3.37 and 6.22 p.m. The V. F. magnet was twice thrown off its balance and hence its range is lost."

About a year since it was discovered that a wrongly divided glass had for many years been used for measuring the rain, hence all the observations of previous years required conversion, in order to render them correct; this has been done, and in the pamphlet before us a corrected table is given for 23 years, of which the mean is 46·3 inches, the max. 61·6 inches in 1866, and the min. 35·6 inches in 1855.

Report of the Rugby School Natural History Society for the Year 1870. 8vo, 61 pp., 8 plates. Rugby: W. Billington.

A WELL written, well edited, and well printed series of papers on various branches of Natural Science, *e.g.*, "Squirrels," "Time of Flowering of Plants"—(a capital paper by Mr. Kitchener, illustrated by diagrams, and tracing the accelerating and retarding influence of the temperature and rainfall)—"Asparagus Beetles," "Sun Spots," "Aurora Borealis, of October, 1870," by Mr. J. M. Wilson; this is a short note, and will be interesting for comparison with the report from Stonyhurst; we therefore transcribe it:—

"On the evenings of October 24 and 25, there were splendid displays of the Aurora Borealis, probably finer than have ever been recorded in this country. It most nearly resembles one described by Roger Cotes as observed at Cambridge, on March 6, 1715. It was exceptional from the brilliancy of the colouring, and from the extent of it, the whole even of the southern horizon being tinged with deep red, and large masses of colour being seen to the north, east, and west. It was also exceptional from the clearness with which the point of convergence of the rays was marked on both nights. At times the focus was occupied by brilliant white light. The point was near η Pegasi at 8.30 on the 24th, which gives a point 22° or 23° from the zenith, and about 5° east of south. On the 25th the point was between ζ and ε Cygni at 6.30, which would be 8° from the zenith, and 1° east of south. On the 24th, therefore, the auroral rays were nearly but not accurately parallel to the direction of the freely suspended magnet.

"It is specially to be noticed that the most splendid auroras have been seen at this time of year. The greatest auroras of this century were on October 23, 1804, October 24, 1847, and October 24 and 25, 1870. This indicates a cosmical rather than a terrestrial origin to auroras as well as to meteors.

"Mr. Seabroke and I made some observations of the light with my hand spectroscope of the Browning-Herschel pattern. The slit had to be made wide in order to obtain enough light. There was one bright broad band which must have been near D, but nearer the green, and three others, easily visible, which lay between F and E, by estimation. Even in looking at the reddest part of the aurora no lines were visible towards the red end of the spectrum, but this was probably owing to the imperfection of the instrument for such an observation.

"It is satisfactory to record that the phenomenon was thoroughly well observed by the school, nearly every one having been aware of it, and having been out to witness it."

Another useful paper is on "The Starlight Evenings of 1870," showing the relative frequency of those available for telescopic work. This subject has for many years been followed by Mr. Lawton, of Hull,* and might with advantage be copied in other parts of the country. The volume also contains a description of the Total Solar Eclipse of 1870, as seen in Sicily, by Mr. Seabroke, and registers of the flowering, &c., of plants, for 1869 and 1870. From this cursory notice our readers will realize the ability and completeness of the present report, and will join us in wishing that the Society may continue as it has begun: we need not wish it more.

* See our useful contemporary, "The Astronomical Registers," for the present month, November, 1871.

Illustrated Catalogue of Surveying, Optical, Standard. Meteorological, and other Instruments. Manufactured by L. CASELLA. 8vo, 260 pages, and about 500 engravings.

Where Otto Struve leads, lesser men may humbly follow. Opticians' catalogues find their appropriate recognition in Struve's splendid work,* and we know of no reason for omitting to notify similar publications in our own pages, provided always that we confine our remarks to the book, and avoid puffing or censuring the instruments described in it. We believe that if any optician brings out a new instrument, or modifies an old one, and submits it to us for examination, it is our duty to publish our opinion, whether it be favourable or the reverse; and so, with catalogues, it is our duty to collate them with others, to compare the descriptions, the engravings, &c., and to give our judgment thereupon. We think it is a good, complete, and well-illustrated catalogue. The descriptions are well-written, and to the point, as may be judged by the following specimen :—

"CIRCULAR OR DIAL BAROMETERS.—This popular and interesting arrangement of household instrument was first designed by that able philosopher, Dr. Hook, who took great pains to make it perfect, so much so that had his plans been carried out with fair progressive improvement, and the instrument been of a slightly more portable character, any other arrangement of weather indicator for general use might almost be considered superfluous ; the clear and expanded graduations on the dial, as well as its well known response to the simple tap so frequently given 'to see which way the mercury is going,' is familar to all. Not only did the Doctor attach a thermometer to it, but a hygrometer also, and even a level for the purpose of carrying out his arrangement with greater delicacy ; the ultimate rude combination however of these from commercial competition, has brought an unmerited distrust on the design, and hence its recent unpopularity. As regards the hygrometer, however, the simplicity and efficiency of the wet and dry bulb has subsequently caused it to supplant almost every other form. The following brief list, therefore, combines only instruments in which the desire of the Doctor is fully carried out, excepting that the above-named hygrometer (wet and dry bulb) is advised and its use recommended as a separate instrument."

