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INDEX.

ILLUSTRATIONS.

SYMONS'S
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METEOROLOGICAL MAGAZINE.

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ON CERTAIN VARIATIONS OF TEMPERATURE DURING THE SOLAR ECLIPSE OF DECEMBER 22ND, 1870.

THE observations described in the following paper were conducted in the neighbourhood of Barnstaple, North Devon; where, in consequence of the fineness of the weather, the eclipse was seen to the greatest possible advantage.

During the night of December 21-22 there was a severe frost, and when my usual meteorological observations were taken at 10 a.m. on the 22nd, the wind was E.S.E. and the barometer (corrected for sea level) stood at 30·16. The sun was shining brightly, and, with the exception of a few cumuli along the eastern horizon, no clouds were visible in any part of the sky. During the whole of the day it was freezing in the shade.

As the wind was blowing in occasional gusts, I found that any thermometrical observations made in the open air, would be comparatively useless for the purpose of showing the actual variation of temperature produced by the eclipse, whilst the erection of any shelter between the instrument and the wind would have been objectionable from its tendency to cause side draughts. The thermometer was therefore placed in a large room on the ground floor, with a southern aspect, where it was perfectly free from the influence of any currents of air, which might cause an undue depression. It was attached in a slightly inclined position to an oak board, placed 2 feet from the window, which was a large one, opening down to the ground, and having a superficial area of 36 square feet. Every care was taken to insure the accuracy of the observations; but, if any error exists in them, it would tend, as far as I can see, to show an excess instead of a diminution in the several readings. Such error might arise from one of two sources. Either from the refraction of the glass of the intervening window; or, secondly, from the occasional presence of the observer in the room. Neither of these causes would, however, materially affect the observations; and the latter I especially guarded against, by entering the room only at each interval of five minutes, and remaining no longer than the few seconds requisite to examine the thermometer. No fire had been lighted in the room for several days previously.

The thermometer was put in position, and fully exposed to the sun, some time before the commencement of the eclipse, when the tempera-

ture marked 69°. The first contact took place at 11h. 1m., Greenwich time, but no perceptible difference was indicated during the succeeding 40 minutes. Between 11.40 and 11.45 the temperature fell 1°, and from that time there was a rapid and regular depression until 12.30, when the *minimum* of 49° was reached. This was immediately followed by a steady rise, and at 1.35 the atmosphere had regained its normal temperature.

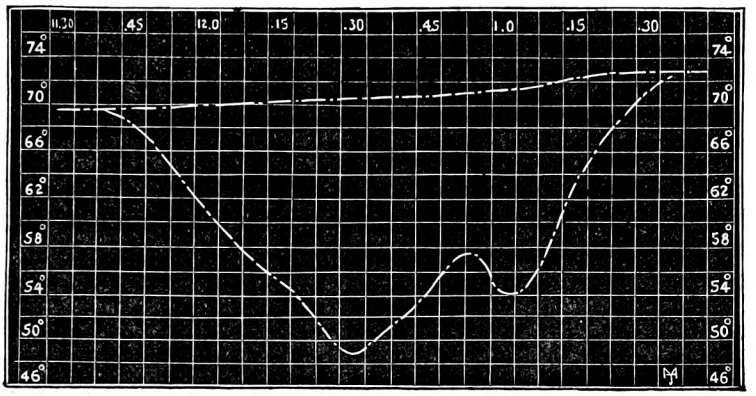
In the accompanying table I have given, in the second column, the temperature in the sun for each interval of five minutes during the period of variation, that is to say from 11.40 to 1.40. In the next column, taking the difference between the mean temperature before and after the eclipse, and considering, from former observations made under ordinary circumstances, that the temperature steadily increases from sunrise till nearly 2 p.m., I have estimated the exact ratio in which it would have progressed during the two hours under normal conditions. From these corrected temperatures I have subtracted the observed temperatures, and formed from them the accompanying diagram, as well as the results shown in the column headed "difference from mean." The last line of figures gives the difference between each successive interval of five minutes.

Summary of Thermometrical Observations taken at Pilton Parsonage, near Barnstaple, during the Solar Eclipse of December 22, 1870.

Hour.	Temperature in the sun.	Estimated normal temperature.	Difference from mean.	Difference between each interval.
	deg.	deg.	deg.	deg.
11.30	69·0	...	...	...
11.35	69·5	...	...	0·5
11.40	69·5	69·5	0·0	...
11.45	68·5	69·625	1·125	...
11.50	66·25	69·75	3·5	2·375
11.55	63·5	69·875	6·375	2·875
12	61·25	70·0	8·75	2·375
12.5	59·0	70·125	11·125	2·375
12.10	56·75	70·25	13·5	2·375
12.15	55·25	70·375	15·125	1·625
12.20	53·75	70·5	16·75	1·625
12.25	50·0	70·625	20·625	3·875
12.30	49·0	70·75	21·75	1·125
12.35	50·25	70·875	20·625	1·125
12.40	52·0	71·0	19·0	1·625
12.45	54·25	71·125	16·875	2·125
12.50	56·75	71·25	14·5	2·375
12.55	57·25	71·375	14·125	0·375
1	54·0	71·5	17·5	+3·375
1.5	54·75	71·625	16·875	0·625
1.10	58·0	71·75	13·75	3·125
1.15	64·0	71·875	7·875	5·875
1.20	67·25	72·0	4·75	3·125
1.25	69·75	72·125	2·375	2·375
1.30	71·75	72·25	0·50	1·875
1.35	72·25	72·375	0·125	0·375
1.40	72·50	72·50	0·0	0·125

Commencement, 11h. 1m.; greatest phase, 12h. 19m.; termination, 1h. 37m.

Diagram showing the variations of temperature during the Solar Eclipse, December 22nd, 1870.



Notes.—From 12h. 21m. 0s. to 12h. 27m. 30s. a few small detached clouds passed rapidly over the sun, but they were not of sufficient density at any time, to obscure it. A series of bright white rays, diverging upwards from above the clouds, contrasted strongly in colour with the deep indigo blue of the whole sky. At 12.25 three stars faintly visible in the north. 12.54 a narrow broken belt of clouds beginning to pass over the sun, continuing till 12.57, when a thicker cloud completely obscured it till 1.2, causing a fall in the thermometer of 3°·25. At 1·4 all the remaining portions of the cloud had disappeared.

Results.—In the foregoing observations I have endeavoured to show the extent to which the atmosphere is affected by a partial eclipse during the middle of winter. It will be seen that the total amount of depression at the time of the greatest obscuration was 21°·75, and I would submit that these figures represent more exactly the influence of an eclipse, than if the observations had been taken at any other period of the year.

During the summer months both the atmosphere and the earth are so charged with heat, that a partial darkening over of the sun for so short a time loses, to a certain degree, its effect—the diminution of warmth being partially neutralised, before it can reach the earth, by reason of its passage through the intervening atmosphere. It is to be hoped that similar observations will have been made at some point along the line of total obscuration; whilst, on a future occasion, it will remain an interesting question to be determined by meteorologists, how far the thermal depression varies with the season of the year and the climate of the locality.

Pilton, Barnstaple. TOWNSHEND M. HALL, F.G.S.

To the Editor of the Meteorological Magazine.

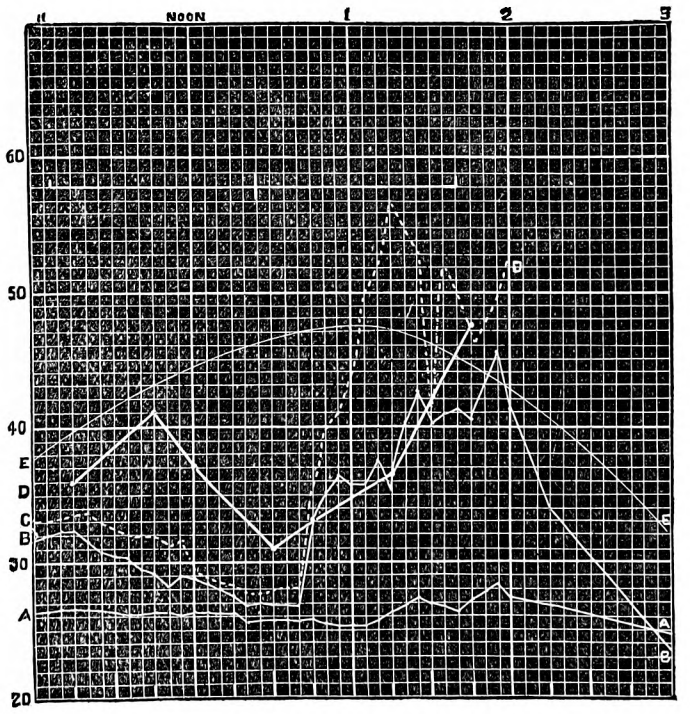
SIR,—The season of the year and the variable character of the weather during the eclipse rendered its effect upon the temperature less marked than is usual. I have no report from any station where the

sun was unclouded during the whole of the eclipse, and this renders any exact determination of the diminution of this heat by obscuration impossible. It will be best simply to place, side by side, an abstract of the observations which have been placed at my disposal, leaving it to your judgment to make any additions to the figures or comments on them that may be desirable.—I am, Sir, your obedient servant,

F. W. STOW.

P.S.—The thermometers used for determining the sun's heat are the "dull black bulb in vacuo," and have the bulb and 1 inch of the stem blackened. The others are the ordinary dry bulb mercurial thermometer (except where otherwise stated). * indicates a minimum, † the maximum for the day.

[In order to throw a little further light on the information afforded by Mr. Stow's tables, we add the following diagram, wherein A is the shade temperature at Camden Square, B the vacuum black bulb readings at the same station, C and D the readings of similar instruments at Holloway and Hawsker respectively, and E represents approximately the normal curve of the vacuum black bulb thermometer at Camden Square for a cloudless midwinter day. The period of the eclipse is denoted by the thick horizontal line, and the epoch of maximum obscuration by the short transverse mark in its centre.—ED.]



Time.	Camden Square. G. J. Symons, Esq.				Holloway. Leighton Kesteven, Esq.				Hawsker, Whitby. Rev. F. W. Stow.				Sunderland. T.W. Backhouse, Esq.		Halifax. J. Gledhill, Esq., F.G.S.			
	Thermometers at 4 ft.		Decrease (—) or Increase (+)		Thermometers at 4 ft.		Decrease (—) or Increase (+)		Thermometers at 4 ft.		Decrease (—) or Increase (+)		Ther. at 4 ft.	Decrease(—) or Increase (+)	Thermometers at 4 ft.		Decrease (—) or Increase (+)	
	Shade.	Sun.	Shade.	Sun.	Shade.	Sun.	Shade.	Sun.	Shade.	Sun.	Shade.	Sun.	Shade.	Shade.	Shade. dry.	Shade. wet.	Dry.	Wet.
	deg.	deg.	deg.	deg.	deg.	deg.	deg.	deg.	deg.	deg.	deg.	deg.	deg.	deg.	deg.	deg.	deg.	deg.
9 a.m.	25·1	...	..	...	...	...	...	...	28·5	28·0	...	...	28·5	...	25·0	24·7	...	...
11	26·2	31·9	+1·1	...	30·0	33·0	...	...	...	...	...	...	(8 a.m.)	...	23·4	22 3	—1·6	—2·4
11.15	26·4	32·2	+1·3	+0·3	29·0	33·6	—1·0	+ 0·6	29·8†	36·0	+1·3	+ 8·0	...	...	...	...	...	...
11.30	26·3	30·4	—0·1	—1·8	28·0	32·5	—2·0	— 1·1	...	...	...	..	29·0	+0·5	24·0	23·0	—1·0	—1·7
11.45	26·2	29·1	—0·2	—3·1	28·0	32·0	—2·0	— 1·6	28·7	41·0	—1·1	+13·0	...	...	...	...	...	...
noon	26·1	28·8	—0·3	—3·4	27·0	29·5	—3·0	— 4·1	28·2	37·0	—1·6	— 4·0	30·0	+1·0	24·0	23·0	—1·0	—1·7
12.15	26·1	27·5	—0·3	—4·7	26·8	28·5	—3·2	— 5·1	...	...	...	...	29·5	—0·5	...	...	...	...
12.20	25·7	26·8	—0·7	—5·4	26·8	27·8*	—3·2	— 5·8	...	...	...	...	...		...	...	...	...
12.25	25·8	26·9*	—0·6	—5·3	26·8	27·8*	—3·2	— 5·8	...	...	...	...	30·3	+0·8	...	...	...	..
12.30	25·8	26·8*	—0·6	—5·4	27·0	28·0	—3·0	+ 0·2	28·0*	31·0	—1·8	—10·0	31·0	+1·5	23·7	22·2	—1·3	—2·5
12.35	25·8	26·8*	—0·6	—5·4	27·0	28·0	—3·0	+ 0·2	...	...	...		...		...	...	...	...
12.40	25·7	26·8*	—0·7	—5·4	26·5	28·0	—3·5	+ 0·2	...	...	...	...	28·0*	—3·0	...	..	...	...
12.45	25·8	30·0	—0·6	+3·2	26·5	35·0	—3·5	+ 7·2	28·0*	33·0	—1·8	+ 2·0	...		...	...	...	...
12.50	25·5	35·3	—0·9	+8·5	26·0*	40·0	—4·0	+12·2	...	...		...	...	...	...	...	...	...
1	25·4*	35·8	—1·0	+9·0	26·5	44·0	+0·5	+16·2	...	...	...	...	...	...	23·7	22·4	—1·3	—2·3
1.15	26·3	35·5	+0·9	+8·7	28·5	57·0	+2·5	+29·2	29·8†	36·5	+1·8	+ 5·5	30·0	+2·0	...	...	...	...
1.30	26·8	40·2	+1·4	+13·4	28·5	41·0	+2·5	—16·0	...	...	...	...	30·5	+2·5	24·8	23·4	+1·1	+1·0
1.45	27·2	40·8	+1·8	+14·0	29·0	46·0	+3·0	+ 5·0	29·8†	47·5†	+1·8	+16·5	31·0	+3·0	...	...	...	...
2	27·2	41·4	+1·8	+14·6	30·0	52·5	+4 0	+11·5	...	...	...	...	31·0	+3·0	24·4	23·1	—0·4	—0·3
2.30	...	...	— —	..	...	...	...	...	...	...	...	...	...	...	24·4	23·0	—0·4	—0·4
3	24·8	23·8	—2·4	—17·6	...	...	...	...	...	...	...	...	31·0	+3·0	24·8	22·8	+0·4	—0·6

Amount of Solar Radiation (=sun, —shade). Thermometers at 4 feet.

Time.	Camden Square.	Holloway.	Hawsker.
	deg.	deg.	deg.
11	5·7	3·0	...
11.15	5·8	4·6	6·2
11.30	3·9	4·5	..
11.45	2·9	4·0	12·3
noon	2·7	2·5	8·8
12.15	1·4	1·7	...
12.20	0·9	1·0	...
12.30	1·0	1·0	3·0
12.45	4·2	8·5	5·0
1	10·4	17·5	...
1.15	9·2	28·5	6·7
1.30	13·4	12·5	...
1.45	13·6	17·0	17·7
2	14·2	22·5	...

To the Editor of the Meteorological Magazine.

Temperature during the latter half of the Solar Eclipse, 22nd December, 1870, observed at Sidmouth.

Chronometer showing Greenwich time.			Thermometers A.	B.	C.
h. m. s.					
12 19 43,	middle of eclipse				
,, 24	... bright sun	...	31°·3	... —	... —
,, 25	... ,,	...	31 ·0	... —	... 29°·5
,, 29 30	... ,,	...	32 ·0	... 36°·0	... —
,, 32	... cloud	...	31 ·1	... —	... —
,, 36	... sun	...	32 ·5	... —	... —
,, 38	... ,,	...	33 ·5	... —	... —
,, 39	... ,,	...	34 ·0	... —	... —
,, 41	... cloud	...	33 ·4	... —	... —
,, 45	... sun	...	35 ·0	... —	... —
,, 46 30	... ,,	...	36 ·0	... —	... —
,, 48	... ,,	...	37 ·0	... —	... —
,, 50	... ,,	...	38 ·0	... 45 ·0	... —
,, 58	... ,,	...	40 ·0	... 53 ·0	... —
1.0	... ,,	...	41 ·5	... 55 ·0	... —
,, 3	... ,,	...	43 ·0	... 57 ·0	... —
,, 9	... ,,	...	44 ·0	... 62 ·0	... —
,, 10	... ,,	...	45 ·5	.. —	... —
,, 13	... ,,	...	46 ·5	... 64 ·0	... —
,, 20	... ,,	...	48 ·8	... 67 ·0	... —
,, 27	... ,,	...	50 ·5	.. 71 ·0	... —
,, 37	... clouds	...	50 ·5	... 73 ·0	... 31 ·0
1 37 57,	end of the eclipse.				

N.B.—The time was mostly taken at the moment the mercury in rising touched the line marking the whole degrees. During the longer intervals the sun was more or less clouded. As long as the sun shone the mercury rose visibly and continuously, but the slightest film of cloud, almost invisible, caused a check and then a fall.

Thermometer A was laid on the side of a window facing south, so

that it could be observed with a magnifier through the glass. This thermometer is extremely sensitive, having a spiral bulb of 20 turns, a very fine bore, and being divided to the tenth of a degree (10° = 3½ in.) It has been verified at Kew, the correction only twice amounting to 0°·1; mounted on box wood scale.

Thermometer B has an exhausted jacket and black glass bulb; it is fixed parallel to A. Owing to reflected heat its readings are considerably higher than they would be if it were in a proper position. (On May 26, 1870, it stood at 168°.) When the white linen blind is drawn down inside the closed window, in full sunshine, it rises 2°. No lamp black. It rose to 97° on the 23rd of December.

Thermometer C, in a wooden box (like a sentry box), outside same window.

Sidmouth. R.

To the Editor of the Meteorological Magazine.

SIR,—I beg to enclose a few observations made during the late solar eclipse. As I was unable to leave the equatorial room, L. J. Crossley, Esq., F.M.S., of Willow Hall, very kindly instructed his assistant to read the thermometers. The remarks on the clouds, &c., are mine.—I am, dear Sir, yours very truly,

JOSEPH GLEDHILL, F.G.S., F.M.S.

Park Road Observatory, Halifax, Dec. 22nd, 1870.

Readings of Hygrometer in Shade, 4 feet from ground.