There is strong evidence of the pressure of other matters on Mr. Casella's attention in the rather plentiful supply of trifling errors—the names of such well-known men as Daniell, Glaisher, Dines, &c., wrongly spelled; Kew Observatory supplied with the prefix of Royal; reference made to the *members* of the British Meteorological Society, forgetful of the fact that they (and the author among them) have long been transformed into *Fellows* of the Meteorological Society. These slips are of course of no moment to those to whom the author is known, but others may by them be lead to the false conclusion that the author is writing on subjects and bodies with which and whom he is unfamiliar. They could hardly make a greater mistake, but in his next edition we trust that Mr. Casella will remove the excuse he now gives for such misinterpretation.

---

*"Librorum in Bibliotheca Speculæ Pulcovensis, anno 1858, excunte contentorum catalogus systematicus. Petropoli, 1860, large 8vo, 970 pp.

OCTOBER, 1871.

Div.	Country	STATIONS. [The Roman numerals denote the division of the Annual Tables to which each station belongs.]	RAINFALL. Total Fall.	Difference from average 1860–5	Greatest Fall in 24 hours. Dpth	Date.	Days on which ·01 or more fell.	TEMPERATURE. Max. Deg.	Max. Date.	Min. Deg.	Min. Date.	No. of Nights below 32° In shade	On grass
			inches	inches.	in.								
I.	ENGLAND.	Camden Town	1·34	— 1·25	·34	1	12	67·0	18	31·2	13	1	9
II.		Maidstone (Linton Park)	1·44	— 1·66	·39	1	12	70·0	17	31·0	26	3	...
,,		Selborne (The Wakes)	1·85	— 2·36	·31	21	11	64·0	17†	27·5	10§	8	13
III.		Hitchen	·81	— 1·74	·17	21	15	61·0	17†	30·0	9‖	2	...
,,		Banbury	1·21	— 1·22	·28	19	13	63·0	17	27·5	13	3	...
IV.		Bury St. Edmunds (Culford)	1·40	— 1·31	·35	19	8	63·0	17‡	27·0	9	7	12
V.		Bridport	2·75	— 1·28	·75	29	14	63·0	18	34·0	21	0	...
,,		Barnstaple	6·12	+ 2·00	·83	27	27	64·5	19	36·0	9	0	...
,,		Bodmin	7·68	+ 2·36	1·53	28	22	61·0	15	41·0	25	0	0
VI.		Cirencester	2·30	— 1·19	1·00	4	9	...	...	...	...	...	...
,,		Shiffnal (Haughton Hall)	2·98	+ ·74	·47	28	18	63·0	18	29·0	10	4	...
,,		Tenbury (Orleton)	2·93	— ·30	·46	6	19	66·0	18	28·0	10	4	10
VII.		Leicester (Wigston)	1·12	— 1·58	·22	6	14	66·0	17	28·0	9, 11	4	...
,,		Boston	1·04	— 1·08	·25	6	13	63·0	17	31·0	9	1	...
,,		Grimsby (Killingholme)	1·71	..	·38	6	19	63·0	19	31·0	10§	2	...
,,		Derby	2·37	— ·47	·50	1	18	64·0	18	30 0	10‖	5	...
VIII.		Manchester	4·51	+ ·70	...	...	18	67·0	18	30·0	9	2	2
IX.		York	2·62	+ ·10	1·22	6	12	62·0	19	31·0	10	2	...
,,		Skipton (Arncliffe)	5·13	— 1·53	·94	6	18	60·0	19	26·0	12	6	...
X.		North Shields	1·96	— 1·32	·42	28	17	61·2	19	31·2	10	1	2
,,		Borrowdale (Seathwaite)	9·91	— 6·41	1·23	20	17	...	...	...	...	...	...
XI.	WALES.	Cardiff (Town Hall)	...	...	...	...	...	...	...	...	...	...	...
,,		Haverfordwest	7·64	+ 2·45	1·41	28	19	62·0	17	31·5	8	..	6
,,		Rhayader (Cefnfaes)	6·89	+ 1·29	1·00	18*	15	61·0	...	29·0	...	3	...
,,		Llandudno	6·17	+ 2·21	1·73	6	19	65·4	18	37·4	10	...	...
XII.	SCOTLAND.	Dumfries	3·54	— 1·38	·54	28	15	62·0	18	27·0	10	5	...
,,		Hawick (Silverbut Hall)	2·45	...	·46	28	18	...	...	...	...	...	...
XIV.		Ayr (Auchendrane House)	2·65	— 2·30	·51	21	18	62·0	18	26·0	10	4	8
XV.		Castle Toward	4·69	— 1·06	·97	6	21	...	...	...	...	...	...
XVI.		Leven (Nookton)	3·24	— ·51	·45	28	22	60·0	15	27·0	10	6	13
,,		Stirling (Deanston)	3·54	— 1·37	·52	5	21	59·0	18	22·0	10	6	13
,,		Logierait	3·25	...	·66	29	17	...	...	...	...	...	...
XVII.		Ballater	5·22	...	1·87	1	12	60·0	15	24·5	10	8	...
,,		Aberdeen	3·89	...	1·47	1	20	57·2	15	34·8	10	0	15
XVIII.		Inverness (Culloden)	1·01	...	·23	9	...	58·0	18	35·9	12	...	...
,,		Portree	8·85	— 1·93	1·95	26	23	...	...	...	...	...	...
,,		Loch Broom	5·04	...	·84	5	16	...	...	...	...	...	...
XIX.		Helmsdale	2·15	...	·54	1	18	...	...	...	...	...	...
,,		Sandwick	3·98	— ·94	1·29	26	15	56·5	13	36·7	29	0	13
XX.	IRELAND.	Cork	5·16	...	1·04	28	22	...	...	...	...	...	...
,,		Waterford	5·31	+ ·91	·73	28	27	61·0	18	35·0	9	0	...
,,		Killaloe	4·50	— ·52	·77	20	23	66·5	14	31·0	3¶	...	...
XXI.		Portarlington	2·83	— 2·30	·37	30	25	61·5	16	29·5	9	2	...
,,		Monkstown	2·22	— 1·70	·77	28	17	...	...	...	...	...	...
XXII.		Galway	2·20	...	·47	25	19	61·0	16	37·0	11	0	...
,,		Bunninadden (Doo Castle)	3·67	...	·50	30	25	54·0	11	25·0	10	3	...
XXIII.		Bawnboy (Owendoon)	...	...	..	...	...	...	...	...	..	...	...
,,		Waringstown	2·28	...	·65	28	17	64·0	13	28·0	9	3	9
,,		Strabane (Leckpatrick)	3·76	..	·69	28	24	65·0	13	..	...	...	...