Time.	Dry Bulb.	Wet Bulb.	Time.	Dry Bulb.	Wet Bulb.
9 a.m.	25°·0	24°·7	1 p.m.	23°·7	22°·4
11 ,,	23 ·4	22 ·3	1.30 ,,	24 ·8	23 ·4
11.30 ,,	24 ·0	23 ·0	2 ,,	24 ·4	23 ·1
noon	24 ·0	23 ·0	2.30 ,,	24 ·4	23 ·0
12.30 p.m.	23 ·7	22 ·2	3 ,,	24 ·8	22 ·8

Remarks on Cloud, &c.—6 a.m. Some detached clouds pass slowly from N.E.—7 a.m. More cloud.—8 a.m. Cloudless zenith, sun rising in dark beds of cloud.—9 a.m. as at 8 a.m., with warm haze in S.E. —10.30 a.m. White clouds gather about sun, soon free from them. From this time until noon clouds often gathered near the sun.—11.45 a.m. The wind rose a little.—12.15 p.m. Dark clouds pass.—12.20 p.m. The southern sky now put on a stormy appearance, a dull haze covering the sky and cutting off the sun's light considerably; then a well defined glory surrounded the sun; the zenith was cloudless. From this time until 2 p.m. the sky was clear. At 1.30 the coloured fringes were well seen on the detached white clouds near the sun.

ADDITIONAL NOTES ON THE SQUALL OF OCT. 19, 1870.

The number of additional observations of this squall which we have received appearing to us insufficient to throw much further light upon its character, we think that the wisest course is to chronicle the additional reports which we have received, to point out that the longitude

of Chepstow was entered wrongly in our first table (Vol. V., p. 149), and to give in a second table the correct figures for Chepstow, and those for the additional returns received since November :—

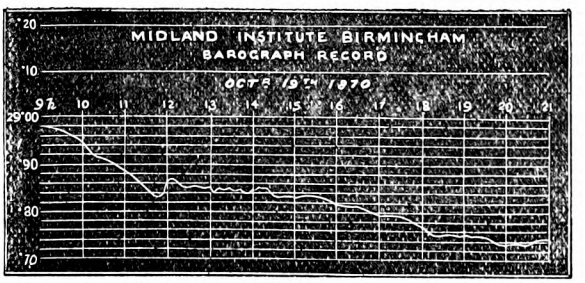
Station.	County.	Longitude.	Time of occurrence.		
			Reported.	Computed.	Difference.
St. Anne's	Pembroke..	5° 8′ W.	10.15	9.38	—37 min.
Ilminster.....	Somerset ...	2 54	about noon	11.30	—30 ,,
Chepstow	Monmouth.	2 41	11.15	11.41	+26 ,,
Frome Vanchurch	Dorset	2 33	11.42	11.47	+5 ,,
Birmingham	Warwick...	1 54	11.55	0.20	+25 ,,
Halifax	York	1 54	0.30	0.20	—10 ,,
Lymington	Hants	1 34	noon	0.37	+37 ,,
Banbury	Oxford.....	1 20	0.30	0.48	+18 ,,
Swyncombe.....	,, ...	1 0	0.40	1.5	+25 ,,
Winchmore Hill...	Middlesex..	0 6 W.	1.45	1.50	+5 ,,
Audley End	Essex	0 13 E.	2.3	2.6	+3 ,,
Eridge	Sussex	0 16 E.	1.55	2.7	+12 ,,

From the combined results of the two tables it appears that the rate of progress originally assumed was very nearly correct, if anything about three miles per hour too slow ; 53 miles per hour would apparently agree better with the recorded times than 50 miles, but the error is not serious.

St. Anne's, Milford, South Wales.—October 19th, 8 a.m., bar. 29·11 ; ther., 58° ; wind, S.W. ; force, 8 ; rain during preceding 24 hours, 0·51. *Note.*—A gale from S.W. at 2 p.m. on the 18th until 10.30 a.m. on the 19th, with a very severe squall at 10.15 a.m. on the 19th.—*T. L. Marriott.*

Ilminster.—On the 19th, about noon, there was a violent hailstorm, which did not last beyond half-an-hour, and tore down some trees. During this storm the thermometer fell to 45° from 56°·5 at 9 a.m. On this day, also, was the greatest fall of rain (·87 in.).—*J. Knott.*

Sir,—I enclose tracings from our instruments, which will give you the variations of wind and of barometric pressure for the time you name.



The actual corrected reading of the standard barometer at 9 a.m. on October 19th was 28·928 in., so that, as you see, the barograph readings are somewhat higher than the standard. The following

pressures of wind on the square foot occurred at the times named, October 19th, 1870 :—

9·0 a.m.	... 2 lbs.	11·0 a.m.	... 5·5 lbs.
9·5 ,,	... 3·5 ,,	11·5 ,,	... 6·2 ,, (max.)
9·6 ,,	... 4·0 ,,	12·0	... 5·8 ,,
10·3 ,,	.. 2·0 ,,	1·0 p.m.	... 0·8 ,,

The record is imperfect after this hour.—Yours truly,

C. J. WOODWARD.

Midland Institute, Birmingham, Dec. 23rd, 1870.

Willow Hall Observatory, Halifax.

Lat. 53° 43′ 7″ N. Lon. 1° 53′ 56″ W. 630 feet above sea level.

Time.	Bar.	Temp.	Direction of Wind.	Velocity	Remarks.
Oct. 19, 1 a.m.	...	...	S.S.W.	19	Rain ·004.
2 ,,	...	...	W.S.W.	17	,, ·005, veering suddenly towards the west.
3 ,,	...	...	W.E.S.	22	
4 ,,	...	...	W.S.W.	23	
5 ,,	...	...	S.S.W.	22	
6 ,,	...	...	S.S.W.	10	
7 ,,	...	...	S.S.W.	7	
8 ,,	...	...	S.S.W.	6	
9 ,,	29·362	50·48	S.E.W.	9	Rain for previous 24 hours, ·105.
10 ,,	...	...	S.E.W.	9	
11 ,,	...	...	S.	12	
Noon.	29·195	52·50	S.	16	
1 p.m.	...	...	S.W.	22	At 12.30 the wind changed suddenly into the S.W.
2 ,,	...	...	S.S.W.	12	
3 ,,	29·160	51·47	S.W.	15	
4 ,,	...	...	S.W.	13	At 6.30, 6.50, and 7.10 there were peculiar puffs of wind from the S.W.
5 ,,	...	...	S.W., E.S.	11	
6 ,,	...	...	S.S.W.	12	
7 ,,	...	...	S.S.W.	17	
8 ,,	...	...	S.W., E.W.	18	
9 ,,	29·029	...	S.W., E.W.	20	
10 ,,	...	...	W.N.W.	20	A sudden change here at 9·55 into the W.N.W.
11 ,,	...	...	W.	19	
Midnight.	...	...	W.	21	
Oct. 20, 1 a.m.	...	...	W.E.S.	19	Heavy squalls from N.W. to W.S.W.
2 ,,	...	...	W.E.N.	21	
3 ,,	...	...	W.S.W.	19	
4 ,,	...	...	W.S.W.	20	The wind here became more steady, but backing gradually into the S.W.
5 ,,	...	...	W.S.W.	21	
6 ,,	...	...	S.W., E.W.	22	
7 ,,	...	...	S.W., E.W.	21	Rain previous 24 hours ·485; the wind here became squally, and at 11.40 veered suddenly from S.W. into N.W., in which quarter it remained throughout the whole day, the velocity averaging about 15 miles per hour.
8 ,,	...	...	S.W.	21	
9 ,,	29·128	43·42	W.S.W.	29	
10 ,,	...	...	...	14	

L. J. Crossley.

WAINSFORD, LYMINGTON, HANTS.—I give you an extract from my register of the gale of 19th October last, and also the readings of my

barometer the day previous and two days after. You will observe the gale began at night on the 18th from S.W., thence round to N.N.W., ending in a flat calm.

	10 A.M. Bar.	Wind and Force.	10 P.M. Bar.	Wind and Force.	
18th...	29·83...	W.S.W., IV.	29·54 ..	S.W., IX.	Strong gale at night.
19th...	29·49...	W.S.W., VIII.	29·36...	W., IX.	Fresh to a strong gale; heavy squall midday.
20th...	29·51...	N.W. V.	29·53...	N.W., VII.	Fresh breeze, increasing to a moderate gale at night.
21st...	29·85...	N.N.W., III.	29·95...	Z. O.	Fine.

Rainfall:—18th, 0·18 in.; 19th, 0·44 in.; 20th, 0·15 in.; 21st, 0·0 in. —*H. Fawcett.*

BANBURY.—Extracts from Meteorological Register at 5, High Street. October 18th, 9 a.m. :—Bar. at 32°, 29·543 ; dry ther., 45·0 ; wet ther, 44·5 ; wind, N.W. 3 p.m. :—Bar. at 32°, 29·405 ; dry ther., 55° ; wet ther., 51·0 ; wind, S.; max. temp., 55·0 ; min. temp., 38·0 ; rain, 0·21. October 19th, 9 a.m. :—Bar. at 32°, 29·136 ; dry ther., 50 9; wet ther., 49·0. 3 p.m.:—Bar. at 32°, 28·977; dry ther., 48·5 ; wet ther., 47·0 ; max. temp., 56°·0 ; min. temp., 44°·0 ; rain, 0·37.—*T. Beesley.—Erratum.*—In the account of the storm of Oct. 19th, in last month's *Meteorological Magazine*, "Burton Danete" should have been "Burton Dassett."

WINCHMORE HILL.—A violent storm of wind, hail, and rain passed over here at 1.45 on the 19th of October. The wind at the time was strong from S.W., but suddenly shifted to N.W. during the storm. The storm lasted for about ten minutes, during which time the rainfall was ·30 inch. Another, though less violent, passed over at 4.30, accompanied with hail and distant thunder.—*Thos. Paulin.*

DATE.	Bar. reduced to 32° and sea level.		Wind.			Rain.	Mean Temp.
	9 a.m.	10 p.m.	9 a.m.	1 p.m.	4 p.m.		
Oct. 18th ...	29·861	29·702	S.W.	S.S.W.	S.S.W.	0·14	47·6
,, 19th ...	29·630	29·392	S.W.	S.W.	S.W.	0·29	52·1
,, 20th ...	29·503	29·500	W.S.W.	W.	S.W.	0·17	46·2
,, 21st ...	29·884	30·029	N.W.	N.W.	W.N.W.	...	48·9

Weather on 19th—Unsettled, gusty, rainy afternoon.

Francis Nunes, Chislehurst.

AUDLEY END GARDENS, SAFFRON WALDEN.—In my letter to you of November 23rd, respecting the squall of October 19th, and published by you this month, I find there is an error respecting the temperature, which should have been 57° instead of 67°.—*J. Bryan.*

KILLINGHOLME, NEAR ULCEBY.—In compliance with the request made in your last number for notes of the weather on October 19th, I send you an extract from my log-book for that day. Ther.: min. 48°,

max. 56°; bar. at 9 a.m., 29·55; wind S.W., squalls, with rain; rainfall, ·21. A telegram of this date from Washington, reports—"severe storm on Lakes Erie and Ontario." October 20th:—wind, W.S.W.; force, 5; heavy showers; rainfall, ·21. An earthquake in Canada.—*J. Byron, M.A.*

HOW OUGHT THE TEMPERATURE AND RAINFALL TO BE ENTERED?

To the Editor of the Meteorological Magazine.

DEAR SIR,—You will, I have no doubt, recollect that some few years since the observers of rainfall were not all of the same opinion as to the entry of the same,—some entering to the day on which it was measured, while others entered to the day on which it fell. They are, I believe, now quite agreed in very properly entering to the day on which the rain actually fell. And as regards the temperature, I was surprised to read as follows, at p. 205, in the *Meteorological Magazine* for January, 1871:—"The minimum temperature indicated by the thermometer, when read at 9 a.m., is the minimum of that day, and is always to be so entered." Now, without the gift of prophecy, I cannot understand how the minimum or maximum temperature of any given day can be ascertained at 9 a.m. of that day. Surely the day must have closed before its history can be written, and the day does not, I suppose, close until 12 p.m. But as this is an inconvenient time to make observations, and 9 a.m. is admitted to be the most convenient to do so, is it not advisable to consider the day, as far as meteorological observations are concerned, to commence at 9 a.m.; and to enter the maximum and minimum temperature, as well as the rainfall, then read to the preceding day?

Such has always been my practice, and the indices of maximum as well as minimum thermometers are never moved except at that time.

It does not follow that the greatest depression should always take place during the night. Indeed, during the winter, 9 a.m. is not unfrequently the coldest period during the 24 hours, and the exact time of the minimum temperature of two consecutive days occurs sometimes at the same moment. Thus, on any given day—say January 20th, at 9 a.m.—the temperature we will suppose to be 32°, and the index or float close to the top of the spirit column, showing that there could have been no greater depression during the preceding 24 hours, 32° would be consequently entered as the minimum temperature of January 19th; and the index, being at the extremity of the spirit, could not, and would not, require to be moved. And should it so happen that no greater depression of temperature occurred during the succeeding 24 hours, 32° would again be read, on the morning of the 21st, at 9 a.m., as the minimum temperature of January 20th.

If my practice is wrong, I am quite willing to endeavour to reform it, but we certainly ought to have something like uniformity in the matter.—I am, yours, &c., P. GRIEVE.

Culford, Bury St. Edmunds, Jan. 23rd, 1871.

To the Editor of the Meteorological Magazine.

SIR,—Nothing can be more useful in the way of conducing to accuracy of observation in meteorology than the discussion of matters of detail, for which your Magazine supplies the only available medium. In the number for this month, at p. 205, you quote with approval the remark of a correspondent, to the effect that the minimum thermometer should be read and set at 9 a.m., and the reading assigned to the day on which it is taken. Now I fully agree with your correspondent, that it the reading of the minimum thermometer is to be taken at 9 a.m-, it should be set down to the day on which it is taken rather than to the previous day; but I wish to state the grounds upon which I hold that the reading of the minimum thermometer should *not* be taken at 9 a.m.

To read the minimum thermometer at 9 a.m. in winter, or to read the maximum thermometer at 3 p.m. in summer, is to give to every exceptional extreme double its proper value. That is to say, every very low minimum will count as two very low minima, and every very high maximum will count as two very high maxima. Undoubtedly, the minimum recorded should be the minimum of 24 hours, and the maximum recorded should be the maximum of 24 hours; but the 24 hours for the minimum should be the 24 hours of which the normal minimum is the centre, as nearly as may consist with the general scheme of observations; and, similarly, the 24 hours for the maximum should be the 24 hours of which the normal maximum is the centre, as nearly as may be. In other words, if the observations are taken at 9 a.m. and 3 p.m., the minimum should be read and set at 3 p.m. and the maximum at 9 a.m. Strictly, both instruments should be *read* at both times, and all the readings should be entered in the rough memorandum book. An excellent check will thus be obtained. If the readings agree, each will confirm the other. If they differ, then the case must be investigated, in order to ascertain whether one of the readings was erroneous, or whether the index has actually moved in the interval. If it be found, for example, at 9 a.m. that the minimum is 30°, and at 3 p.m. that it is 28°, and the known circumstances of the weather of the day do not forbid the supposition that both readings are true, then 28° must be set down in the permanent record as the minimum of that day, and a note may be appended in the following form—"min. to 9 a.m. 30°."

It appears to me that this is the correct method, whether we regard index readings as data for the calculation of mean temperatures, or whether we regard them as observations having an interest *per se*. Under the former aspect, I have already referred to the impropriety of cutting each extreme reading into two by selecting an hour likely to coincide very nearly with the occurrence of such extreme. Under the latter aspect, the adoption of 9 a.m. readings for the minimum, or of 3 p.m. readings for the maximum, must involve hopeless confusion in the investigation of any particular wave of heat or cold. Suppose, for example, that on a certain morning—say the 24th of December—an

intense frost prevailed throughout the country, followed in the latter part of the day by a rapid rise of temperature, except in a few places where severe frost continued through the next night. It is desired to ascertain the area within which the frost persisted. But the observations are taken and the instruments set at 9 a.m., about which hour the minimum would very likely have occurred in most places, while in some the temperature might have continued falling until after 9. Accordingly, the minimum of the 25th will be everywhere nearly as low as that of the 24th, and in some places, even where the change had occurred, it will be the lower of the two. Under these circumstances, it would be evidently impossible, by an inspection of the records, to distinguish those places in which severe frost prevailed in the night between the 24th and 25th from those in which that night was comparatively warm.

If it be said, in reply, that for such a purpose special observations must be taken, I answer that there is no occasion. The ordinary observations, conducted in the way I suggest, representing, as they would, something more real and true than when taken in the other method, would not only be the best possible for the calculation of means, but would also be readily available for the purpose of any special inquiry.

Yours truly,

GEORGE F. BURDER, M.D.

Clifton, 24th January, 1871.

To the Editor of the Meteorological Magazine.

SIR,—Will you allow me to make some remarks on a passage in your last number, on page 205—"when the minimum of the thermometer is noted at 9 a.m., *as it should be?*" Surely 9 a.m. is a very bad time, as in winter it is very near the ordinary time of minimum, so that it will frequently happen that one occurrence of cold will be entered on two days. This will make a great difference in estimating the average minimum temperature. I should have thought the usual time of greatest heat to be the proper time to record the minimum; so I always record it at 2 p.m.—I am, yours truly,

T. W. BACKHOUSE.

Sunderland, Jan. 25th, 1871.

To the Editor of the Meteorological Magazine.

SIR,—I shall be much obliged if you will put me right in this matter. I understand, from p. 205 of your *Meteorological Magazine*, that the temperature of the minimum thermometer read at 9 a.m., say on the 2nd of February, is the minimum temp. of the *2nd* not the *1st* of that month. Am I right in this? If so, take this case:—On the 1st of February, at 9 a.m., the temp. is at the minimum of that day, say 30°; then, on setting the thermometer, the minimum cannot be higher for the 2nd inst. than 30°, although the temp. may considerably increase after the morning of the 1st inst.; so that the minimum, on the 2nd of February, would be as low as that of the 1st inst., though

the temp. since 9 a.m. of the 1st had risen considerably. I hope I make myself understood. The minimum temperature, I believe, is, *as a rule*, just before sunrise, so that that temp. would be the minimum of the same day, not of that before. With many apologies for this muddle, yours very truly, W. D. NASH.

Buckingham Villas, Clifton, January 31st, 1871.

SOLAR RADIATION.

To the Editor of the Meteorological Magazine.

SIR,—I read with much interest Mr. Procter's letter on solar thermometers in your December number. That the thermometer *in vacuo* is a kind of "heat-trap" is in substance what I have always maintained, and I have often combated the notion that it or any other thermometer can give an absolute measure of solar radiation. It is only a convenient means of measuring the variations in the amount of radiation, and the more of a heat-trap it is, the more easily is it affected by the slightest change in the intensity of the sun's rays.

With reference to Mr. Nunes' letter, in which he reminds me that one of his two solar thermometers by Casella reads 3° higher than the other, I need only say that I do not consider 3° a very extraordinary difference, but I believe it is more than the average. I have very recently had four to test for a friend; and when compared with mine, there was on sunny days an average difference of 2°·3 between the highest and the lowest of the five on each day, and the average readings of the five on 14 such days were 78°·4, 77°·7, 77°·3, 77°·3, 76°·4.

I can assure Mr. Pastorelli I have not the least wish or intention to impugn the well-known accuracy of his instruments. Still the evidence against A seemed to me conclusive. But if A, after being re-exhausted with all possible care, behaves no better, we must look for some other reason, His quotations, however, are not to the point. He first referred to the utmost difference I had observed between thermometers *in vacuo* blackened both on bulb and stem and those blackened only on the bulb. The second proved not the badness of the instruments used in your experiments, but the folly of expecting exact results from thermometers *in vacuo* placed on the grass. When placed on the uniform surface of a tray, you found them, if I remember rightly, to agree very closely.—I remain, Sir, your obedient servant,

FENWICK W. STOW.

ANEROID BAROMETERS.

To the Editor of the Meteorological Magazine.

SIR,—The correspondence which has recently appeared in your columns on the subject of aneroid barometers induced me to retest one which I bought some eight years ago from Messrs. Negretti and Zambra. At 2 p.m. to-day the instrument read 29·782 in. in a room having a temperature of 40°. I placed it in another room where a thermometer near it showed a temperature of 64°. Having remained there for a full half hour, it read 29·784 in., showing an increase of ·002 in. I

then removed the aneroid out of doors, where the temperature was 33°. In half an hour I again read it and found it stood at 29·786 in., showing still an increase of ·002 in. This increase of ·004 in. in the hour could not be due to imperfect compensation, as it occurred both with an increased and diminished temperature. It was, in fact, a natural increase of atmospheric pressure, which continued at the same rate for some hours afterwards. I may add, that on former occasions I have tested the aneroid much more severely with similar results. It has had very hard work, too, as I have used it for taking altitudes on some two or three hundred occasions, a purpose for which I find it admirably adapted. I have not compared its readings with the mercurial standard daily, but have only had occasion to alter it two or three times since I bought it. I have great faith in well-made aneroids, and consider them superior, even for scientific purposes, to many so-called "standard" instruments.—Yours truly, JOHN THRUSTANS, F.M.S.

Merridale, Wolverhampton, Jan. 27th, 1871.

A LUNAR RAINBOW.

To the Editor of the Meteorological Magazine.

SIR,—Last night a beautiful lunar rainbow was seen to the W.N.W. of this place. I first saw it at 10.35 p.m., and it lasted after that for ten minutes, finally dying away at 10.45 p.m. Faint colours were distinctly visible, but the arc was apparently narrower than that of a solar rainbow. The night was tolerably calm and mild for the season (the temperature being 45°), with a slight sea fog, and thick drizzling rain; and the moon shone with a pale light through the misty atmosphere.—I remain, Sir, yours very truly,

ARCHDALL E. BUTTEMER.

Burnham, Somerset, Feb. 8th, 1871.

BEST GUIDE TO AIR TEMPERATURE.

To the Editor of the Meteorological Magazine.

SIR,—Your correspondent, Mr. Ffolkes, is disposed to come to the conclusion, "that the plan of affixing a thermometer to an exposed wall or a bare board is the most accurate index of the cold."

I shall be glad if you will allow me to say a few words in arrest of this judgment.

As Englishmen are great sticklers for authority, I will first of all appeal to the law as laid down by one whose opinion ought to carry as much weight as that of any living man on every subject to which he has given his attention, Astronomy, Meteorology, or Optics.

Sir John Herschell insists (*Admiralty Manual*, 3rd Ed., p. 131) that the external thermometer "should be especially guarded from rain and from spray, so that the bulb should never be wetted;" "it should be *completely screened from the sky*, so as to annihilate all loss of heat by upward radiation."

It is very well known that on clear nights the temperature of the

ground falls much lower than that of the air immediately above it, and every meteorologist is aware that the reason of the difference lies in the fact that the earth radiates its heat to the sky, and receives no heat in return. Now, just as the earth radiates, the bulb of the thermometer must radiate too, "*pro viribus suis.*" And that the radiating powers of glass are by no means contemptible every astronomer knows to his cost. If, on a damp night, the dew cap of his refractor be forgotten, the object glass is soon obscured by dew. Now what does this prove? It proves that the temperature of the object glass has fallen not only below the temperature of the air but below the temperature of the dew point, yet the object glass is mounted in a brass cell, and has only one surface exposed to the air. Can any reason be assigned why the bulb of an exposed thermometer should not do the same? And the mischief does not end here. The dew once deposited may evaporate again; the evaporation demands a certain amount of heat, and this heat must either be abstracted from the bulb of the thermometer, or intercepted on the way to it. If the bulb of the thermometer be wetted with snow, it falls to the freezing point at once, though the air may still be some degrees above it; if wetted with rain at or near the time when the temperature is lowest, we have the minimum of the wet bulb instead of the minimum of the dry one.

As Mr. Ffolkes overlooks the influence of radiation on the minimum thermometer, he probably makes less account of the influence of reflection on the maximum. Here, again, I quote from Sir John Herschell: "An exposure should be chosen perfectly shaded both from direct sunshine and that reflected from the sea [ground] or radiated from any hot object." Perhaps in their anxiety to secure free exposure to the air, meteorologists may sometimes be inclined to neglect precautions which are scarcely less essential.

One day last week, by way of experiment, I threw the light of the sun, reflected from a small piece of window glass, on the bulb of a sensitive thermometer about 14 feet distant. In one minute the mercury rose 1°; in five minutes, 2°; in ten minutes, 3°. When the sun was turned off, the mercury fell rather more rapidly than it rose. During the whole time the sun was more or less obscured by haze, and his rays passed obliquely through a window. The thermometer, which is divided to tenths of a degree, was observed through a telescope. In this case the heat rays were also, in part at least, luminous; but, as the larger portion of the heat rays reflected or radiated upon the bulb of an exposed thermometer from the surrounding objects are mostly obscure, their action may be quite invisible. But whenever such objects are heated by the sun above the temperature of the air, the bulb of an exposed thermometer *must* receive more heat than it gives, *i. e.*, must stand higher *pro tanto* than it ought to do. It has been remarked that the temperatures registered at Greenwich, on the hottest days of the year, are considerably higher than the maxima at Kew. Perhaps the difference in the thermometer stands respectively employed may go far to account for the difference.

R.

JANUARY, 1871.

Div.		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.	Date.	Min. Deg.	Date.	No. of Nights below 32° In shade	On grass
			inches	inches.	in.								
I.	ENGLAND.	Camden Town	1·99	+ ·04	·42	22	17	45·2	7	19·7	13	23	27
II.		Maidstone (Linton Park)	3·50	+ 1·44	·48	25	22	47·0	17	15·0	5	26	...
,,		Selborne (The Wakes)	3·12	— ·15	·54	16	18	45·0	7	3·0	1	24	26
III.		Hitchen	1·17	— ·97	·23	15	16	44·0	6	12·0	1	31	...
,,		Banbury	1·13	— ·96	·45	15	12	44·0	6	11·0	1	28	...
IV.		Bury St. Edmunds (Culford)	1·08	— ·79	·20	6	13	43·0	6	14·0	1	25	31
V.		Bridport	2·99	— ·20	·59	21	14	47·0	6	15·0	5	21	...
,,		Barnstaple	3·78	+ ·26	·75	15	16	50·0	15	14·0	1	5	...
,,		Bodmin	5·06	— ·13	1·02	15	22	47·0	13	23·0	1	7	23
VI.		Cirencester	1·86	— 1·14	·57	9	6	...	...	...	...	...	...
,,		Shiffnal (Haughton Hall)	1·78	— ·12	·65	9	11	40·0	5, 15	9·0	1	30	...
,,		Tenbury (Orleton)	2·82	+ ·29	·68	15	15	48·0	6	5·5	1	23	27
VII.		Leicester (Wigston)	0·96	— 1·02	·33	16	10	44·0	6	16·0	1	27	...
,,		Boston	0·89	— ·82	·35	15	14	48·0	6	4·0	1	25	29
,,		Grimsby (Killingholme)	0·97	...	·20	15	17	43·0	14*	11·0	1	20	...
,,		Derby	0·82	— ·97	·27	15	12	45·0	6	10 0	1	22	...
VIII.		Manchester	3·30	+ ·78	..	...	13	..	...	...	...	...	...
IX.		York	0·70	— ·88	·46	15	7	46·0	6	10·0	1	21	...
,,		Skipton (Arncliffe)	2·65	— 2·99	·95	5	11	44·0	7	2·0	1	26	...
X.		North Shields	1·13	— ·98	·28	22	17	47·0	14	12·0	1	20	28
,,		Borrowdale (Seathwaite)	11·95	— 4·41	3·63	7	11	...	...	...	...	...	...
XI.	WALES.	Cardiff (Town Hall)	...	...	...	...	...	...	...	...	...	...	...
,,		Haverfordwest	6·05	+ 1·00	·93	16	16	49·0	6	18·0	28	20	26
,,		Rhayader (Cefnfaes)	3·19	— 1·33	1·00	6	9	53·0	...	5·0	4	28	...
,,		Llandudno	1·87	— ·67	·29	15	16	51·4	14	23·0	1	14	...
XII.	SCOTLAND.	Dumfries	2·58	— 2·02	·54	4	10	48·5	6	12·5	28	22	...
,,		Hawick (Silverbut Hall)	1·81	...	·44	6	9	...	...	..		...	...
XIV.		Ayr (Auchendrane House)	3·99	— ·53	·74	7	12	53·0	16	17·0	25	16	28
XV.		Castle Toward	3·39	— 2·90	·76	1	19	49·0	6	21·0	24	22	26
XVI.		Leven (Nookton)	1·31	— 1·56	·25	4, 6	15	46·0	14	13·0	28	26	30
,,		Stirling (Deanston)	2·93	— 1·79	·76	6	17	46·0	14	16·8	28	28	29
,,		Logierait	1·67	...	·42	6	14	...	...	...	...	...	...
XVII.		Ballater	1·74	...	·75	15	6	46·0	6	7·5	24	25	...
,,		Aberdeen	1·53	...	·45	15	17	44·9	14	21·4	3	19	31
XVIII.		Inverness (Culloden)	1·74	...	·80	14	14	46·1	6	25·7	24	14	29
,,		Portree	8·26	— 4·83	1·58	16	24	...	...	...	...	...	...
,,		Loch Broom	4·11	...	·90	15	12	...	...	...	...	...	...
XIX.		Helmsdale	1·85	...	·46	6	18	...	..	...	...	...	...
,,		Sandwick	1·65	— 1·64	·22	9, 10	18	48·0	6	27·7	21	8	21
XX.	IRELAND.	Cork	4·92	...	·58	15	24	...	...	...	...	...	...
,,		Waterford	4·81	— ·05	·64	31	26	50·0	6	27·0	22	12	...
,,		Killaloe	4·96	+ ·10	·63	5	24	50·0	5, 6	22·0	26	13	...
XXI.		Portarlington	3·43	— ·58	·44	11	29	55·0	6	26·0	1	20	...
,,		Monkstown	2·90	— ·49	·61	10	18	...	...	...	...	...	...
XXII		Galway	6·44	...	·87	14	26	50·0	20	29·0	24	9	...
,,		Bunninadden (Doo Castle)	4·57	...	·31	9	20	48·0	13	21·0	25	13	...
XXIII		Bawnboy (Owendoon)	...	...	..	...	...	...	...	...	..	...	..
,,		Waringstown	3·10	...	·74	1	20	52·0	6	22·0	26	22	28
,,		Strabane (Leckpatrick)	4·37	..	·43	15	24	47·0	5	20·0	25	30	31

* And 15.

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

METEOROLOGICAL NOTES ON JANUARY.

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.—The severe frost that commenced on the 21st of December continued with only a partial cessation of one day till the 13th of January, when a cold thaw, with occasional heavy falls of R and sleet, set in till the 24th, when more S fell, accompanied with frost, which continued to the end; the whole being an exceedingly wintry month, S being on the ground nearly the whole of it.

SELBORNE.—Intense cold, ther. 3° on the 1st. A wretchedly gloomy month, scarcely a ray of sunshine to enliven the prospect. Max. ther. down to 32° on eight days; much dense fog the latter end of the month, much illness and distress from want of work amongst the labouring class; thaw on 14th, ther. 40° at 9 a.m.; on 15th, ther. 39° at 11 a.m., fell to 35° by 12.30; most tempestuous night on 16th, R at night, H and S in morning; faint aurora on 17th.

CULFORD.—This has been the coldest January that I have recorded, even the max. temp. of five days was below the freezing point, and the mean temp. of the month was only 32°.; S has fallen slightly on five days; on 16th T was heard at intervals from 12.30 p.m. until about 2 p.m.

BRIDPORT.—S nearly 5 inches deep on the 2nd; heavy south-westerly gales on 15th and 16th; frosty weather the last week and good skating.

BODMIN.—A very heavy S.S.E. gale on the 15th; mean temp. of the month, 37°·2.

HAUGHTON HALL, SHIFNAL.—A severe month, fully justifying Mr. Brumham's calculations; the min. ther. only averaged 25°·75, the max. do. 34°, and only one night above 32°. The month opened with a severe frost (9°), with a beautiful rime and bright sun; S fell on 4th, 11th, 25th and 29th; a rapid thaw set in on 15th with R and sleet, but the frost returned on 17th with a S.W. wind and very low bar. (28·47), and lasted through the month. The sun was visible only on six days. The winds came chiefly from the S. and S.W. up to the 23rd, and from N.W. and N.E. to the close; a remarkable absence of gales; the ice was $7\frac{1}{4}$ inches thick on the pools, and bore skaters throughout the month; the roads a continual sheet of ice.

ORLETON.—A remarkably cold month, with severe and continuous frost, a great prevalence of fog and cloud, and very little clear sky; ther. on 1st fell to 5°·5 in shade (protected) and to 1°·5 on grass plot; temp. of month about 6° below the average, and 0°·6 lower than that of January, 1861; all the rivers frozen over at the beginning of the month; S on the 9th 12 inches deep on the high lands; bar. very low on the 16th.

BOSTON.—Very severe frost in the first week; on the 1st the ther. registered the min. reading of the month, viz. 4° at 4 feet above the ground, while the grass min. fell to —4°; very severe gale from the S.W. on the 16th; the latter part of the month was cold and foggy, with frequent S showers.

GRIMSBY, KILLINGHOLME.—A month of frost and cloudy skies, with scarce any intermission.

MANCHESTER.—We have not had so long a season of continuous frost for many years.

SEATHWAITE.—Two days on which more than 3 inches of rain fell.

WALES.

HAVERFORDWEST.—Very wet and cold month; the last fortnight the frost was severe, the E. wind rising to a gale during the last two days of the month. Very severe gale on 16th and 17th; great depression of the mercury, which continued below 29·00 from the 16th to the afternoon of the 18th; lowest depression 28·597 at 3 a.m. on the 16th.

CEFNFAES.—An extremely cold month, wind generally N.E. or S.E., temp. low, S at intervals, and on the night of the 21st a heavy fall from 7 to 9 inches deep, which continued on the ground to the end of the month; great loss of sheep on the hills, and general want of fodder.

LLANDUDNO.—S on the hills from the 18th to 31st.

SCOTLAND.

DUMFRIES.—R fell on three days in the first week, and from the 12th to the 17th, during which time the weather was stormy; the rest of the month frosty, with falls of S; the plough has been stopped for six weeks; mean temp. of the month 32°·69 or 3°·66 below the corresponding month of last year and 9°·1 below January of 1869.

HAWICK.—The frost throughout the month has been most severe—nothing like it since 1861.

AUCHENDRANE.—A low mean temp., with even its small capacity for vapour not fully saturated, prevailed during the month, along with bar. pressure and range slightly differing from the January means; also a small rainfall, small elastic force of vapour, low dew point and weak evaporation. There was likewise an unusual number of ice days, with a few slight snowfalls and a rather low force of wind and amount of cloud. Gales occurred on the 1st, 6th, 7th, 14th and 16th, all equatorial, and the month closes with a strong polar breeze from the E. on the 30th and 31st; the gale of the 16th was well marked by the lowest bar. and highest ther. in shade in the month. The exposed ther. on grass during the calm night and early morning of the 25th had fallen to 11°; according to the self-registering thermometer in shade, the nights were from 8° to 15° colder than the days; rivers generally large and filled with fixed and loose ice. The month has been throughout very wintry, ploughing and out-door labour has been much interrupted, horizon frequently hazy, but few dense fogs.

CASTLE TOWARD.—A cold, cloudy and wintry month, with frequent frosts, wet days, and small amount of sunshine; gales on the 1st and 16th from the S.W., but the prevailing winds were N., N.E. and N.W.; about 1 inch of S on the 26th and 27th, which still lies close to the salt water edge. During the last eight days the max. has not been above 39°, nor the min. below 29°; bar. steady and high since the 21st; it has not been below 30·20 since the 24th.

DEANSTON.—On the 2nd 3 inches of S; 4th and 5th thaw and R, S all gone, high wind; on the 7th and 9th 1 inch of S, with strong N.W. winds; then bright, calm and frosty till the 13th; great fall of bar. from the 12th to the 16th, from 30·67 to 28·25; gale of wind on the 16th, after which the bar. rose gradually, and on the 31st was 30·10; latter half of month very dull, hazy, frosty, and cold E. winds.

LOGIERAIT.—First half of the month changeable; continued frost, with occasional showers of S, from the 17th; rainfall small, being 2·78 inches less than the average for the five preceding years.

BALLATER.—A month of very severe weather, the ground remaining covered with S throughout, the frost never relapsing, all out-door work completely suspended, the last few days dull, with indications of a change of weather, which was greatly desired.

ABERDEEN.—Bar., mean temp. and rainfall all below the average; winds from S.E., S. and S.W., in excess of frequency above the average; pressure of wind little more than half the average; a cold, dry, hard month; 3 inches below the surface the ground never softened during the month; frequent S and sleet, several auroræ, but all faint; lunar halo during the eclipse.

PORTREE.—Gale from the S. on the 16th and 17th; S, H, sleet, and frost from the 1st to the 22nd; black frost from latter date to the end of the month; T and L on evenings of 5th and 6th; have not had such severe frost in January during the memory of the oldest inhabitant.

LOCHBROOM.—The first half of the month was very wet and stormy, and the last half has been remarkable for the keenness of its frost, blighting everything green, and destroying turnips and all exposed vegetables.

SANDWICK.—This has been one of the driest and coldest Januarys during the whole period of observation, there having been only two drier, viz. 1847 and 1864, and four colder, viz. 1827, 1838, 1841 and 1867. The rainfall, however, at Balfour was 3·3 inches, and at Hoy High Lighthouse 5·45 inches. The bar. was lower on the 16th than for many years, except in December, 1869, when it was 28·094 instead of 28·170. Aurora on the 4th, corruscating to zenith; T and L on the 6th.

IRELAND.