* And 28. † And 18. ‡ And 19. § And 18. ‖ And 11. ¶ And 7, 8.

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

METEOROLOGICAL NOTES ON OCTOBER.

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

ENGLAND.

LINTON PARK.—A very fine month for the season; no high winds, very few fogs, only three frosty mornings, and those slight. But little rain. Winds mostly W. and S.W. Bar. mostly high, but unsteady about the 1st and 20th. The 17th and 18th very warm for October.

SELBORNE.—A foggy, damp, ungenial month. T and L at 6 a.m., on 1st. Extraordinary difference of temp. between 15th and 16th, the min. being 30° on he former and 50° on the latter date; frost on grass on thirteen days.

CULFORD.—A month of very fine weather for the season, from the 11th to the end of the month S.E. winds (with only one or two exceptions) prevailed; the last week remarkably fine; high wind on 6th; T on 7th and 19th.

BODMIN.—The rainfall of this year has already nearly equalled the average of twenty-one years. Average temp. 53°·9.

SHIFNAL.—The peculiarity of this October consisted first, in the absence of equinoctial gales, none having occurred here at the usual period or since; secondly, in the slightness of the frosts, the temp. having fallen to or below freezing point on four nights only, so mild was it that dahlias remained uninjured to the close. R fell for the first six days, after that from the 14th on most days to the end of the month. The winds were westerly for the first ten days, when they changed to S.E., on the 19th back to S.W. and W., and then on the 28th to S.E. again to the end. Owing to the absence of sunshine through Sep-temberand October, the blackberries never ripened on the hedges, nor the tomatoes on the wall.

ORLETON.—A cloudy month, with frequent falls of rain, generally very damp, with much fog and few fine days. Rivers full at the beginning and again at the end of the month. No T or L or violent wind. The temp. about 1° below the average.

WIGSTON.—A fine but cool month; very favourable for agricultural operations.

GRIMSBY, KILLINGHOLME.—Many very pleasant days; the month milder and the trees retained their leaves longer than usual, owing to the abundant rain of last month, and the absence of frost of any consequence. The ground in fine condition for wheat sowing. High tides in the Humber on the 19th. Clap of T at 2 p.m. on 5th.

YORK.—A mock moon and semicircular halo observed at 6.30 and 10 p.m. on 26th.

NORTH SHIELDS.—T on 8th.

SEATHWAITE.—T on 5th and 15th. H on 7th and 20th.

WALES.

HAVERFORDWEST.—One of the wettest Octobers in my register of more than twenty years; at times very stormy and generally very mild; fruit trees budding as in early spring; heavy floods particularly the latter half of the month; only one frosty night. On six nights the temp. was as low as 35°·0. The general health good, no epidemic prevailing.

CEFNFAES RHAYADER.—The month cold, with occasional storms of heavy rain; winds N.W. and S.E.

LLANDUDNO.—Lime tree divested of leaves on 26th; horse chesnut tree divested of leaves on 30th.

SCOTLAND.

DUMFRIES.—On the 4th T and heavy R; weather then fine to the 14th; rainy to 19th; a week of fine weather with occasional frosts, and the close of the month wet and stormy. The mean temp. was 2°·42 above that of corresponding month last year. The autumn has on the whole been very fine. The rainfall for the last nine months is 4·87 in. above that of the corresponding period in 1870.

AYR, AUCHENDRANE.—According to the weather tests this October has been a normal month with the exception of the rainfall and humidity, which are both below the mean of the month; but heavy dues and hoar frosts were frequent at both 9 a.m. and 9 p.m., and although equatorial winds were present on twenty-three days they rose only once to the force of a gale (18th), when slight rain fell with high ther. and falling bar. Taking the mean temp. of this October at 48°·3 the daily temperatures ranged themselves around that mean as fourteen days more or less above it, and seventeen days more or less below it. Of the six days of polar winds in this month one was calm, and five occurred among the seventeen when the temp. was below the mean (48°·3). River low this month.

CASTLE TOWARD.—This month has been very favourable for out-door work, although we have had much rain we have had little frost, and our bedding plants are still fresh in the beds ; dahlias and calceolarias are still in fine bloom ; the ploughs are again in operation turning up the ground for the winter action.

DEANSTON HOUSE.—This month began cold, frosty, and wet; sharp frosts with bright sunshine from 7th to 12th inclusive. From 12th to the end of the month dull and wet. Gale of wind on 27th.

LOGIERAIT, STRATHTAY.—First part of month fine, with much sunshine. A few nights of frosts in the middle of the month, which closed with heavy rainfall.

BALLATER.—Very heavy rainfall in the beginning of this month. Frost was frequent, and strong winds prevailed.

ABERDEEN.—Bar., ther., rainfall, and S.W. winds above the average (of fourteen years) ; wind pressure rather below it. Auroræ on 4th, 9th, 12th, 18th, and 24th. Fog all day on 2nd and 29th, and on the mornings of the 14th, 15th, and 18th. A month of dull, wet, but mild weather.

PORTREE.—A wet and stormy month; a strong S. gale on 26th and 27th. Snow on 28th and 29th, with frosts at night.

LOCHBROOM.—The beginning and end of the month were rather stormy, but from the 9th to the 22nd it was most beautiful weather, which enabled potato lifting to be carried on charmingly, and there never was a better or more plentiful crop of this useful esculent in the district, and perfectly free of disease.

SANDWICK.—A fine month, with moderate wind ; the only gale was one of 46 miles an hour from noon to 1 p.m. on the 27th. Auroræ on three nights.

IRELAND.

MONKSTOWN.—A fine genial month ; dahlias and heliotropes untouched by frost. Brisk gale from E.N.E., with heavy sea.

DOO CASTLE.—Wet month, clay wet for potato digging. Potatoes, turnips, and mangolds light crops this year.

WARINGSTOWN.—Rainfall small, month in other respects much an average one. Potato crop very variable ; early planted very large yield and little disease ; late very bad indeed.

AURORA OF NOVEMBER 9TH, 1871.

10.35 P.M.—White Aurora in N.

10.48—Red in N.W., green from N.N.W. to N.E.

11.1—Red streamer covered γ Ursæ majoris, and reached to an altitude of 29°.

11.7.30—Streamer faded away.

11.24.33—Meteor of 2nd Magnitude, parallel to and about 3° below β and γ Ursæ minoris.

11.38.30—Meteor of 3rd Magnitude, between α Draconis and ζ Ursæ majoris to horizon in N.

11.44.3—Small meteor in E.N.E.

11.56.33—Very fine meteor, globular, and of a yellowish green colour, passed very slowly from a point about N. 74 E. and altitude 8° to N. 78° E. at an altitude of 5°. It was more than twice the apparent size of Jupiter, but not so brilliant.

The aurora continued faintly till after midnight.

Camden Square, N.W., Nov. 10th. G. J. SYMONS.

DECREASE OF RAINFALL WITH ELEVATION.

[Ten pages of additional matter on this question received in one month from some of the most able English Meteorologists, besides much more unprinted, and several protests against the closure of the discussion, render it presumptuous on the part of any Editor to persist in that course. We adopt another. Although a question of high interest and importance, it cannot be allowed to monopolize the pages of this Magazine, so long, therefore, as it lasts we shall, without additional charge, so increase the size of our Magazine, that the full amount of ordinary matter shall not be encroached upon.—ED.]

To the Editor of the Meteorological Magazine.

SIR,—I believe the cause of decrease of rainfall with elevation, so far as it depends upon our method of catching it, is due to eddies of wind round the gauge buoying up the rain-drops, and preventing their fall into the gauge, and to evaporation. The angle cannot count for all that is attributed to it, for a gauge placed on a mountain-top would be equally affected by obliquity, and yet it shows an increase of measurement, instead of a diminution. Observations taken in calm weather would help to clear up this point. It is utterly incredible that 40 or 50 per cent. of rain is lost by a gauge suspended 100 feet in the air, and I think that the solution of the problem must be sought in the mode of production of rain rather than in the means of measuring it. The question to be solved is—Why does a gauge perched upon a high pole collect so much less than one on the ground, whereas another fixed on a hill of similar height catches more than its proper share? The true answer to this will, I believe, be found in the great probability that rainfall is a cumulative process, commencing in the atmosphere and regions of cloud, and only completed near the surface of the earth. I have a strong impression, though with nothing at hand to verify it, that Mr. Glaisher, in his balloon-ascents, found the rain-drops high up small and drizzling, but large and heavy when he was almost close to the ground. He also showed the correctness of Mr. Green's statement, that when rain fell there were always two or more strata of cloud placed one above another. Now, there are doubtless many factors in the production of rain, such as the presence of much moisture, cooling currents and cold mountain summits, the attraction of gravitation, and electricity. The idea that most commends itself to my own mind is that the first link in the *immediate* causation of rain, is the relative position of the superimposed layers of cloud. This is a necessary point as rain does not appear to be formed by a single stratum. The cloud masses are most probably in opposite electrical states, and by their mutual action commence the pluvial process. The lower of two layers would again be in an opposite state to one below it, and the earth itself would complete a series of bodies excited into opposite conditions of electricity by induction. Thus the action begun above might be continued down to the ground, and cause a constant aggregation of rain-drops and watery vapour. I would claim for the earth very great influence by its attraction and electrical activity, and the mountains and woods may be regarded as so many advanced outposts of attraction and of the electric forces. In this way it seems possible to account for the decrease of rainfall with elevation on a plain, and its increase on the top of the hills. This view harmonizes with the remarkable effect of increased magnetism of the earth in producing auroræ and disturbed weather. It is also in complete accordance with ozono-metric observations. I will not digress into these subjects, or refer to objections that are likely to be advanced to this or any other theory.

I remain yours, &c.,

FRANKLEN G. EVANS, M.R.C.S., F.M.S., &c.

Tynant, Radyr, near Cardiff, Oct. 19, 1871.

To the Editor of the Meteorological Magazine.