DOO CASTLE.—A cold and ungenial month.

WARINGSTOWN.—Rainfall about the average, and the month, although the weather was extremely disagreeable and unfavourable to labour in consequence of frequent frosts, was not colder than the average here, though it seems to have been so at other stations.

LECKPATRICK.—Very cold month; great fall of bar. from the 12th to the 16th from 30·243 to 28·307 corrected, on morning of 16th, at 9 a.m., mercury rising fast, so that probably this was not the min.; moderate gale blowing from S.W.; mean min. temp. of month 33°·16; coldest of last seven years, except 1867, when it was 31°·5.

OZONE OBSERVATIONS.

To the Editor of the Meteorological Magazine.

SIR,—I think Mr. Gledhill is rather hard on me in respect to ozone observations. When I first took ozone observations, I did so at 9 a.m. only; and finding sometimes (for it is very seldom I am at home in the daytime) that all colour had disappeared from a previously coloured paper, I thought I would look at these papers every twelve hours. Similar results occurred—as I knew for certain, when being at home in the daytime, I had an opportunity of looking at the papers every three hours. Now, as I can only see the papers (as a rule) twice a day, and I know that a paper, which has been coloured, does lose all its colour sometimes before I can see it; and as I cannot tell how deep a colour a paper may have been during the day, as it is quite white at night, I did not see what use I could make of it. I could not put down in my register "No ozone," as for anything I knew to the contrary, there might have been a great deal. When a person can see his ozone papers at any time of the day, then Mr. Gledhill is right in insisting a record should be kept, and that ozone should not be regarded as a delusion or a snare.

In regard to determining the amount of discoloration, I found considerable difficulty in comparing the papers with the ozonometer at night, and I never yet got the colours represented at p. 31 of Sir Henry James' book on "Instructions for taking Meteorological Observations." London: G. E. Eyre and William Spottiswoode. 1861.

Your obedient servant,

HARRY CHICHESTER, F.M.S.

Fartown, Huddersfield, Jan. 22nd, 1871.

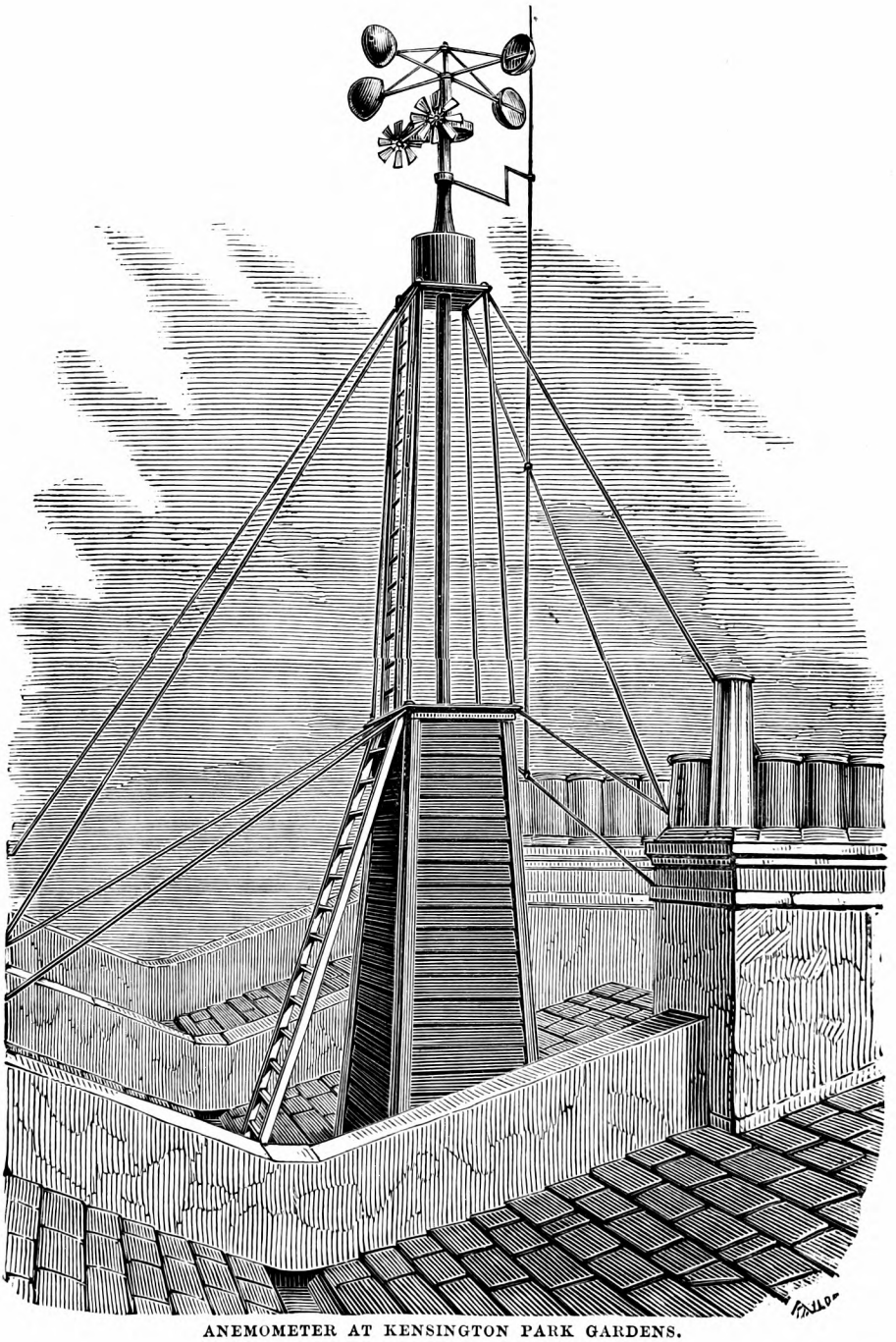
AURORAL LIGHT.

To the Editor of the Meteorological Magazine.

SIR,—On Saturday evening, December 17, 1870, at 6 p.m., two rather considerable masses of auroral light were seen here, Lat. 51° 35′ N., Long. 1 second West of Greenwich; they met near the zenith, and as I pretty well determined the position of the southern boundary amongst the stars, a notice may probably contribute to a determination of their altitude, should the same masses have been observed at other stations. Colour red or crimson north of the constellations mentioned below; boundary well defined, grazing β Aurigæ, ϵ, γ and β Cassiopeiæ, α Cygni and α Lyræ. These masses remained more or less steadily in view for about ten minutes; they were ill-defined towards the north.

W. R. BIRT.

Cynthia Villa Observatory, Walthamstow, Essex.



ANEMOMETER AT KENSINGTON PARK GARDENS.

SYMONS'S

MONTHLY

METEOROLOGICAL MAGAZINE.

LXII.] MARCH, 1871. [PRICE FOURPENCE, *or5s. per ann. post free.*

ANEMOMETRY AT KENSINGTON.

To the Editor of the Meteorological Magazine.

SIR,—I send you a small Table, which perhaps you may think of sufficient interest for a place in your Magazine. It gives the mean velocity of the wind in miles, as registered by my anemograph for every hour of the day for 9½ months [during rather more than a month my instrument was being altered, and for a month I was away from home] of last year.

Table of the Mean Velocity of the Wind in Miles for every hour of the Day from Noon to Noon.

1870.	1st.	2nd.	3rd.	4th.	5th.	6th.	7th.	8th.	9th.	10th.	11th.	12th.
January	9·9	9·5	9·3	8·7	8·1	8·1	7·6	8·2	8·3	8·5	8·2	7·5
February.....	13·0	13·5	13·5	12·9	12·4	11·9	11·5	11·3	11·3	10·8	11·0	11·3
March	11·9	11·3	11·6	11·7	11·2	10·1	9·5	9·5	9·1	9·0	8·5	8·3
April 1 to 24.	9·3	9·7	9·8	9·6	9·5	9·4	8·3	7·3	6·9	6·5	6·0	5·4
June 4 to 30.	11·6	11·5	11·8	12·5	11·6	12·3	10·6	10·0	8·7	8·2	7·5	6·5
July..... ...	10·5	10·9	10·8	11·5	10·8	10·8	10·4	9·1	7·5	7·3	6·5	6·5
Sept. 15 to 30	9·3	8·8	8·9	9·4	7·9	7·9	7·2	7·0	6·7	6·1	5·9	5·5
October	14·0	13·2	12·7	12·1	10·7	10·6	10·4	10·3	10·2	9·6	9·8	10·0
November ...	9·6	9·1	9·1	8·9	8·1	8·6	8·2	8·2	7·4	7·5	7·5	7·4
December ..	10·4	10·5	10·2	10·1	9·0	9·1	9·6	9·4	9·5	9·5	9·7	9·7
Means	10·9	10·8	10·8	10·7	9·9	9·9	9·3	9·0	8·6	8·3	8·1	7·8

1870.	13th.	14th.	15th.	16th.	17th.	18th.	19th.	20th.	21st.	22nd.	23rd.	24th.
January	7·2	7·5	7·8	8·4	8·3	8·6	8·2	8·2	8·6	8·8	8·9	9·4
February	10·1	10·1	10·1	10·3	10·5	11·0	10·3	10·8	11·4	12·4	12·5	12·4
March	8·7	9·0	8·9	8·5	8·8	9·1	9·3	9·7	10·5	10·8	10·8	11·5
April 1 to 24.	4·6	4·6	4·5	4·3	4·0	3·6	3·8	4·8	5·8	7·4	7·3	8·4
June 4 to 30..	6·5	6·7	5·7	5·9	5·8	6·8	7·4	8·7	9·1	10·1	10·9	11·5
July.....	6·2	6·2	5·8	6·0	6·2	6·3	7·1	8·1	8·3	9·1	9·6	9·9
Sept. 15 to 30	4·9	4·5	4·1	4·1	4·7	4·7	4·6	4·8	5·8	6·7	8·3	9·1
October	9·2	9·3	9·1	9·2	9·0	9·6	9·2	10·0	11·3	11·7	12·9	13·6
November ...	6·6	6·8	7·0	6·6	6·5	7·2	7·1	6·9	7·5	8·0	8·7	9·2
December ..	9·0	9·1	9·0	9·6	9·2	9·2	9·2	9·0	8·6	8·7	9·6	9·9
Means	7·3	7·4	7·2	7·3	7·3	7·6	7·6	8·1	8·7	9·4	9·9	10·5

The hours are reckoned from noon to noon, the first hour being from noon to 1 p.m., and so on; and the chief point of interest is the decided tendency of the wind to lull from midnight till 5 a.m., and to freshen from 10 or 11 a.m. till 4 or 5 p.m.

This tendency would perhaps show itself more clearly if my anemometer were more freely exposed than it is, for though apparently well placed, the effect of houses in breaking up and checking the velocity of the wind is very marked.

As a caution, it may perhaps be as well to describe the position of my anemometer, and how and when the wind's velocity is checked. My house itself stands high, as the two terraces which form this street are on a narrow ridge about three-eighths of a mile long, running E.N.E. to W.S.W. nearly, the ground sloping down on all sides, rapidly to the S., S.W., W., N.W., N., and N.E., and, excepting to the S. (in which direction lies the high ground of Notting Hill itself, but distant nearly three-fourths of a mile), there is no high ground for miles. My house is on the Northern side of the street and about one-third down from the E.N.E. end of it, and the roofs of all the houses (excepting two, which, however, are not near mine) are on the same level, or nearly so; and on the Southern side of the opposite terrace is a large open square, and on the Northern side of my terrace is a smaller square, all the houses beyond being much below our level. The cups of my anemometer are 14 feet above the chimney-pots and 22 feet above the walls of the house, and early on a fine summer morning the view from its stand over London and the country to the N., W. and S. is very fine. Notwithstanding, however, this apparently good exposure, nearly always the velocity of the winds from between E.S.E. through S. to W.S.W. is registered below (and considerably so when they are fresh to high) what it is at Kew, as the opposite row of houses, though not continuous but in blocks with spaces between, acts as would a cliff, and throws the wind up, so that it does not reach my cups with its steady full force, but with many lulls. With winds from other quarters my register is generally much the same as at Kew, though even then, when the wind is high, it seems to be much broken by plunging into and again out of the streets and squares, so that I fancy no anemometer within a town, unless raised on some high narrow building, as a church spire, would give the wind's real velocity. Even at Kew, the velocity registered is, I believe, low, and this may, I think, be accounted for by the interference of the many trees near the Observatory, for trees, if close together, would of course have something of the same effect as houses. To give anything like true results as regards velocity, an anemometer should be in a tolerably open country, and well raised above the ground on a narrow building.

I remain, yours faithfully,

R. H. BARNES.

40, *Kensington Park Gardens, London, W., Jan.* 30, 1871.

[Believing that the influence of *position* on anemometric results is so great that there are scarcely two anemometers in the country, the

indications of which are comparable, we requested Mr. Barnes' permission to have a sketch made, showing the position in which his has been erected; the result is shown in the frontispiece.—ED.]

ERRONEOUS MINIMUM TEMPERATURES.

To the Editor of the Meteorological Magazine.

SIR,—In the January number of the *Meteorological Magazine* some observations were made on the discrepancies of minimum readings of thermometers, during the Christmas frost the minimum of the period ranging from 28° in Westmoreland to —9° in Norfolk on the night of the 25th.

Now to any one looking down the columns of these minimum readings on the same night, and observing the strange discrepancy between the registries of different observers, there can be no satisfactory explanation of the anomaly, except that it has arisen from the imperfection of the instruments now in use.

For the last seven years I have been registering observations from thermometers, one minimum being suspended 4 ft. above the ground and another on the grass. Both are on Rutherford's principle, one by Negretti and the other by Casella, the best of their kind, and graduated on the stem. My suspicions were lately excited by several very low readings, and, on placing them on the grass alongside of two Kew verified mercurial thermometers, I find, after about thirty observations, that the grass instrument reads about 8°, and that, usually suspended in air, about 4°, *too low:* consequently all my observations for the last seven years are utterly worthless as regards actual min. temperature, as well as mean temperatures deduced from maximum and minimum readings. I have tried Casella's mercurial minimum, and find it most unsatisfactory. As to the colouring of the spirit, one month's exposure has completely bleached every instrument, and no efforts of restoring these instruments, by swinging and suspension bulb downwards, is of any use. From this discovery I am quite satisfied that *all* minimum observations, as now recorded by spirit thermometers, are valueless, and until our instrument makers can overcome the difficulty of manufacturing a mercurial minimum, observers may cease quoting their minimum temperature.

My lowest temperature of 1870 was 10° on the grass, applying the correction as deduced from observation, on the supposition that the variation is the same at all temperatures, it would appear that 18 or 19 was the correct reading. If other observers will compare their minimum with a verified mercurial thermometer, I think they will find similar errors. A minimum by Casella, very little used, is only about a degree low, but a little exposure would soon increase this error. It is hard for an observer to throw into the fire the readings of 2,555 observations.—I am, Sir, your obedient Servant,

CHARLETON MAXWELL.

Leckpatrick Rectory. Strabane, March 6th, 1871.

HOW OUGHT THE TEMPERATURE AND RAINFALL TO BE ENTERED?

To the Editor of the Meteorological Magazine.

SIR,—With regard to rainfall, I believe that all, or nearly all, observers will be prepared to subscribe to the "dictum" quoted with approval in your editorial remarks for January. But, as regards the entry of the temperature, I venture to think that there are some valid objections to the plan there recommended, which should at least be fairly considered before it is sanctioned by authority. Perhaps a few examples of the inconveniences which would result from a rigid observance of that rule will put the matter in a clearer light than any mere general observations.

1. The temperature at 9 a.m. on a given day in winter stands at 5°, but, during the day, a rapid rise of temperature takes place, and, the thaw continuing, the temperature remains above the freezing point throughout the following night. Yet, if, according to the stringent rule recommended in your January number, the index of minimum thermometer must not be moved during the day, the minimum of the following day, read at 9 a.m., will of course indicate 5°, the temperature of the thermometer at 9 a.m. on the previous day, and there will be nothing to show that the previous night has not been one of intense frost—the effect being, as Dr. Burder well puts it, "to give to an exceptional extreme double its proper value."

2. In a comparatively mild winter there occurs a short frost of such severity that, though it lasts altogether only three or four days, the temperature on the last day of its continuance shows a maximum of only 14°. But in the night following this day of intense cold a sudden change of wind brings about a very rapid thaw, so that at 9 a.m. of the following day the thermometer stands at 38°. Now, according to the rule in question, the maximum temperature for the previous day, read and entered at 9 a.m., would of course appear as 38°, and thus the interesting fact of the occurrence of a day of almost arctic severity, in the midst of a mild season, passes unrecorded.

3. I will mention one other case, of frequent occurrence in spring and early summer, where the method of entering recommended by your correspondent would be very liable to mislead. After an exceptionally cold period, a wave of heat, coming up from the south, begins to make itself felt early in the morning of a given day, so that the temperature at 9 a.m. of that day is higher than the maximum of the previous day. Here, again, if the rule is to be stringently acted on, the high temperature prevailing at 9 a.m. of this day will be entered as the maximum of the previous day, and the impression will be produced that the warm weather commenced a day sooner than was actually the case.

I may add, that if this rule is to apply, as in consistency it ought, to the case of the Solar Radiation Thermometer, the effect would be to introduce a similar element of confusion on every occasion when a sunless day happens to be followed by a bright sunny morning.

My own conviction is that no system of registration is satisfactory which does not provide for at least two observations during the day. But if this should be found practically unattainable, and the "stringent rule" recommended by your correspondent be generally adopted, there ought, at any rate, to be another "stringent rule" coupled with it, viz., that the actual temperature at 9 a.m. should, in every case, be entered with the extremes read at that time. This would obviate much, if not all, of the confusion which would otherwise result from such a method of entry.—I am, Sir, yours truly, GEORGE T. RYVES.

Sutterton Vicarage, March 3rd, 1871.

To the Editor of the Meteorological Magazine.

SIR,—I forward a few notes on recent temperatures, illustrative of the acknowledged difficulty in fixing an hour for observation.

February 21st.—Minimum as noted at 9 a.m., 38°·9; minimum before midnight, 29°·5; minimum noted at 9 a.m. of Feb. 22nd, 31°·0.

February 25th.—Minimum noted at 9 a.m., 42°·4; temperature at midnight, 38°·1, having risen to that point from 32°·3, the true minimum of the day at 8 p.m.

March 8th.—Minimum noted at 9 a.m., 39°·1; temperature at 9.30 a.m., 38°·5.

There is plainly nothing for it but to supplement the usual 9 a.m. observation by one at 9 p.m., or later, if possible. As a rule, however, 9 p.m. would catch most of the abnormal minima, the majority of them occurring before that hour. The maxima are hopeless, except to folks who go to bed at 1 a.m.—Yours faithfully,

T. B. ARMITSTEAD, F.M.S.

Hutton House, Burton, Westmoreland, March 8th, 1871.