SIR,—I see upon referring back to earlier letters that Mr. Pennant alluded to "out-splashing" in May last, but he seems to have put it aside as the cause of the decrease of rainfall with elevation, for this reason, that effects ought to remain constant so long as the cause remains so; and he considers that the effects are not sufficiently constant.

Will you permit me to add the following to my communication of the 4th inst. Splash, it can scarcely be doubted would vary with the strength of the wind, and the size of the rain-drops; consequently, the quantity of water lost must also be variable, though the rain might arrive at the same angle; and the difference would be most apparent in winter, when the average force of the wind is greatest.

With so much difference of opinion amongst *savans*, it might be safest to fall back on a known cause—at any rate till absolute proof has been attained of the existence of a more efficient cause.

I am, &c.,

J. PARK HARRISON.

Ewhurst, Surrey, 20*th Oct.* 1871.

To the Editor of the Meteorological Magazine.

SIR,—Before the discussion is quite closed, I beg to be allowed a few words in reply to Mr. Crallan's letter in the September Magazine.

My first remark will be in the way of explanation. Mr. Crallan seems to think that I have expressed an opinion to the effect that rain is generated nowhere but at the lower surface of a cloud—an opinion which he describes, with studied moderation, as "a very peculiar one, and without the authority of facts." If your readers will turn to my letter in the May number, they will see that I have not committed myself to anything so irrational. For the sake of illustrating a particular proposition, I traced the course of the rain-drops, in a hypothetical instance, from the point at which they leave the cloud. My argument did not require that I should trace them from their origin, or that I should speculate as to what part of the cloud gave them birth, and certainly nothing was farther from my intention than to propound the strange doctrine with which I find myself credited.

Mr. Crallan's theory of the cause of the decrease with elevation, as I understand it, is essentially different from Mr. Stow's. Mr. Crallan does not deny the reality of the phenomenon. He admits that there is actually less rain in a given horizontal space at an elevation than near the ground, and he explains the fact by supposing that the drops approach one another as they fall. That such approximation does occur under ordinary circumstances he has been at pains to show, and it may be, for aught I know, that each step of his demonstration is in itself unassailable, yet a general consideration of the question makes it obvious that a fallacy must lurk somewhere.

It is easy enough to conceive of causes which may tend to approximate the drops. Eddies of wind will do it, even more effectively than the causes which Mr. Crallan assigns, as seen in the extreme instance of a water-spout. But it must be remembered that the phenomenon which we are discussing is a constant phenomenon—constant both in time and place—and you can no more increase the *entire* quantity of rain by approximating the drops than you can increase the number of people in a room by crowding them together. In the one case, as in the other, if the quantity or the number is to be increased, it must be by something more than a re-arrangement of the constituent parts or individuals.

I have had no opportunity as yet of working out the suggestion that I made in the September Magazine– namely, that the increase of rain at the lower levels may be due mainly to the absorption and incorporation by the rain-drops of spray suspended in the air—but I have not abandoned the idea. On the contrary, what little thought I have since given to the matter has tended to impress me with the conviction that the ultimate solution of the problem will be found in the direction I have indicated. This I have some hope of being able to show hereafter.

GEORGE F. BURDER, M.D.

Clifton, Oct. 31, 1871.

To the Editor of the Meteorological Magazine.

SIR,—It seems very difficult in this discussion to keep the points on which we are at issue quite distinct, therefore first of all, and for the sake of clearness only, let me call attention to the fact that Mr. Crallan's theory is quite different from that put forth by Mr. Stow, on p. 69.

Mr. Crallan's theory is to me quite new, but I think too that it is not true: he says, on page 137, "Take one vertical line through our hypothetical cloud," &c.; it is quite true that the parabolas of which he speaks will approximate horizontally, but then we must not forget that other parabolas whose vertices lie on other vertical lines in advance of this one will recede from these, and that the nature of the parabola is such that these recessions will exactly balance the approximations. There can be no doubt that all the drops projected horizontally with the same velocity from different points in the same horizontal line will at every point of their paths preserve the same horizontal distance. This is true of every horizontal plane of projection (and we are concerned with no other) whatever be its height above the ground, and whatever be the thickness of the rain-cloud; it follows from this that the same horizontal area will receive the same quantity of rain at whatever distance below the rain-cloud that area be placed; supposing, of course, that the points of projection are uniformly distributed throughout the rain-cloud.

If anyone wishes to put this statement to a practical test, let him take a sheet of paper ruled with lines at equal distances (of, say, half-an-inch), place the paper with these lines vertical, then draw three lines (say one inch apart) at right angles to the former lines, which shall represent three horizontal planes of discharge of rain-drops; with the help of a card, cut into the shape of a parabola, draw the paths of the rain-drops discharged at the points of intersection of (say a dozen of) the vertical lines with the three horizontal lines; it will then be found that at whatever distance below the lowest horizontal line another horizontal line be drawn, it will intersect three parabolas in any half-inch, six in any inch, nine in any inch-and-a-half, and so on, wherever the intercepting length (which thus represents the mouth of a gauge) be placed: this proves that the decrease of rainfall with elevation is not due to the greater height through which some of the drops have fallen. I will gladly send, by post, a card cut into the shape of a parabola to anyone who wishes to try the experiment, and I enclose a diagram for your inspection.

To Dr. Burder's persistent question, "What has become of the rain which is deficient at the higher level?" I owe my exposition of Mr. Crallan's oversight, which for some days had deceived me.

Mr. Stow, on page 148, adopts Mr. Crallan's theory, but supports it with an argument which refutes itself. "The drops discharged from a horizontal surface," he says, "will *diverge* as they approach the ground but preserve the *same horizontal distance;* the drops from a vertical surface will *approach* each other, but preserve the *same vertical distance;*" by what law of nature these drops are to be made to approach to or diverge from each other, and still maintain the same distance, be it horizontal or vertical, I am at a loss to conceive.

It may possibly be true that there is a relation between angle and decrease with elevation, but I could as soon believe that 2 and 2 could make 5, as believe that "when rain is deflected by wind it is spread over a somewhat larger area than when it falls vertically," except just at the edge of the shower, with which exception we have no concern.

Among the opponents of Mr. Stow's *original* theory given in p. 69, besides Dr. Burder, Mr. Pennant, Mr. Thrustans, and Mr. Warren, I think we may now reckon Mr. Crallan, who admits, on p. 137, that "rain-drops falling from the same altitude under the same circumstances of wind and atmosphere, preserve their horizontal distances throughout unaltered," and also Mr. Kearney, who says, p. 74, "*if* Mr. Stow is right $a = b$;" but Mr. Stow now states, quite correctly, that A C (that is Mr. Kearney's a) is always *greater* than A B (that is b), therefore, in Mr. Kearney's opinion Mr. Stow must be wrong; I think, too, that if Mr. Strachan will allow us to suppose the wind to be horizontal we may count him as an opponent of the theory that "a horizontal gauge presents a smaller area of aperture to rain falling obliquely than to that which falls vertically."

J. M. DU PORT.

Mattishall, Norfolk, 31*st Oct.*

To the Editor of the Meteorological Magazine.

SIR,—Allow me briefly to point out the absurdity of the proposed method of settling this controversy. Either this decrease is caused by difference of angle or it is not. If it is not, the notion will die a natural death, and it is unnecessary to smother it; if it is, no counting of heads will make it otherwise. While, therefore, it is, highly proper that the Editor should "sum up" arguments and express an opinion, I will be no party to settling scientific facts by the vote of a "jury."

I expect that "the majority of your readers" have "followed" the controversy more "carefully" than to suppose that any one denies that horizontal gauges must be the measure of rainfall, or wishes Mr. Bushell to tilt up his gauges. The truth is, that Dr. Burder and Mr. Du Port have given a demonstration which is mathematically correct, but, as I maintain, physically inapplicable, or rather not exactly and exclusively applicable to the case. Mr. Du Port himself admits that the supposition on which his demonstration rests is "not perfectly exact," that "exactness is not attainable;" but how, I would ask, if you start from an inexact supposition can you prove another explanation of the facts to be *impossible?* He is under a mistake, by the way, in supposing that I assumed an invariably horizontal discharging surface, as, in fact, I did (for the sake of argument) assume a vertical discharging surface for the vertical gauges, and thus it was, as Mr. Du Port saw well enough, though Mr. Bushell does not seem to have seen, the suppositions and not the demonstrations which clashed. Such a war of mere hypotheses may last for ever; had we not better wait for some more definite result from the experiments?

I am, Sir, your obedient Servant,

F. W. STOW.

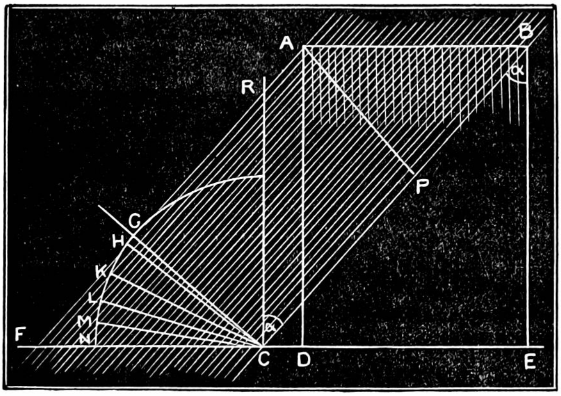
Harpenden, St. Albans.

To the Editor of the Meteorological Magazine.

SIR,—I have read all the letters of your numerous correspondents with the greatest interest, and have been hoping to see some satisfactory solution of this much-vexed question; or, to put it in Dr. Burder's words, to see connected the link, as cause and effect, between the fact that rainfall received on a horizontal surface decreases as we ascend, and the fact that the deviation of the rain from the vertical increases as we ascend. In the hope that the following remarks will in some measure tend to elucidate this, I have ventured to write to you.

Let A B represent a horizontal line of rain-drops at any height, it is clear then that if they fall vertically, they will all fall within a line

D E, of equal length on the horizontal surface of the ground exactly under A B. (See annexed figure.)



Now, suppose they are deflected, say at an angle a, from the vertical, then all the drops, supposing their paths to continue parallel and all to be deflected in the same horizontal plane, which, however, never is the case, although for a short distance they might be assumed so, will likewise fall within a line F C, of equal length to A B or D E, on reaching the horizontal surface of the ground (which agrees with Dr. Burder's view in 2nd paragraph of his letter in your May number); and this will always be so, whatever be the angle a, supposing the direction of all the drops to continue parallel.

Next, the paths of the rain-drops when deflected from the vertical are closer together than they would be if they fell vertically, and the larger the angle the direction of the falling drops makes with the vertical the closer are the paths of the drops to one another, for on looking at the figure it is seen that all the drops which occupied the length A B, when deflected, pass through the shorter length of line A P, and also C G, which are drawn at right angles to the direction of the falling drops.