To the Editor of the Meteorological Magazine.

SIR.—My name has appeared in your columns so often of late, that I must apologise for so soon again intruding on your space. This matter appears to me so very simple and easy of adjustment, that I venture to trouble you with my view of the subject. As you justly remark, "some of us will have to relinquish a pet practice;" but surely this matter should be decided, like most others at the present day, by the opinion or custom of the majority. I take it for granted that by far the greater number of observers read only once a day, at 8 or 9 a.m., mostly at the latter hour. The rainfall difficulty is, I believe, settled by entering the reading at 8 or 9 a.m. to the preceding day, owing, I presume, to the fact of 15 of the 24 hours belonging to that day. The max. temperature is also, I believe, now usually entered to the preceding day; the reason of this no doubt being the fact of the max. temperature occurring on that day at least 350 out of the 365 days of the year. Why, I would ask, should not the same rule apply to the min. temperature? On 350 days at least the min. temperature occurs on the day of reading. Could not the Council of the Meteorological

Society be induced to take the matter up and issue a circular on the subject to the Fellows? This state of "muddle" is neither pleasant nor profitable, and ought to be promptly put an end to.

Yours faithfully,

JOHN THRUSTANS, F.M.S.

Wolverhampton, Feb. 22nd, 1871.

To the Editor of the Meteorological Magazine.

SIR,—The reveille you sounded in your January number seems to have awakened a few observers out of a meteorological dream by the correspondence which has followed. Surely every one is aware of the fact that the rule of registering extremes of temperature at 9 a.m. is not an infallible one, but it has been in use since the invention of self-registering thermometers in the arctic region and torrid zone. It is very easy to find fault, but it is not quite so easy to suggest a remedy. Do not think that I admire individual obstinacy. I can understand a change when it is clearly demonstrated that it is essential, but I certainly deprecate them when they are not necessary. I have looked over the list of Fellows of the Meteorological Society, and, judging from the duties of the generality of them, a more suitable hour could not be adopted, and many of them would not feel disposed to give up a "lucrative appointment" to devote themselves to the subject. For the minimum to occur at 9 a.m., even in the winter months, at this station is of very rare occurrence; it has not exceeded half a dozen times in a period of over thirteen years. However, if you alter the time of reading the minimum, we must alter the time of the maximum also.

I conclude by quoting the following from the *Admiralty Manual of Scientific Enquiry*, page 283 :—

"Both the self-registering thermometers should be read off at the time of the 9 a.m. observation, as it is very improbable that the temperature at that hour should be such as to obliterate either record of the preceding twenty-four hours. Double maxima and minima, when they occur, if remarkable, should be recorded as supernumerary and separately in a diary, and their accompanying circumstances noted."

Yours very truly,

JOHN ARNOLD, F.M.S.

Aldershot, March 2nd, 1871.

SUGGESTED AMENDMENTS IN RAINFALL RULES.

To the Editor of the Meteorological Magazine.

SIR,—While wishing to comply with your requests, and willing to conform to the practice of a decided majority of observers by waiving my individual opinion, I would enter my humble protest against the general adoption of your proposed Rules XII. and XV.

The discussion, two years ago, in your valuable Magazine on the registration of small quantities of rain, treated only of the respective

merits of different systems of *incorrect* registration, but why should not all observers consent to the very small, if any, additional trouble of registering even small quantities *correctly*, recording 0·001 as 0·001, and 0·009 as 0·009.

The observance of your suggested Rule XII. presents various anomalies, such as two days of 0·005 each being recorded as 0·020, while three days of 0·004 each are recorded as 0·000.

With, if not without, a spirit level there is no more difficulty in reading 0·001 of rain than 0·001 of the barometer scale.

An important object of rainfall observations being to ascertain and record the quantity of moisture reaching the earth, Rule XV., for measuring snow, seems to me a bad one; for, supposing 12 in. to fall and be melted the morning following, it will show the equivalent of 1·000 in. of rain; whereas, if the gauge were left undisturbed, as I would suggest, till a thaw, half the snow might have evaporated, and the remainder, melting into the gauge, would show but 0·500 in., and represent the amount of moisture really reaching the earth.

Yours truly, PERCY BICKNELL.

To the Editor of the Meteorological Magazine.

SIR,—As you offer to observers to object to, or suggest improvement in, any of your "Suggestions" enclosed, and to forward substitutes with reasons, may I be allowed to offer the following:—

Substitute for last three lines of No. I. If a thoroughly clear site cannot be obtained, shelter is most endurable from N.E. and S.E., less so from N.W. and W., and not at all from S., S.W., or N.E.

In X., line 6, after "decimal point," add, "but three figures are preferred."

In XI., at the end, add "particularly when the fall exceeds ·50."

XII. I object to this, but prefer to measure anything under ·01.

XV. (1) You say "*melt* what is caught, &c." I think it should be added, which is the best way of *melting* snow, either—

(*a*). If the quantity is small, by breathing on it; or,

(*b*). By bringing it into a warm room, and letting it melt slowly; or,

(*c*). By bringing it near to a fire; or,

(*d*) By adding to the snow a previously ascertained quantity of hot water, and then deducting this quantity from the total measurement.

Of your divisions, 1, 2, and 3 of XV., I prefer 1; and of *a*, *b*, *c*, and *d*, I prefer *d*.

XVII. I think some instruction is required, in the case of monthly gauges in frosty weather, if the water collected should be frozen, whether to melt it, and how, or how otherwise.

Reasons for substitute or addition to

I. Because rain from S. is so frequently accompanied by wind, and sometimes strong wind.

Because rain from S.E. is generally while it is calm, or only very slight wind.

Because although it does not often rain from N.W., yet when it does, it is often after a sudden shift from W. in a squall, and sometimes violent wind.

These reasons are founded on close observation of the anemometer records.

XII. Because any quantity which is large enough or capable of being measured ought to be measured and entered. This is not intended to conflict with your rule that ·01 constitutes a 'rainy day.'

XV. There seems not much to choose between 1 and 2, but both are preferred to 3, because snow is not always of the same density, and therefore one-twelfth would not be always the right equivalent.

d is preferred to *b* and *c*, because in *b* and *c* there must, it would seem, be always more loss by evaporation; *a* not practicable, except when the quantity is very small.

Reasons for additions to the other "Suggestions" referred to are either given or will speak for themselves. C. O. F. CATOR.

A GUIDE TO THE RAINFALL IN FUTURE.

To the Editor of the Meteorological Magazine.

SIR,—I have been drawn to the conclusion that our rainfall season commences not on January 1st, but at sometime in the autumn; and that the wetness or dryness of any summer will be indicated by the wetness or dryness of the preceding winter.

I have been for sometime engaged in investigating this law, and have found that, as far as my observations for this place (Hayward's Heath) go, it is as follows :—

If R represent the rainfall in any year, and n be the next whole number not less than the number of inches of rain between Nov. 1st and March 1st immediately preceding, then R will lie between $2n$ and $2(n+1)$.

Now the rainfall here, during the past four months, has been 9·95 in. I venture, therefore, to predict that the rainfall for this place, for the year 1871, will lie between 20·00 in. and 22·00 in.; in other words, that this year will be at least as dry as last year, in which the rainfall here was 21·80 in.

I hope, when I am in possession of monthly records of rainfall up to the end of last year, to be able to investigate this law for other parts of the country.

I am only in a position now to add, that for Middlesex, as represented by the three stations at Hammersmith, Camden Town, and Hampstead, the law indicated by the data now in my possession seems to be as follows :—

If R = rainfall for the year in inches, n = whole number next to the number of inches for November 1st to March 1st, then R lies between $3n$ and $3(n+1)$.

Perhaps you may be able to procure the value of n on the average of the three stations I have named for the last four months, and then we shall see, at the end of the year, what difference there may be between the calculated and the actual value of R for Middlesex for this year.

Of course I am aware that the returns for the last three years and further investigations may lead to a modification of this law, but I am almost convinced that some such law exists. I am prepared to find that occasionally the law, as at present enunciated, seems to fail when the following year is to be wet and the rainfall at the end of the year is large.—Yours truly, THOMAS E. CRALLAN.

Hayward's Heath, March 1st, 1871.

WINTER PREDICTIONS.

To the Editor of the Meteorological Magazine.

SIR,—Your correspondent in December, in his article written to prove that severe winters succeed dry summers, introduced the winter 1864-65 as a hard winter. With us it was quite the reverse, but his theory is indeed strengthened by the appalling winter we are now groaning under. The following little table may interest your readers :—

		1855.	1860-61.	1870-1.
Mean daily temperature	28 days	27·0	25·0	24·5
,, ,, ,, ...	12 ,, .. .	21·4	24·3	18·9
,, ,, ,, ...	7 ,, ...	20·4	20·2	19·0

The winter of 1860-61 followed a very wet summer. These are the three memorable winters since I have been a follower of the fox, which makes one very keenly sensible of a long frost. My record does not go back beyond 1849, but I think we must go back to the time of the first Napoleon for a winter as severe as the present.—Yours obediently,

W. LUCAS.

Hitchen, Feb. 2nd, 1871.

To the Editor of the Meteorological Magazine.

SIR,—The mean temperature of the three months ending February 28th, 1871 (at the Royal Observatory, Greenwich), was 36°·4, which is 2°·1 below Mr. Glaisher's adopted average of 50 years, and 1°·5 below the average of 99 years. Except in 1865, when the mean temperature of January to March, inclusive, was 2°·04 below the average of 99 years, so severe a winter period of three months has not occurred at Greenwich since 1855.

The mean temperature of December, 1870, and January, 1871, at Greenwich, was 33°·4. This is colder than the corresponding period of any other winter since 1830. In 1840-41, however, the mean temperature of December and February was almost as low.—I am, &c.,

GEORGE D. BRUMHAM.

Barnsbury, March, 1871.

STORM AT KILKENNY.

To the Editor of the Meteorological Magazine.

SIR,—A rotatory storm of a very violent nature passed across Kilkenny on the morning of the 10th February. I was a guest at the Deanery, at the time, and happened to be lying awake about 3 o'clock a.m. The evening before and the night had been blustering, the wind S., veering to S.S.W. towards dusk, with squalls of rain. About half-past 3 a.m. the house was struck by a sudden squall, which rapidly increased in violence, until it became a perfect hurricane, the wind shifting from S.S.W. to W. and N.W. In about half an hour the storm moderated, and I fell asleep. Next morning Kilkenny presented the appearance of a bombarded town—chimneys down, gables fallen into the street, great chasms in the roofs of nearly every second house, the streets littered with slates in every direction; whilst the ancient trees in the lawn of Kilkenny College, on the Canal Walk, and in the grounds of Lord Ormonde's residence (Kilkenny Castle) were laid prostrate from the various points of the compass above indicated. At one small place, a mile north of Kilkenny, over sixty trees were blown down. At another, about the same distance south, great devastation was apparent amongst the old timber; whilst here, six miles south-west of Kilkenny, very little damage was done.

I append some cuttings from the *Kilkenny Moderator* of the 11th and 15th of February. The barometer did not fall below 29·50, which will account for the destructive effects of the wind.

TERRIFIC STORM.—Yesterday morning we were visited with, by many degrees, the most serious of all the storms of this stormy winter. There was no premonitory symptom or gradual rising of the wind, but just before four o'clock a.m. it suddenly burst over our city like an eastern tornado, shaking every house and building in such a way as to waken up all the sleepers; and for more than an hour the shocks of the wind, coming from the north-west, was repeated momentarily, rocking the buildings, dashing in windows, carrying away slates, tiles, and chimney-pots in showers, and in many places levelling houses to the ground. The scene which our streets presented when day broke was extraordinary. Ruin and devastation was to be seen in various districts, and under several houses the highway bore the aspect of a slate-quarry. There was scarcely a house in the city which was not more or less stripped of slates, and we should say not a single one which did not receive at least some damage to windows, ridge-poles or chimney-pots; however, as regards more serious injury, the entire front gable of the old Elizabethan house, occupied by Miss Birch, corner of Bull-alley, fell out into the street from the second story. Four smaller houses were levelled at Greenshill. The end gable of Miss Dunne's house, in Walkin-street, fell bodily into Mr. Brophy's stone-yard adjoining, and the front now leans into the street in the most threatening and dangerous way. At Newpark House, a stack of chimneys fell through the roof, and narrowly missed falling on the bed in which a member of Colonel Bull's family was sleeping. Some plate-glass windows at Kilkenny Castle were blown in. Seven large stones were knocked off the parapet of the ancient Round Tower at St. Canice's Cathedral. The roof of the south transept of the Roman Catholic Cathedral was much injured. At. St. Kyran's College, the pinnacle and carved stone cross which surmounted it were dashed from the great central-gable to the ground, and some of the parapets in other parts of the building sustained injury. The vane surmounting the Tholsel cupola was crookened by the force of the gale. The fine old elms on the Canal-walk were severely dealt with. Sixteen trees on that promenade were blown down, to say nothing of the broken branches;

and amongst them were five of those growing at the narrow part of the walk, a strip of the Castle demesne ground to widen which was given by the Marquis of Ormonde in 1861. Some of those, in falling, broke down the Castle wall. In the College-lawn, seven of the remaining trees of the line of splendid old tall poplars, which formed so striking a feature to the eye of the visitor in search of the picturesque, now measure their length upon the sward. Some trees were also blown down in the Castle grounds; and all along the various roads leading into our city, the traffic from the country was seriously impeded in the morning by the many trees lying across the way. Much damage has been everywhere done, the only consolation being that no life seems to have been lost, nor even any serious personal injury sustained.

THE STORM OF FRIDAY MORNING.—We find that although the hurricane of Friday morning last was not as general as we had supposed it might have been, it was very destructive to property in a considerable portion of this county. From Limerick, Ennis, Parsonstown, Carlow and Cork, we have reports of the serious effect of the severe gale; but it was not felt in Dublin, or even Waterford, although on Saturday night the latter district was visited by a storm, when everything here was calm. It is curious that from one place in England, and one only, we have the report of a storm, attended with serious loss of life, on Friday—Bridlington—a seaport in East Yorkshire. In our own city, the damage done to house property is more severe than we had even supposed when announcing the results of the storm in our last issue. Amongst public institutions which we had supposed at the time to have escaped damage, the County Gaol, the Military Barracks, the Lunatic Asylum and the Militia Stores, old House of Correction, suffered considerable injury. Throughout the northern and middle portions of our county the number of trees everywhere blown down is extraordinary. The southern end of the county escaped the blast.

This winter has been a very stormy one, and much rain has fallen with an unusually high barometer, accompanied by an upper stratum of calm cirrus cloud, and a lower stratum of nimbus and cumulo-stratus in rapid motion.—Yours, &c., JAMES GRAVES.

Inisnag, Stoneyford, March 4th, 1871.

SOLAR RADIATION.

To the Editor of the Meteorological Magazine.

SIR,—So much doubt appears to exist as to the best mode of measuring the amount of solar radiation, that I think the subject ought to be tested in every manner possible.

I would suggest that the outer glass or jacket of the black bulb thermometer in vacuo be also blackened, as well as the bulb itself, and ground or deadened so as to render it opaque. This would prevent all chance of reflection, and it would be highly interesting to see how such a thermometer would work against those of the ordinary description.—I am, Sir, yours very truly, W. H. E.

FINE METEOR ON FEBRUARY 13TH.

To the Editor of the Meteorological Magazine.

SIR,—About a quarter past nine, on the evening of the 13th inst., happening to be in a room without a light, I was so greatly surprised to find it, all of a sudden, most brilliantly illuminated, that I rushed to the window to ascertain the cause, when I perceived that the whole country round—even to its minutest features—was as clearly visible as at noontide: but irradiated with a bluish tinge, more resembling full-moon light than solar effulgence. Casually casting my eyes

upwards, in search of an explanation, I was just in time to behold (at an elevation of about 70°, and in a westerly direction,) the explosion of what appeared to me to have been a splendid meteor—a fact since confirmed by various newspapers. The duration of the whole affair was probably a minute.

I forward you this account simply under the impression that it may tend to verify the extent of country over which the phenomenon was visible. The night was a clear starlit one, with a sky perfectly free from clouds.—I remain, Sir, yours truly,

F. BONNYCASTLE GRITTON.

West Tytherton, Chippenham, Wilts, Feb. 22*nd*, 1871.

A METEOR.

To the Editor of the Devizes Advertiser.

SIR,—Last Monday night, about ten minutes past nine, a most brilliant meteor was seen here. It appeared to have begun near the belt of Orion, and proceeded in a southward direction, gradually getting smaller till it finally disappeared near the horizon. It was about the size of a cannon ball, exploded twice inaudibly, and gave off many smaller ones, like a display of fireworks. The light emitted was as bright as that of the sun at noon, and continued more than a minute. A streak of light was visible in its track for five minutes. Hoping to see a fuller account from some of your numerous readers, I am, &c., C.

Calne, Feb. 14*th*, 1871.

[A correspondent, writing from Bristol, says that he observed the meteor at about five minutes past nine o'clock, and that the whole sky was illuminated by its light. When at its brightest, the light was equal to that of the moon when half full, and it left a train of about two degrees in length, which remained distinctly visible for ten minutes after the meteor was extinguished.]

EARTHQUAKE OF MARCH 17TH.

To the Editor of the Metcorological Magazine.

SIR,—I felt a decided shock of earthquake on Friday night—a curious noise and shaking of the house. It lasted but a few seconds, not so long as the last one, two or three years ago. Several of my neighbours in the Vale of Clwyd felt it, also the servants at the other end of the house. I was particular in timing it, and had corrected my watch by the railway telegraph that morning and also next day by a reliable time-keeper. I believe it to have been a few seconds before 11.5 p.m. The night was quite still, and I was at an end of the house where nobody slept.—Yours faithfully, WHITEHALL DOD.

Llannerch, St. Asaph, March 19*th*, 1871.

To the Editor of the Meteorological Magazine.

SIR,—Last night, at 11.15, a decided shock of an earthquake was felt in several parts of this house, accompanied with a rumbling noise.

A picture frame and candlestick were shaken out of their places. The night was very clear, and there was a white aurora in the north. This morning the weather is spring-like, and the snow and cold of the last few days have disappeared.—Yours, &c.,

THOS. DODGSON.

Thorpe Grange, Greta Bridge, Darlington,
18th March, 1871.

RAINFALL IN NORWAY.

We are again indebted to Mr. Cator for translating and favouring us with a copy of the observations made at Flekkefjord, in continuation of those which we have published for several years :—

Diameter of Funnel, 12½ in. ; Height above Ground, 8 ft. ; above Sea Level, 18 ft.

Month.	Total Depth.	Greatest Fall in 24 hours.		Days on which ·01 or more fell.	Days of Snow.
	English ins.	Depth.	Date.		
January ..	3·384	·480	1 & 8	12	6
February ...	·964	·366	27	7	6
March	1·356	·299	2	11	7
April	3·222	·825	10	12	...
May	3·033	·638	1	14	...
June.....	1·343	·765	12	11	1
July.....	2·741	·493	17	11	...
August ...	2·770	1·133	13	15	...
September.	3·677	1·522	6	15	...
October ...	9·254	2·598	24	14	...
November..	4·676	1·059	17	14	...
December..	1·475	·274	18	10	6
Total	37·895	...	...	146	26

On the 11th of June, there fell so much snow that the nearest hills were covered, down to within 50-100 feet of the base, as if it was in winter; the snow melted very soon again. In about two hours ·765 in. of rain fell; thermometer at 4 p.m., 41°·0; at 5 p.m., 39°·2; and at 10 p.m., 43°·2, and bright weather. No one can remember it so cold at this time.

On the 13th of August, from 2.30 to 3 p.m., heavy rain, with hail-stones as large as a hazel-nut; in this half-hour there fell 1·013 in., thunder and lightning in two directions, and a hurricane-like storm. The hail destroyed much corn, and the telegraph was affected. In August there was thunder weather daily for about two weeks or so; otherwise, of late years, uncommonly little thunder in the summer, but rather more than usual in the winter.

On the 8th of October, 28°·6 in.; 11th, 23°·0; and 14th, 27°·5 in. So early a frost and so hard on October 11th, no one can remember; there was even ice on the Fjord.

On the 16th of November, hail, snow, rain, and thunder.

On the 17th of October, 1·386 in. fell in ten hours. In October, four days in which upwards of 1 in. fell.

We have had a severe winter, the frost has reached + 0°·5; frequently, however, 9°·5, 5°·0, 3°·0, and sometimes only 27°·0. ; but fine weather, such as we can have in Norway. The weather has been generally calm, few storms, and of short duration; the greatest one lasted two days.

JENS BEER.

January 10th, 1871.

FEBRUARY, 1871.

Div.		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	Greatest Fall in 24 hours. Date.	Days on which ·01 or more fell.	TEMPERATURE. Max. Deg.	Max. Date.	Min. Deg.	Min. Date.	No. of Nights below 32° In shade	No. of Nights below 32° On grass
			inches	inches.	in.								
I.	ENGLAND.	Camden Town	1·27	+ ·05	·31	7	14	56·2	27	25·8	12	3	7
II.		Maidstone (Linton Park)	1·07	— ·44	·54	10	13	56·0	8*	23·0	12	6	...
,,		Selborne (The Wakes)	1·78	+ ·07	·28	12	15	53·0	27	23·5	11	5	6
III.		Hitchen	1·20	— ·06	·31	7	15	55·0	27	25·0	10‡‡	4	...
,,		Banbury	1·20	— ·23	·28	7	15	55·0	27	27·0	12	7	...
IV.		Bury St. Edmunds (Culford)	2·07	+ ·65	·80	10	12	57·0	27	22·0	11	7	11
V.		Bridport	2·26	+ ·20	·40	9	18	56·0	6	27·0	22	6	...
,,		Barnstaple	2·68	+ ·60	·53	6	22	57·0	17	31·0	22	...	...
,,		Bodmin	3·69	+ ·90	·52	9	22	57·0	18	31·0	11	1	4
VI.		Cirencester	1·72	+ ·11	·38	26	8	...	...	...	...	...	...
,,		Shiffnal (Haughton Hall)	1·62	+ ·73	·32	7	12	55·0	27	26·0	1	8	...
,,		Tenbury (Orleton)	1·93	+ ·36	·25	9	19	55·7	23	28·6	22	6	7
VII.		Leicester (Wigston)	1·29	— ·05	·31	8	12	56·0	27	26·0	11	6	...
,,		Boston	1·61	+ ·40	·43	10	12	56·0	27	24·2	12	3	9
,,		Grimsby (Killingholme)	1·78	...	·49	10	14	55·0	27	25·0	12	3	...
,,		Derby	1·51	+ ·03	·47	5	14	58·0	23	27·0	12	5	...
VIII.		Manchester	2·73	+ ·78	·63	5	17	55·0	19	...	...	...	...
IX.		York	2·51	+ 1·13	·45	10	15	56·0	19	27·5	12	2	...
,,		Skipton (Arncliffe)	6·64	+ 2·97	1·00	20	17	49·0	20	22·0	12	8	...
X.		North Shields	1·97	+ ·44	·40	4	18	53·1	18	25·6	12	3	8
,,		Borrowdale (Seathwaite)	15·99	+ 4·61	2·80	20	22	...	...	...	...	...	...
XI.	WALES.	Cardiff (Town Hall)	...	...	...	...	...	...	...	...	...	...	...
,,		Haverfordwest	3·31	+ ·45	·50	3, 27	15	53·0	18	29·0	10	3	3
,,		Rhayader (Cefnfaes)	4·88	+ 1·90	1·50	4	20	52·0	...	26·0	...	5	...
,,		Llandudno	2·02	+ ·67	·40	5	15	58·5	22	28·7	1§§	3	...
XII.	SCOTLAND.	Dumfries	3·93	+ 1·38	·53	4	18	52·5	23†	24·5	1	6	...
,,		Hawick (Silverbut Hall)	1·91	...	·34	3	17	...	...	...	...	...	...
XIV.		Ayr (Auchendrane House)	4·53	+ 1·17	·64	5	22	53·0	13‡	20·0	1	4	6
XV.		Castle Toward	6·51	+ 2·77	·91	11	22	52·0	25	29·0	1	6	9
XVI.		Leven (Nookton)	3·89	+ 2·19	·81	4	20	50·0	18‖	24·0	13	10	21
,,		Stirling (Deanston)	5·70	+ 2·70	1·14	11	28	52·0	25	22·9	1	9	15
,,		Logierait	4·08	...	1·02	4	16	...	...	...	...	...	...
XVII.		Ballater	2·39	...	1·40	4	8	53·5	16§	26·0	4	9	..
,,		Aberdeen	3·99	...	·89	4	18	54·8	25	30·9	28	2	16
XVIII		Inverness (Culloden)	·98	...	·25	28	17	52·0	25	26·6	3	3	17
,,		Portree	7·52	— 2·71	1·12	18	24	...	...	...	...	...	...
,,		Loch Broom	4·67	...	·65	8	26	...	...	...	...	...	...
XIX.		Helmsdale	4·08	...	1·03	6	13	...	...	...	...	...	...
,,		Sandwick	4·40	+ 1·92	·86	7	24	49·8	19	29·7	28	1	7
XX.	IRELAND.	Cork	4·47	...	1·32	2	19	...	...	...	...	...	...
,,		Waterford	3·93	+ 1·90	·83	11	23	53·0	28	33·0	2	...	...
,,		Killaloe	3·70	+ ·79	·63	11	22	57·0	17¶	31·0	11	1	...
XXI.		Portarlington	2·00	— ·03	·42	12	21	55·0	19	31·0	10	2	...
,,		Monkstown	2·24	+ ·60	·50	2	14	...	...	...	...	...	...
XXII.		Galway	4·78	...	·47	28	23	58·0	21**	30·0	1	2	...
,,		Bunninadden (Doo Castle)	3·86	...	·80	10	17	52·0	14††	29·0	3	1	...
XXIII		Bawnboy (Owendoon)	...	...	..	...	...	...	...	...	..	...	..
,,		Waringstown	2·95	...	·73	11	19	56·0	16¶	31·0	2	1	10
,,		Strabane (Leckpatrick)	2·86	..	·61	9	20	...	...	...	...	...	...

* And 23, 27. † And 26. ‡ And 19, 20. ‖ And 20, 24, 25. § And 18.
¶ And 19. ** And 23. †† And 16. ‡‡ And 11. §§ And 2, 11.
+ Shows that the fall was above the average; —that it was below it.

METEOROLOGICAL NOTES ON FEBRUARY.

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 mild but dull month; no very high winds; bar. very changeable on the 10th; ther. never rose higher than 31° on the 11th; nevertheless the month must be regarded as a mild one, there being only six frosty days in it, a smaller number than on any previous occasion I have on record, excepting 1867 and 1869. The rainfall also is below the average of the last 16 years.

BANBURY.—Fog on the 2nd, snow on 1st and 11th; high winds on 5th, 10th, and 11th.

CULFORD.—High wind on 5th and 27th.

BODMIN.—Average bar. 30·01; average temp. 45°·1; being 2°·5 above the average.

ORLETON.—The month opened with a low temperature and a cloudy sky; on the 3rd a steady thaw set in, the frost having continued 44 days. The weather afterwards changeable, with frequent slight falls of rain. The 11th was very cold and cloudy (max. 31°·8), with a rough wind from the N.E. The latter part of the month generally fine and pleasant. The temperature of the whole month was about 2°·5 above the average, and more than 6° above that of 1870.

WIGSTON.—Slight S on the 1st; S also on the 10th, and sleet on the 11th.

BOSTON.—Gale with T and L at 9 p.m., and during the night of the 5th; R and S on the 10th.

GRIMSBY, KILLINGHOLME.—Very variable month—stormy and wintry 10th to 12th, but more pleasant days than usual. Many turnips destroyed by frost, and straw and fodder of all kinds scarce; the work of the farm, which was backward, has gone on rapidly. 12th, very cold all day, the max. temp. being only 38°. First house-fly in the window on 8th; aconite in flower on the same day; hepatica in flower on 19th, and crocus on 25th.

DERBY.—Less rain falls in February than in any other month, as observed during 21 years; the amount recorded is slightly in excess of the mean, and the temp. is about 2° above the average; the weather has been most enjoyable, and garden operations not uncommon.

ARNCLIFFE.—Snow on 11th.

NORTH SHIELDS.—Snow on 1st, 10th, 11th, and 12th.

SEATHWAITE.—2·11 in. on 6th, and 2·80 on 20th; S on 3rd, 10th, and 12th.

WALES.

HAVERFORDWEST.—A mild damp month, at times very dense fogs, principally at night; prevailing winds southerly and westerly; only three frosty nights; heavy gale from N.N.E. on 21st; month ended spring-like.

CEFNFAES.—The month has been very favourable; wind generally S.E. or N.E. The soil in good order for husbandry; lark heard on the 14th; blackbirds and thrushes early in the month; catkins in full flower.

LLANDUDNO.—Bar. fell during the night of the 9th-10th, 0·950; 10th, windy; 11th, snow; 12th, stormy; snow on the hills till the 16th. Thrush singing beautifully at 5.30 p.m. on 18th.

SCOTLAND.

DUMFRIES.—The first half of the month was wet and occasionally stormy; on the night of the 12th, the heaviest fall of snow for some years, but it soon disappeared. The latter half of the month generally fine and mild. The average temp. 4°·26 above the corresponding month; the rainfall is also above the average. Snowdrop in flower on the 8th.

SILVERBUT HALL.—The singularly beautiful aurora on the morning of the 12th, succeeded by 10 days of very squally weather; the month, however, has been very favourable for getting forward all kinds of out-of-door work.

AUCHENDRANE.—This February, with a slightly deficient rain and evaporation, has been warm and moist—quite contrary to the February of 1870. The mean temp. of the month, elastic force of vapour, dew point, humidity, and amount of cloud, all more or less exceeded the February means; the bar. pressure, however, accords with the mean, but it was very unsteady within a rather limited range; although the winds were slightly below the mean, there were sharp gales on 11th, 12th, 14th, 18th, 19th, 20th, and 22nd, all from equinoctial points; on 9th the thrush was heard singing, and on the 25th the bees were at work on the snowdrop blossoms, and the daffodils were coming into flower. The rivers were in flood during the whole month.

CASTLE TOWARD.—A wet month, with but few frosty nights; 5·02 in. (of the total 6·51 that fell during the month) fell on 10 days from the 3rd to the 13th; it has since the 14th been comparatively mild, and free of frosty nights, so that deciduous trees and shrubs are swelling their buds, while many of the spring plants are now in full flower: snowdrops since the 1st, primulas on the 10th, hepaticas, ericas, and rhododendrons since the 20th.

DEANSTON.—Frosty and dry cold for two days, then rain with occasional bright days. Heavy fall of 11 in. of snow on the 12th, but all of it gone in two days from wind and rain. Mild and dry, 22nd and 23rd; blowing a gale thence to the end of the month; more dry and mild, favourable for field operations; spring rapidly appearing.

LOGIERAIT.—The month opened with heavy rains; deep snows on the 12th; on 15th a favourable change set in; since that date the weather has been very fine and mild, and all kinds of labour is progressing rapidly.

BALLATER.—Dull, with fogs and heavy rain, in the beginning of month; open weather throughout latter half of the month, strong cold winds prevailed, and little R; much L observed on the evening of the 22nd.

ABERDEEN.—Auroræ on 14 nights; much L on 20th and 21st; the first half of the month remarkably wet, the latter half fine, warm, and dry; mean bar. 29·795, or 0·046 below the mean of 14 years; mean temp. 40°·7, or 2°·9 above mean; rainfall also above the mean; winds from S.E., S.W., and N.W., above the average; estimated pressure of wind rather below it.

PORTREE.—The frost of January continued to the 7th of this month; on the 8th there was distant T the whole day; sleet, H, and S showers every day from the 9th to 15th; very squally from the 10th to the 15th; close fog on 17th, strong gale on 18th, from S., and on 20th from W., 21st N.W., 23rd from W.; 24th and 25th very squally. On the whole, the month was milder than usual in this locality; vegetation is making rapid progress in garden, shrubs, and bushes.

LOCHBROOM.—This month has been as wet and unpleasant as January was frosty and exhilarating, though the difference in the rainfall is very small.

SANDWICK.—The R, temp., and wind, are all above the mean; the wind, which was bound up during the frost, was let loose in the mild weather of February, and we had gales on 5th and 7th, 40 to 50 miles an hour, from 10 a.m. on to midnight on 5th, and 50 miles an hour from 11 a.m. to 5 p.m. on 7th, with the greatest fall of rain during the month; one continued gale from the earliest hour on the 21st, to 4 a.m. on 25th; 50 miles an hour generally, but during some part, 55 and 60 miles an hour; the winds in the early part of the month S.E. and W., and S.W.; in the latter part, remarkable absence of aurora; much light was seen on the nights of the 11th and 12th, supposed to be aurora behind the clouds.

IRELAND.

MONKSTOWN.—The commencement and end of the month were wet, the middle unusually fine and spring-like; a slight frost on the night of the 15th; wind very variable; 1st to 5th, S.E. to W., 6th to 11th, N.W. to N.E., 12th to 20th, S. to S.E.; this was the driest period, which is very unusual with a wind at S. and S.E.; the heaviest rainfall was on the 3rd, with a S.E. wind.

DOO CASTLE.—Beginning of month cold and severe, middle fine, and the end wet; gale on the night of the 5th.

SYMONS'S
MONTHLY
METEOROLOGICAL MAGAZINE.

LXIII.] APRIL, 1871. [PRICE FOURPENCE, or 5s. per ann. post free.

EARTHQUAKE ON MARCH 17TH.

IN our last number we had the pleasure of inserting two letters descriptive of the recent slight earthquake shock; in the present we complete the narrative by the insertion of an abstract of the published accounts, and of the following sketch map, which shows by dots all the spots at which we have heard of the shock being felt. The area may be roughly described as being the whole of England north of the Mersey and the Trent, but, as will be seen from page 50, it was felt in Dumfriesshire, so that Scotland was not entirely exempt. Moreover, it will be noticed that it was reported from many more stations in the west than in the east, and that the mechanical effects, although in no case of any importance, are uniformly reported as greater in Lancashire and the Lake District than elsewhere.

The velocity of transit of earthquake shocks is approximately known; hence if the various reports had given us the *real* time at which the shocks were felt in the different districts, much more light could have been thrown upon the subject, and possibly the position and depth of the centre of disturbance computed.

Probably many of our readers noticed that the two letters in our last, assigned times differing by ten minutes, and very likely they set this down as another illustration of bad time-keeping. Inconsistent as

are several of the entries in the following table, and discreditable as they are to a country with the thousands of miles of telegraph wires which England has, it is nevertheless possible to extract some general system from them, and it seems to us clear that the 11 o'clock shock was felt between 11.0 and 11.5 in the north-western counties, but not till 11.10 or 11.15 in the north-eastern—thus supporting *both* our correspondents.

6.0	Ulverstone	11.5	Singleton Brook, Manchester
6.20	Kendal	11.5	St. Asaph
6.30	Manchester	11.5	Burton, Westmoreland
6.30	Ambleside	11·5 to 11.10	Stonyhurst
6.40	Grasmere	11.5	Ulverstone
6.45	Askrigg	11.10	Doncaster
7.00	Coniston	11.10	North Shields
10.54	Singleton Brook, Manchester	11.15	Dumfries
11.0	Grasmere	11.15	Blencowe, Penrith
11.0	Coniston	11.15	Kendal
11.0	Nent Head, Alston	11.15	Darlington
11.0	Llandudno	11.15	Hexham
11.0	Lingen Presteign	11.15	Scarborough
11.3	Ambleside	11.15	Leeds
11.4	Preston	11.15	Liverpool
11.4	Bowden, Manchester	11.30	Tyneside
11.4	Penrith	11.30	Newcastle

CARLISLE.—On Friday night an earthquake was distinctly felt in the northern counties of England. Our correspondent writes that the accounts from various parts of the country agree that there were more shocks than one. The first was much less severe than the second, which occurred a few minutes afterwards. At Silloth and Aspatria, twenty miles west and north-west of Carlisle, the windows of houses were shaken with alarming violence. A gentleman who resides near Aspatria states that he felt the floor of the room in which he was sitting heave, the piano was perceptibly moved, and a statuette upon it was rocked so much that it was nearly overturned. At Castle Canock, on the eastern side of the county, the windows were severely shaken, and the experiences of inhabitants of the southern districts about Penrith were of a similar nature. In Carlisle the trembling of the earth was distinctly felt in various parts of the city, preceded or accompanied by a loud rumbling noise resembling the sound of distant thunder or of a cart rattling over a stony street. It was noticed in several places that cage birds were much alarmed, and at Hutton Hall, near Penrith, the pheasants in the adjoining preserves made so much commotion that their unusual movements attracted the notice of the inmates of the hall. No damage has been reported.