It is seen, therefore, that if three gauges were placed so that the diameters of their receiving surfaces were in the positions, and of the respective sizes, shown by the lines D E, C F, and C G, they would all catch the same amount or volume of rain.

Now, suppose a gauge, the diameter of whose receiving surface is in the position C G, and let it be moved so that its diameter will occupy successively the positions shown by the lines C H, C K, C L, C M, C N, then it is plain that at each successive position it will catch less and less rain the nearer its receiving surface is to the horizontal, or, in other words, the smaller the angle the direction of the rain-drops makes with the receiving surface of the gauge.

Or, consider the subject in another light, which will amount to the same thing, and will bring us nearer to the gist of the question: instead of supposing the gauge to change its position with regard to the direction of the falling drops, imagine the gauge in each of the supposed cases to be horizontal and the direction of the rain-drops to be successively changed, which can easily be done by turning the figure round and consider the receiving surface of the gauge first to be in the position C G, and let this be conceived as horizontal; then the diameter of the receiving surface C G, will catch *all* the drops—their direction in this case being vertical—in the line R C; next, suppose the position C H to be horizontal, then the diameter of the gauge will catch a less number of drops, their direction in this case making a small angle with the vertical; next conceive the position C K to be horizontal, and a still less number of drops will be caught, and the angle from the vertical so much greater, and so on, and if we lastly conceive the position C N to be horizontal, the number of drops caught will be still fewer, and the angle which their direction makes with the vertical will be still greater. From this it follows that when rain falls vertically, a horizontal rain-gauge catches most, and the greater the angle of deflection from the vertical the less amount of rain such a gauge will catch—and this accounts for a gauge at a height from the ground catching less than one on the ground (except in the case of a calm) the amount caught decreasing with the height; because the higher from the ground the stronger the wind, and consequently the more the direction of the rain is deflected from the vertical. I trust that this may be a partial answer to what you call the "real problem," in your May number, p. 64.

Let us now find some expression, in terms of the angle, for the amount of loss due to the deflection of the rain-drops from the vertical: taking the above figure—

$$\text{F G C being a right angle } \frac{CG}{CF} = \cos a$$
$$\therefore\ CF = \frac{CG}{\cos a} = \frac{CN}{\cos a};\ \text{or } CN + FN = CN \sec a$$
$$\therefore\ FN = CN(\sec a - 1) =$$

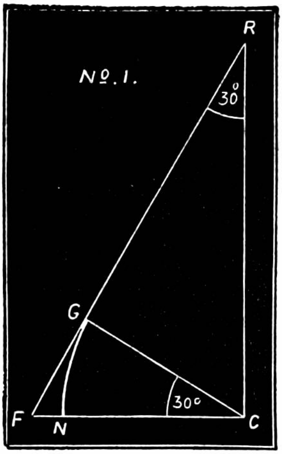
= the loss in a particular line of rain drops; and if C N represent the diameter of a circular gauge or side of a square gauge, the total loss will be = area of gauge (sec $a - 1$).

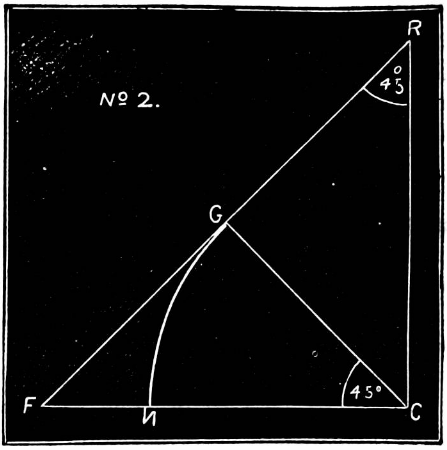
Now, let us apply this formula to two or three examples, and the results will correspond with what might be expected from a glance at the figures.

1st. See fig. No. 1.

$$\text{Let } a = 30°, \text{ then } \frac{CF}{CG} = \sec 30°$$
$$\text{Sec } 30° - 1 = \frac{2}{\sqrt{3}} - 1 = \frac{2}{\frac{7}{4}} - 1 \text{ nearly} = \frac{8}{7} - 1 = \frac{1}{7} \text{ nearly}$$
$$\therefore \text{ the loss } = \tfrac{1}{7} \text{ area.}$$

or, in other words, if rain is falling at any particular height at an angle of 30° with the vertical, a horizontal gauge at such height will catch about seven inches instead of eight.





2nd. See fig. No. 2.

Let $a = 45°$, then $\frac{CF}{CG} = \sec 45°$

$\sec 45° - 1 = \sqrt{2} - 1 = \frac{17}{12} - 1$ nearly $= \frac{5}{12}$ nearly.

$\therefore$ loss $= \frac{5}{12}$ of area

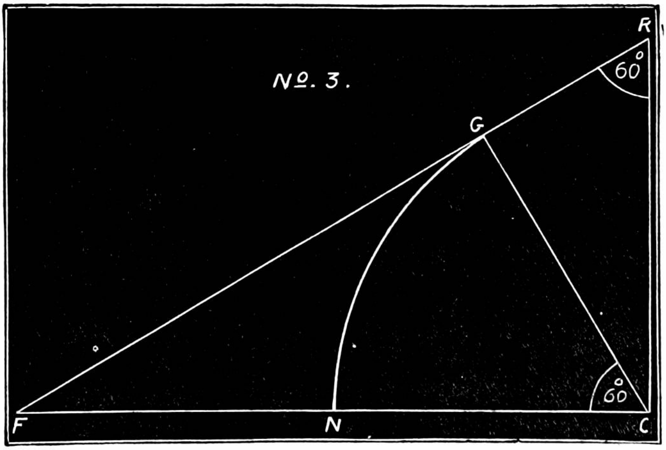
or, in this case, a horizontal gauge at whatever height will catch twelve inches instead of seventeen.