THE LAKE DISTRICT.—About three or four minutes past eleven on Friday night a smart shock was experienced over this district. The effect was sudden and the agitation powerful, but of short duration. It was accompanied by a sound as if a heavy goods train passed at express speed, and the shock was followed by a rushing wind which quickly died away. Articles of furniture rocked fearfully, and many persons who had retired to rest sprung out of bed in the greatest alarm, expecting the houses they occupied to fall. The recent gunpowder explosions suggested an accident at one or other of these manufactories, and one man actually ran two miles partially dressed to satisfy himself that the works in which he was interested were not destroyed. The shock lasted fifteen or twenty seconds, and appears to have extended over a wide area. Lancaster Castle is said to have been damaged so much as to need repairs. Opinions differ as to the course taken by the wave, but those who were sufficiently calm and self-possessed to be observant, and feel a scientific interest in the phenomenon, consider the earthquake travelled from east to west. The vibration was so powerful that beds were lifted, and persons standing were thrown on the floor. On Friday it is asserted by several persons that shocks were felt about noon, and again in the evening, about six o'clock. It was difficult to

account for these sounds and vibrations until after the more severe shaking at eleven, but the experience of the latter convinced these persons that the sensations of the earlier part of the day were due to the same mysterious cause. Cries of the pheasants in the woods were heard for some time after the event, and dogs gave unmistakable evidence of alarm.

KENDAL.—A correspondent writes that the first shock occurred about twenty minutes past six in the evening. It was accompanied by a low rumbling noise like what might be produced by the passing of a heavily-laden waggon, but there was not much vibration, and, generally, the occurrence did not attract much notice. About a quarter past eleven, however, a most severe shock was experienced, throwing down in two or three cases flower-pots on window-sills, and this time the violent vibration of the earth occasioned great alarm—so much so that numbers of people started from their beds and rushed half-dressed into the streets to ascertain what was the cause of the concussion. At first it was attributed to a supposed explosion of some of the powder-works in the neighbourhood, and the telegraph was at once set in motion to ascertain if anything of the kind had happened; but, as nothing could be learnt of any explosion having occurred, people forthwith concluded that it was a shock of earthquake.

GRASMERE.—Mr. R. Farquhar writes to us that the inhabitants were disturbed on Saturday evening by two shocks of earthquake. The first occurred at about twenty minutes to seven p.m., the second at about eleven p.m. Each was accompanied by sounds and motion of similar kinds, but the last was much the more severe of the two. A loud boom, as if an immense explosion had occurred at a distance of, say, five miles, preceded the first shock, which moved apparently from east to west; the same phenomena, though far more decided, occurring on the second occasion, with a great jingling of crockery, shaking of windows, and barking of dogs. Another shock subsequently occurred.

ULVERSTONE.—About 11.5 an alarming earthquake was experienced in this town. The writer of this communication had just retired for the night, and was composing himself for rest when a slight tremor was felt. It was like the approach of a carriage, but in the space of a second or two the vibration had increased to so great an extent that the walls of the house rocked, the window frames rattled, and the bedstead shook as though grasped by the arm of a strong man. The quaking continued from ten to fifteen seconds. The police on their beat distinctly experienced the sensation. The evening was, for the season of the year, peculiarly still and warm, though the thermometer stood at 42 degrees.

BLACKPOOL.—In this town and neighbourhood the action of the earthquake was noticed by numerous persons. It was very violent in some parts,—glass and crockery having been thrown off shelves and broken.

MANCHESTER.—The oscillations are described as producing only a slight, though perceptible, tremor. At Singleton Brook, near the city, the first shock was felt at precisely six minutes to eleven. A resident says that the windows of his house were violently shaken, as though a heavy vehicle was passing along the road. Several inmates of the house remarked the effect as peculiar, but it did not then suggest the idea of an earthquake, and had nothing further occurred the impression produced would have been forgotten. About five minutes past eleven, however, the noise was again heard, accompanied, as before, by a tremulous motion. This time the effect was much more marked and continuous. All the inmates of the house (nine in number) were in bed, and each felt the shock. At first the impression produced was merely that of trembling, which lasted for, perhaps, two seconds. This was succeeded by a slight pause of about half a second, and then the beds were distinctly felt to roll from side to side, exactly like the heaving of a ship at anchor, and with the same sharp and sudden check to the motion. The time occupied by the second shock was about four seconds.

BOWDEN—A correspondent at Bowden, near Manchester, says that he had just retired to bed when, exactly at 11 4 p.m., Greenwich time, he experienced the tremulous motion peculiar to an earthquake. He adds that the shock lasted as nearly as possible twelve seconds, and that the course of the earthquake was from north-east to south-west.

LIVERPOOL.—About 11.15 a very perceptible shock of an earthquake was felt

in Liverpool and the neighbourhood. About Brook and Seaforth, and along the coast to Southport, the movement was very plainly felt, and on Breeze Hill, Walton, the furniture in some of the houses rocked to and fro. The shocks, of which there were two, lasting about three or four seconds, appeared to travel from west to east.

TYNESIDE.—On the Tyne, west of Newcastle, the earthquake, about half-past eleven o'clock on Friday night, shook the windows and doors of many of the houses. It was very distinctly felt in the large manufacturing village of Blaydon, and, indeed, all up Tyneside. Several families jumped out of bed in great alarm through the noise occasioned by the rattling of the lighter articles of furniture. The shock was felt in Newcastle and Sunderland, but less distinctly than in the neighbouring villages. The weather on Saturday afternoon became suddenly warm in Newcastle, and more resembled that of June than March. It had been cold and bleak during the week, with occasional snow showers.

ASKRIGG, YORKS, 17th.—A slight shock of earthquake at 6.45 ; the duration about four seconds ; another very violent one at 11.15, duration about six seconds. The weather was very fine at the time, and has been so to the end of the month, except a slight shower on the 25th. There have been several shocks since the 17th.

SCARBOROUGH—The shock was felt here about 11.15 : the effects are variously described by several parties who felt it ; and it is somewhat singular that while it was felt more or less in every quarter of the town, it was not generally noticed. Thus, a lady residing at Westborough very distinctly felt the tremor, and one side of her bed was disturbed, so that she was on the point of raising an alarm, feeling sure that thieves had entered the house ; while her neighbours, a few yards off, felt nothing whatever. It was felt in St. Nicholas-street and the Crescent, while the intermediate neighbourhood was not affected. The shock was experienced on the South Cliff, the glass and china in some of the houses responding to the mysterious force exerted upon them. No injury to person or property has been reported.

YORK.—Some persons were awoke by the rattling of doors and windows and crockery, and several who had not retired to rest rushed into the street, fearing that some catastrophe had occurred.

LEEDS.—At about 11.15 p.m. on Friday a slight tremor of the earth was perceived—so slight that it would not have attracted notice had it not been almost immediately succeeded by a more unmistakeable agitation or vibration of the ground.

DONCASTER.—The earthquake was felt in this neighbourhood on Friday night about 10.10 p.m. [11.10 ? The vibrations lasted a few seconds, and were strong enough to shake the windows, beds, and other articles of furniture.

To the Editor of the Meteorological Magazine.

SIR,—The earthquake of March 17th was felt very distinctly here. My house was shaken very violently, the motion, which was accompanied by a loud rumbling noise, lasting nearly ten seconds. The time was about 11.5 p.m. The air was very calm, the temperature (4 feet above ground), 42°; and the barometer (corrected) 30·21 in. A slight shock was also perceived in this neighbourhood at 6.20 p.m. on the same day, and one of my servants noticed another at 10.30 p.m. The movement was from W. to E. There was a small auroral display on the evening of the 16th.

T. B. ARMITSTEAD, B.A., F.M.S.

Hutton House, Burton, Westmoreland, March 21st, 1871.

AURORA OF DECEMBER 17TH, 1870.

To the Editor of the Meteorological Magazine.

SIR,—Mr. Birt's description, in your February number, of the aurora of December 17th, does not agree with my observations of it at 6 p.m.,

but it agrees very well with mine a few minutes earlier, as the following extracts from my notes will show :—

5.50 to 5.53 p.m. (Greenwich time).—There is a beautiful red band from N.E. to W.N.W., but passing about 15° S. of the zenith, where it is bright red. It is 10° or 15° wide.

5.56 p.m.—The red very faint, visible only in the W., and the aurora is little but diffused light, covering the greater part of the sky. No part is particularly bright.

6.4 p.m.—There are a good many flashing rays, but not bright ones; they are chiefly near the corona.

6.6 p.m.—The aurora much the same as at 5.56, but there is no red, and it is brighter in the N. It covers all the sky faintly.

From the above account, the southern boundary of the red band would be 21° S. of the zenith, instead of, as with Mr. Birt, 7° N. of it. Assuming that we both saw the same band, the distance between the magnetic parallels of latitude on which Sunderland and Walthamstow are situated being 234 miles, the height of the band would be between 450 and 580 miles.—Yours truly, T. W. BACKHOUSE.

West Hendon House, March 23rd, 1871.

P.S.—The heights of auroræ seem to be very imperfectly known. I do not see why it should be so; if a systematic series of observations were made in distant places, I have no doubt our knowledge on the subject would soon be greatly increased. I, for one, should be very willing to co-operate in such an undertaking.

[A capital suggestion, which we will gladly aid in any way that we can.—ED.]

AURORA OF APRIL 9TH, 1871.

To the Editor of the Meteorological Magazine.

SIR,—On the night of Easter-day, the 9th April, between 10.20 and and 11 p.m., there was a very magnificent display of aurora borealis, nearly equal to that of the 24th and 25th October last year. The colour was principally a brilliant carmine, and twice was the light so suddenly shot upwards and so bright as to resemble a flash of lightning. The base of the auroral light extended from E.N.E. to S.S.W., and the rays converged in a bright crimson fan on Cor Caroli, which was then about in the zenith of this place.—Yours truly,

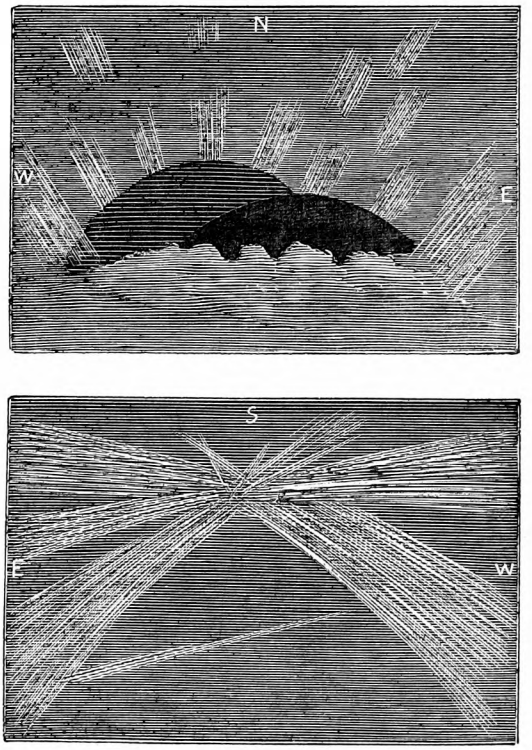
J. M. DU PORT.

Mattishall, Norfolk, April 10th, 1871.

To the Editor of the Meteorological Magazine.

SIR,—The sky was illuminated last night between 10 and 11 o'clock with a magnificent aurora borealis. It was far more brilliant than the most splendid display that I have ever witnessed. I send you a sketch of the N. and S. heavens made by me. The great peculiarity about these northern lights observable here last night consisted in the absence of all streamers and of any luminous appearance in a triangular space

in the south, whilst all the rest of the heavens were a-blaze with light. The apex of this triangular dark space was about 70° from the southern horizon. The streamers seemed to be collected together at this angle, as if tied in a knot, or as if they emanated from this spot, which was, as intimated before, some little distance south of the zenith.



The streamers were most brilliant in the west. Pale green streamers were occasionally intermingled with the crimson. Lightning was said to have been noticed. I here subjoin the state of the meteorological instruments during the display:—Bar. 29·914; dry bulb, 40·9; wet bulb, 38·8; wind, E.; force, 3 (scale 6); clouds, 2 (scale 10).

Yours faithfully,

CORNELIUS B. FOX, M.D., F.M.S.

South Cliff, Scarborough, April 10th, 1871.

To the Editor of the Meteorological Magazine.

SIR,—A most magnificent display of aurora borealis was observed here last night, surpassing in brilliancy and duration the displays of last October.

At 8 p.m. the whole northern sky became lit up with brilliant white light; at 8.45 bright red streamers appeared in N.E., which faded away at 9 p.m., the sky in the north and west remaining very brilliant.

Distant lightning was seen in N.E. from 8.45 to 9 p.m. At 10.30 a body of intensely vivid light appeared in the W., with streamers and waves passing right across the sky to the E. horizon, blending with a hazy cloud which obscured the sky in that quarter and in the N. and and N.E.; the light near the horizon in W. was brilliant green, but as it neared the zenith, became a deep blood red. At 11 p.m. the sky, with the exception of a small portion of the S. horizon, was completely covered with pale streamers, passing from W. to E. At 11.30 a dark cloud, through which the stars could be distinctly seen, partially obscured the light in the W., and bright streamers passed from the N. at right angles to the main body. At midnight the streamers in the W. and near the zenith faded considerably, but the phenomenon continued till near daybreak in the N. and E.—Yours truly,

THOS. PAULIN.

Winchmore Hill, April 10th, 1871.

RAINFALL RULES.

To the Editor of the Meteorological Magazine.

SIR,—I am glad to hear that the rules for observing rainfall are not (with perhaps one exception) the laws of the Medes and Persians, and that *our* government *does* consult its supporters. May I then make a few criticisms?

Rule I.—It is hard to choose among evils. Different parts of the country have different rainy quarters. At Tunbridge Wells it used to pour with S.W. gales; here I find S.E. and N.N.W. the most rainy and windy. Would it not be better, then, to omit the last sentence of this rule?

Rule V. is all very well; but I should say, "Have a copper or zinc funnel put in instead."

Rule XII. involves a distinction between ·005 and ·004, which with nine glasses out of ten I am unable to make, owing to the irregularities of the bottom. Besides, since this rule was made, who knows what is the least fall to constitute a "day of rain?" Is it the real ·01 or the regulation ·01 which may be ·005? I quite agree with Mr. Cator.

Rule XV.—I would have every gauge made with an upright rim, 3 or more inches high, or else a cylinder should be used. (3) should be struck out as delusive; sometimes it would not give results right to the nearest inch of rain! (2) does very well when the ground is frozen underneath, and there has been no wind to drift the snow. For melting snow perhaps Mr. Cator's proposal is best. I have tried it, sometimes by pouring in a measured quantity of warm brine. But it is hazardous to put hot water into frosty glasses, and I generally put funnel and bottle before the fire, and the water runs down into the bottle as fast as the snow melts. If the bottle has ice in it, put it in a pan half full of cold water upon the fire; as the water gets hot, the ice will melt rapidly without danger to the bottle.

I ought to have added to my paper in *British Rainfall* an explana-

tion of the column headed "Deduced Velocity." The figures are the velocities which I have found by observation with the anemometer to correspond approximately to the figures at which the force is estimated on the Beaufort scale, and differ slightly from the values given by the Meteorological Office. They are—force 1, 5 miles; 2, 10; 3, 13; 4, 18; 5, 25; 6, 31; 7, 37; 8, 43; 9, 50; for forces 10, 11, and 12 I have no observations, and all are liable to correction from more experience.—I remain, Sir, your obedient Servant,

FENWICK W. STOW.

Hawsker, March 29th, 1871.

To the Editor of the Meteorological Magazine.

SIR,—From the discussion, which has been going on in your valuable magazine, on the present rules laid down for taking meteorological observations, it is evident they are not considered, "according to the laws of the Medes and Persians," for they seem likely to be subject to the same variableness as the various and varying phenomena of our atmosphere which they are intended to record. In your last number, Mr. Bicknell enters a protest against Rules XII. and XV. for "Rainfall Observers." Now, with reference to the former, he states, that "there is no more difficulty in reading 0·001 of rain than 0·001 of the barometer scale." A standard barometer is furnished with a vernier to show 1-500th of an inch, but glass measures are only graduated to hundredths of an inch, with a gauge having a receiving surface of eight inches; in many instances, the graduation of a measure for a 5 inch gauge begins with 0·02 in. after which, they are 0·01 in. Now 50 drops of water, as determined by a minimum measure, is equivalent to 0·01 in. in a measure for a 5 in. gauge, so that a gauge of that dimensions would yield 5 drops for 0·001 in. of rain; such a measurement appears to me simply absurd, and if it is necessary to be exact with small quantities, it is equally so with extraordinary falls. It may look a simple thing to those with only one gauge, but when they exceed half-a-dozen, I doubt whether any special advantage would be obtained, especially if rain were falling heavily at the time of reading. When a beginner I measured with nicety, but I soon found it was not measured in such small quantities in our principal observatories, and came to the conclusion that I was more nice than wise.

With reference to Rule XV., for measuring snow, that gentleman states that it is a bad one. Admitting it to be so, what he proposed would only make bad worse. Whatever method is adopted it should be with the least possible delay, as it is generally accompanied by a rough wind, but I certainly am surprised at the last suggestion, that is, to allow 12 in. of snow to remain until a thaw for half the snow to evaporate. Supposing it fell on the 1st January, it would take until the end of February to lose half of it by evaporation.—Yours obediently,

JNO. ARNOLD.

Aldershot, 8th April, 1871.

BRITISH RAINFALL, 1870.

To the Editor of the Meteorological Magazine.

SIR,—I have just got through *British Rainfall*, 1870, and I wish to make a few remarks. In the first place it is satisfactory to find that my investigation of the results from the Rotherham experimental rain-gauges falls in so consistently with the deductions of the Rev. F. W. Stow, the Rev. C. H. Griffith, Sergeant Arnold's observations, and your own conclusions. Unfortunately, on page 28, line 21, the sign for multiplication has been printed instead of that for addition; and the same mistake exists in line 27. These errors were not in the manuscript, as I find by the press copy which I kept.* However, you have I think made a more important mistake; at p. 45, line 3, "a less angle, such as 35 or 30°," should have been "a greater angle, such as 50 or 60°"; because, if the vertical gauge collected *more* rain, the inference would be that the showers were more nearly horizontal, or the angle from the vertical was greater.

You may well be congratulated on having arrived so nearly to the solution of the problem, which, as you say, "has baffled observers for more than a century" namely, the cause of diminution of rainfall, with elevation above the ground. It would seem that a vertical rotating gauge must henceforth be used conjointly with a horizontal gauge by all observers who desire to ascertain the correct amount of rain, and have a good position for exposure of the instruments. From the lucid exposition of Mr. Stow, meteorologists will perceive the necessity of taking into consideration the nature of the exposure of the gauges before making deductions from rainfall statistics. Mr. Stow's instrument, figured on page 15, seems a very good model for a vertical and a horizontal gauge combined.

At page 19 Mr. Stow gives, against the "estimated force of wind," the "deduced velocity per hour." I should like to know how it is deduced.† I find the following inconsistent relations between the force of wind, as estimated by the Beaufort scale, and the corresponding velocity in miles per hour, and of pressure in pounds on the square foot. Columns A and E are derived from Sir H. James' *Instructions for taking Meteorological Observations*, appendix, pp. 31 and 32; B and F are inferred from a table accompanying Sir W. S. Harris's account of a modification of Lind's anemometer, in the *Nautical Magazine* for 1858; C is given by J. K. Laughton in his *Physical Geography in relation to Winds and Currents*, p. 4; and D is the result of experiments, as stated in the *Quarterly Weather Report*, No. 1, for 1869, issued by the Meteorological Committee.