3rd. See fig. No. 3.

Let $a = 60°$, then $\frac{CF}{CG} = \sec 60°$

$\sec. 60° - 1 = 2 - 1 = 1$

$\therefore$ loss $=$ area



or, in this case, a horizontal gauge at whatever height will only catch half as much as if the rain were to fall vertically.

Again, let the formula be tested by applying it to the two extreme cases, when $a = 0°$ and $90°$ respectively.

Let $a = 0°$, then sec $0°—1 = 1—1 = 0$ or loss is nothing, *i.e.*, when rain falls vertically, a horizontal gauge has nothing to lose from deflection, for there is no deflection, and it will catch the same amount at whatever height. And this is self-evident from the figure, for in this case R F coincides with the vertical line R C, and C G with C F, and F N vanishes, or the loss = 0.

Let $a = 90°$, then sec. $90° = \infty - 1 = \infty$, or a gauge must reach to infinity to catch any rain at all, which is manifestly the case, viz., that when rain is driven (it cannot be said "falls") horizontally, it never reaches the earth at all, or only meets it at infinity. In this case, F R being horizontal, it would only meet F C at infinity, and F N would $= \infty$.

I trust that the correctness of the formula is proved by these tests, which agree with what must be patent to all.

I would just remark on the differences between the above results and those of Mr. Stow (2nd paragraph of p. 71, June number), where he gives the diminution in amount caught as 13, 30, 50, and 100 per cent. for 30°, 45°, 60°, and 90° respectively: turning my values into per-centages, they would be respectively 14¼, 41, 100, and ∞ for the corresponding angles. Test Mr. Stow's results by the last-named angle, if rain *is driven* at an angle of 90° with the vertical, and, therefore, would never reach the earth, how can it be said that the loss is 100 per cent.?

The above does not assume that as a matter of course an elevated guage will always catch less than one on the ground, for in the case of a calm it does not do so, but it depends on the angle which the direction of the falling rain makes with the receiving surface of the gauge, and this in turn depends on the force of the wind, which is greater according to the height from the ground.

It will be seen in the above remarks that I have treated the angle of the direction of the rain with the surface of the gauge the only element, on which the differences of the amounts caught depend at whatever height the gauge may be placed, and independent of where the rain may have come from; and have omitted as immaterial, or as having little if any effect, the questions of alteration of size of the drops in their passage, and of the difference of distances between the several drops from one another and evaporation.

The above was written previous to the issue of your October number, and I would now, if not trespassing too much on your space, offer a few remarks in conclusion. As to the relative merits of Mr. Stow's theory and Dr. Burder's views, and their respective followers, I cannot help thinking that both are for the most part right, although I do not see the utility of dwelling so much, as Mr. Stow does, on vertical gauges, except so far as their investigation may lead to the truth of the question—why a gauge which receives rain perpendicular to its surface catches more than one which receives it in a direction inclined to its surface—for *the* important thing, after all, to be ascertained and discussed is the amount of rain which falls on the earth in all situations, whether horizontal or undulating, as Dr. Burder has very clearly described it in your June number.

Next, as to the actual path of rain-drops through the air; I think Mr. Crallan has very cleverly brought it to our notice that they do not describe straight parallel lines (except in a calm), but parabolas (approximately, subject to the resistance of the air,) and that their course is as shewn on the 2nd figure, p. 137. This agrees with Mr. Strachan's figure 2, on p. 116, for the actual course of the rain-drops may be supposed to be made up of an infinite number of deflections, so close together that they assume the shape of a curve as above referred to. And I think if the above formula were applied to a horizontal gauge at any part of Mr. Crallan's 2nd figure, p. 137, it would show the loss or difference due to the deflection of the rain-drops from what a gauge on the ground would catch. I cannot see that the fact that rain-drops do not travel in straight lines is, as Mr. Bushell says, inimical to Mr. Stow's theory.

One word as to the general expression which is so often made use of—viz., "the angle at which rain falls." It seems to me that this cannot be used with any meaning, unless the height referred to is coupled with it, as Mr. Crallan has shown that the angle is continually varying with the height

I am, Sir, your obedient servant,

C. O. F. CATOR.

UNDERGROUND TEMPERATURE.

To the Editor of the Meteorological Magazine.

SIR,—In reference to this subject at p. 52, in your Magazine for May, 1870, will you allow me to ask you or your readers, why the variable results noticed in the two figure tables, and in the text, are not due to the pressure of upper on lower strata?

Professor Hull, at p. 55, assumes a constant supply of heat from the interior of the earth, but there is no geological proof of the existence of that heat; he remarks on the discordant results of temperature at varied depths, and thinks that the position of certain strata may have something to do with it. It seems that under the natural condition of the deposits, a discordance of temperature in different places, or in the same place at varied depths, must necessarily take place; a glance at the table p. 55, will show that the greatest increase of heat takes place in those strata which contain most gas, and as there is a constant pressure increasing in depth, discordance in heat must arise from the varied quantities of gas contained in the materials subjected to the varied pressure, while, if the heat came from one internal source there is no reason why that heat should not increase regularly as we descend, but in the ungaseous excavation of the Mont Cenis tunnel the heat was never great, though the depth was greater than man had ever delved before.—Your obedient servant,

H. P. MALET.