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* Unfortunately true, but it is only fair to mention that the errors of × for + occurred in the proof, which was submitted to Mr. Strachan, so that the Editor can hardly be considered to be solely responsible for that which escaped the notice of both of them—as to the other it is a mistake, pure, simple, and unmitigated. —ED.

† Singularly enough Mr. Stow has, in his letter of March 29th, p. 44, supplied the particulars requested.—ED.

Beaufort's Scale.	Velocity (miles).				Pressure (lbs.)	
	A	B	C	D	E	F
0	0	0	0	...	0	0
1	7	3	2	...	0·20	0·04
2	14	6	4	...	1·00	0·16
3	21	10	8	...	2·25	0·45
4	28	14	16	...	4·00	0·91
5	35	17	24	...	6·25	1·40
6	42	19	32	36	9·00	1·60
7	49	22	40	44	12·25	2·10
8	56	30	50	...	16·00	4·10
9	63	48	62	...	20·25	10·40
10	70	76	78	...	25·00	26·00
11	77	90	96	...	30·25	36·00
12	84	114	120	...	36·00	57·00

Now, the question is which set of values is the most correct for converting estimated force of wind into velocity, or into pressure? If no one of the above is satisfactory, cannot a relation be agreed upon? It would not so much matter about it being absolutely correct, provided it was an approximation to truth, and received general sanction. It is absolutely necessary to settle upon a basis for converting the Beaufort Scale into velocity, or pressure, because, although nominally a unit scale, it is not founded upon any unit of definite value. As regards velocity Sir H. James gives it a unit value, but the other authorities are far from recognizing this principle. The nominal units have so deceived meteorologists that they are in the habit of averaging the estimates by the Beaufort Scale, although it is evident that if the grades of the scales are of unequal values, they cannot be averaged by simply taking the arithmetical mean. The correct method seems to be to convert them into velocity first, and then to average the velocities. Perhaps you may think it worth while to ventilate this subject in the *Meteorological Magazine*.—Yours faithfully, R. STRACHAN.

11, *Offord-road, N., 6th April*, 1871.

[Our opinion as to the importance of this subject, enunciated in an article on "Equivalent Expressions of Wind Force," in the *Meteorological Magazine*, Vol. I., p. 19, remains unchanged, except, perhaps, that it has gathered additional strength from the experience of the five years which have passed since it was penned.—ED.]

GALE IN THE CHANNEL, MARCH 16TH.

RECORD OF OSLER'S ANEMOMETER.

To the Editor of the Meteorological Magazine.

Wednesday, March 15th, 9 a.m., strong breeze N.W., pressure 6lbs. on the square foot, moderating during the day to a light breeze at 8 p.m., the wind backing through S.W. as far as S. at midnight.

9 p.m., S.S.W., barometer 29·992, (sea level corrected). A furious gale now set in, the pressure reading from 11 p.m. to 3 a.m., 14lbs. on the square foot, velocity 53 miles an hour. Thunder and lightning, with heavy squalls of hail and rain.

Thursday, 16th, 5 a.m., S.W., pressure moderated to 6lbs., velocity

35 miles. 6 a.m., gale again rapidly rising, wind W., veering to W.N.W. at 8 a.m., when the storm culminated, the pressure reading 21lbs., and 25lbs. in the gusts, velocity 65 to 70 miles an hour, until 10 a.m.

9 a.m., barometer (sea level corrected) 29·421, a fall of nearly six-tenths in twelve hours. Rainfall 0·50 inch.

1 p.m., the gale still continues from N.N.W., with a force of 12 to 15lbs., velocity 50 to 53 miles. Barometer has risen $1\frac{1}{2}$-tenth.

This gale is, I believe, the outskirt of a cyclone, the axis of which has proceeded N.E., many miles to the north of this island, and we shall probably hear of much worse weather along the English coast.

Yours truly, TH. L. MANSELL.

Guernsey, March 16th, 1871.

PERIODICAL RETURN OF THE SEASONS.

To the Editor of the Meteorological Magazine.

SIR,—I perceive that several of your staff of monthly observers include in their observations notices of the appearances of insects, and other natural historical details; as these remarks are of great importance in marking the periodical return of the seasons, may I suggest that they would be more comparable and interesting if separated from the general meteorological notices, and tabulated by themselves.

Yours truly, C. H. GRIFFITH.

Strathfield-Turgiss, Winchfield, Hants.

[We are not sure that the notices of the above class are sufficiently numerous to warrant separate tabulation, but we should gladly devote the requisite space, if Mr. Griffith would undertake it, and a few additional observers would supply him with the requisite information.—ED.]

REVIEWS.

Quarterly Weather Report of the Meteorological Office. Part III., July to October, 1869. 4to, 80 pages, 36 plates.

Barometer Manual, Board of Trade. Compiled by R. H. SCOTT, M.A., F.R.S. 8vo, 76 pages, 4 plates.

THE first of these works is sufficiently noticed by its title, whence it will be seen to be the continuation of the serial, the two previous numbers of which have been fully noticed in these pages.

The barometer manual is a rewritten and considerably improved edition of that prepared by the late Admiral FitzRoy, and contains much useful information at (of course) a moderate price. There are a few points which we think require consideration when another edition is prepared, but they are mostly of minor importance.

We do not agree with Mr. Scott when (on page 10), speaking of the wet bulb thermometer as a hygrometer, he says—"The moisture is usually measured by the pressure or tension of its vapour."

Captain Toynbee, F.R.A.S., contributes a paper on the use of the barometer to seamen, which appears to us of extreme utility. Mr. Strachan's paper on the construction and management of barometers contains many useful hints, and with some reduction tables appropriately closes a very excellent manual.

MARCH, 1871.

Div.		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	1·19	— ·89	·38	15	12	68·7	26	29·0	15	7	12
II.		Maidstone (Linton Park)	1·44	— 1·05	·40	16	10	71·0	23†	30·0	2	...	...
,,		Selborne (The Wakes)	2·04	— ·56	·68	15	10	63·5	24	26·5	3, 22	11	15
III.		Hitchen	1·40	— ·77	·62	15	13	63·0	26	27·0	24†	6	...
,,		Banbury	1·33	— ·87	·56	15	9	65·0	26	27·5	2, 17	8	...
IV.		Bury St. Edmunds (Culford)	1·47	— ·73	·30	14*	12	65·0	25‡	26·0	14	9	17
V.		Bridport	1·77	— 1·10	·39	9	11	64·0	24	28·0	17	5	...
,,		Barnstaple	1·66	— 1·49	·32	9	12	67·5	25	32·0	17	...	...
,,		Bodmin	1·91	— 1·84	·62	9	13	63·0	24	31·0	30	1	10
VI.		Cirencester	1·65	— ·95	·63	9	8	...	...	...	...	...	...
,,		Shiffnal (Haughton Hall)	·84	— 1·10	·19	15	11	62·0	25	26·0	15	9	...
,,		Tenbury (Orleton)	1·76	— ·66	·43	15	15	66·5	26	27·0	17	9	19
VII.		Leicester (Wigston)	·94	— 1·17	·43	16	8	70·0	24‖	...	...	10	...
,,		Boston	1·02	— ·77	·45	15	9	66·4	25	29·3	17	2	11
,,		Grimsby (Killingholme)	·88	...	·29	15	10	61·0	25	28·0	15	3	...
,,		Derby	1·15	— 1·09	·53	15	13	66·0	25	27·0	15	5	...
VIII.		Manchester	1·56	— 1·13	...	...	8	71·2	25	31·0	28	...	...
IX.		York	1·21	— ·78	·39	15	12	64·5	24†	29·0	15	2	...
,,		Skipton (Arncliffe)	4·67	— ·14	1·24	10	11	69·0	26	20·0	16	14	...
X.		North Shields	·69	— 1·66	·16	9	13	57·6	3	21·3	15	5	8
,,		Borrowdale (Seathwaite)	10·26	— 3·14	1·80	10	15	...	...	...	...	...	...
XI.	WALES.	Cardiff (Town Hall)	...	...	...	...	...	...	...	...	...	...	...
,,		Haverfordwest	2·24	— 1·21	·64	9	10	65·0	26	30·0	15	3	5
,,		Rhayader (Cefnfaes)	1·48	— 2·36	·50	9	9	64·0	...	25·0	...	3	...
,,		Llandudno	·77	— 1·49	·16	12	9	67·6	24	32·5	15	...	...
XII.	SCOTLAND.	Dumfries	2·09	— ·89	·73	9	13	69·5	24	13·0	15	6	...
,,		Hawick (Silverbut Hall)	2·00	...	·59	9	11	...	...	...	...	...	...
XIV.		Ayr (Auchendrane House)	4·04	+ ·31	·70	15	17	68·0	24	15·0	15	6	14
XV.		Castle Toward	4·04	— ·55	·62	15	19	64·0	25	20·0	15	7	10
XVI.		Leven (Nookton)	1·06	— 1·01	·38	9	15	64·0	25	21·0	15	9	23
,,		Stirling (Deanston)	3·49	— ·04	·91	11	16	64·5	25	19·2	15	6	16
,,		Logierait	2·03	...	·49	6	15	...	...	...	...	...	...
XVII.		Ballater	1·00	...	·28	12	8	66·0	25	18·5	15	11	...
,,		Aberdeen	·53	...	·12	9	10	60·5	25	25·3	15	5	18
XVIII		Inverness (Culloden)	1·72	...	·68	13	15	59·1	24	27·1	15	3	16
,,		Portree	8·16	— ·88	1·32	11	24	...	...	...	...	...	...
,,		Loch Broom	3·95	...	·48	10	25	...	...	...	...	...	...
XIX.		Helmsdale	1·27	...	...	...	...	...	...	...	...	...	...
,,		Sandwick	2·30	— 1·03	·30	8	21	57·0	3	28·5	14	6	9
XX.	IRELAND.	Cork	2·64	...	·68	8	11	...	...	...	...	...	...
,,		Waterford	2·18	— ·71	·37	9	15	62·0	...	31·0	15§	3	...
,,		Killaloe	2·52	— 1·80	·60	10	14	67·0	24	27·0	29	6	...
XXI.		Portarlington	1·46	— 1·85	·29	9	19	64·0	24	28·0	14	5	...
,,		Monkstown	·71	— 1·87	·21	6	10	...	...	...	...	2	...
XXII.		Galway	2·21	...	·36	15	15	60·0	25	30·0	28	2	...
,,		Bunninadden (Doo Castle)	3·06	...	·60	12	14	61·0	22	24·0	24	6	...
XXIII		Bawnboy (Owendoon)	...	...	..	...	...	...	...	...	...	..	..
,,		Waringstown	1·63	...	·25	8	14	69·0	25	20·0	28	8	19
,,		Strabane (Leckpatrick)	2·87	...	·44	9	16	65·0	...	...	...	...	...

* And 16. † And 25. ‡ And 26. ‖ And 25, 26. § And 30.

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

METEOROLOGICAL NOTES ON MARCH.

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, scarcely any frosts, while the temp. of the 23rd and three following days resembled June rather than March. Fogs on 20th, 21st, and 22nd; no high winds; wind mostly S. and S.W., but often changeable. S fell unexpectedly on the 16th, accompanied by but little frost, ther. falling only to 31°. Max. bar. 30·17 on 1st; min. bar. 29·13 on 16th. Winds S. and compounds of S., on 18 days; N. and compounds of N., 9; W., 3; and E., 1.

SELBORNE.—Violent wind from S.W., with R, at 10 p.m. on 5th; bar. fell ·4 between 9 a.m. and noon on 9th; a most violent storm of wind, R, H, and some S, from 2 p.m., lasting three hours; wind W. Very rough, high wind, much S with R, early on the morning of the 16th; white frost on 20th; fog on 22nd; very dense fog with white frost on 23rd, and another dense fog on 24th, when the wind changed from N.E. to S.W. Sudden rise of bar. on 27th, when the wind changed from S.W. to N.E. Prevailing winds first three days E., then S.W. mostly for 10 days, and N.E. for the remainder of the month. Max. bar. 29 9 on 1st; bar. min. 28·79 on 16th; latter part of the month favourable for gardening and agricultural work, but a bleak and unhealthy month.

HITCHEN.—Tremendous gale and R on 9th; the heaviest fall of S on the 16th since January, 1866. Splendid meteor seen at 6.30 on 23rd. The highest temp. (63°), recorded so early in the year since March, 1858.

BANBURY.—High winds on 7th, 9th, and three following days; S on 14th, 15th, and 16th; T on 26th. Hedges leafing at the end of the third week.

CULFORD.—A month of very seasonable weather, with frequent slight morning frosts at the commencement of fine days. An almost summer temp. and aspect was experienced from the 23rd to the 27th, when a sudden change took place, as may be inferred from the fact of the max. temp. of the 25th and 26th being 65°, while those of the 28th and 29th were 44° and 48° respectively; the mean temp. of the month was 44°·3; high wind on 9th; S on 15th, 16th and 28th.

BRIDPORT.—Latter part of the month fine, and some days very mild, the temp. of the month being rather above the average.

BODMIN.—Bar. average of the month 30·000, average temp. 47°·2, being 3°·2 above the average for March.

SHIFNAL.—Great and sudden changes of wind and temp. This month opened pleasantly with S. and S.E. winds; on 15th it changed to N.W., and then went round by W., S.W., S. to S.E. on 22nd, and then by E. to N.E. on 24th, where it continued till the close of the month. A heavy storm all day on the 9th from S., veering round by S.W. to N.W. A severe frost with S on night of 18th; S with R on the following night; T without R in the N.E. on 26th at 4.30 p.m.; temp. that day 61°, following day 51°, and next day 41°,—20° difference in 48 hours. A dry month, suiting the lambing time and the resowing of the wheat, which had perished on strong lands. Crocus began to flower on 2nd; hawthorn to bud on 4th; apricot to blossom on 11th, willow on 13th; celandine to flower on 20th, wild daffodil on 24th; gooseberry bushes to blossom on 25th. First appearance of large humble bee on 18th; sulphur butterfly first seen on 24th; fog on 19th.

ORLETON.—A dry month, with a temp. 3° above the average, although more than half the nights were frosty. Much R from 5th to 16th, then very dry, generally fine till the end. Temp. at midday on 23rd, 24th, 25th, and 26th, was very high; a sudden change occurred on the evening of the 27th, and the remainder of the month was cold. Apricot in bloom about the 12th, and peach trees about the 24th. Distant T heard on the 26th, and L seen at night on 25th.

WIGSTON.—The unusual high temp. of the early and latter part of the month stimulated vegetation very much, so that the aspect of the country was very

different from that which it usually is in March. A heavy fall of S on the night of 15th. T on 26th.

GRIMSBY.—The month drier than usual, vegetation forward, and many pleasant days. High winds from the 6th to 13th. Max. temp. 61° on 25th, a clap of T at 5.45 p.m. Rooks began to build on the 1st; queen wasp seen on 3rd; gossamer web across funnel of gauge on 4th; apricot began to flower on 11th, and peach on 18th. Shock of earthquake felt at Barrow-in-Furnace and Ravendale on 17th.

DERBY.—General character of the weather magnificent, many days more like June than March. Temp. about 3° above the mean, rainfall considerably below it.

ARNCLIFFE.—S on 16th.

NORTH SHIELDS.—Lunar halos on 1st and 4th; aurora on 17th, on which night a shock, which was said to be an earthquake, was felt about 11.10 p.m; we were moving about at the time, and thus did not feel the motion, but the noise was as if the windows rattled. My sister living in Newcastle, 8 miles distant, was awakened by the shaking of her bed; two of our clerks living at Newcastle felt the shaking of their houses very clearly, and another living at Gateshead was awakened by all the bells ringing, and a small glass ornament was thrown down and broken.

SEATHWAITE.—S on 6 days; H on 4, and T on 8th and 26th.

WALES.

HAVERFORDWEST.—A mild month; wet from the 6th to the 16th, and at times very stormy; rainfall and frost below the average; a cowslip observed in full flower on the 5th.

CEFNFAES.—The month has been cold; prevailing winds N.E. and S.E., and the nights more or less frosty. Lambs doing well, although there is but little food for the ewes.

LLANDUDNO.—Primroses gathered in the hedges on the 4th; S on the distant hills on the 6th and 7th. The month has been most changeable, from great heat to cold—March weather. The wind generally W., only E. on 10 days during the month; an earthquake felt on Friday, the 17th, at 11 p.m., rousing many from their beds by the shaking of windows and doors, as if some heavy thing had fallen in the house; a peculiar lurid light for a few moments whilst the earthquake lasted.

SCOTLAND.

DUMFRIES.—The first half of the month wet and stormy, with occasional showers of S and sleet. On the morning of 15th the most intense frost known in the month of March for upwards of 20 years, the protected ther. being 19° below freezing point, only twice lower during the winter. The latter half of the month dry and generally cold, except from 23rd to 25th, when it was very warm. T on 23rd. A slight shock of earthquake was felt here between 11 and 11.30 p.m. on 17th; in some cases doors and windows rattled, as well as the slates on the roofs; in some houses articles of furniture were thrown down; people in bed felt as if the bed was raised up by some person beneath; at Kirkbean, in the neighbourhood of Criffel Mountain, the shock was experienced throughout the whole parish, a deep rumbling noise was heard, and a violent motion, followed by a sound as if of air rushing to fill up a vacuum.

SILVERBUT HALL.—Violent gales on 5th, 6th, 7th, 20th and 21st. Snowstorms on 13th and 14th. The month has been favourable for getting in seeds; sowing has been actively prosecuted, and has been concluded on most farms, and on all is far advanced. The lambs have made their appearance on the low grounds, and there is a good proportion of twins, but the chill air has not been in their favour. The pastures were rapidly getting fresh and green till checked by the very severe frosts of the last five days.

AUCHENDRANE.—This month the diminished amount of cloud, the high temp., and strong winds, chiefly equinoctial, did not lower the bar. pressure much below the mean, though they narrowed somewhat the extremes of bar. range, and raised the rainfall and evaporation considerably above the mean, producing at some

times a humidity of 83. R slightly intermitted out-door work till the 21st, afterwards March dust and dew on grass appeared. The north of England earthquake was not felt here. Rivers still amply supplied with water.

CASTLE TOWARD.—The first half of the month was wet and occasionally stormy, but free of frost up to the 14th; the latter half generally fine, mild and clear; early spring plants are quite gay, and fruit trees promise an abundant crop.

DEANSTON.—First week changeable, without much R; second week wet and stormy; on 8th T and L, with wind and sleet, and a fall of S on 9th; gale with R on 12th; from 15th to the end but little R; bright sun, E. wind, and sharp frost with ice a quarter of an inch thick, on 29th.

LOGIERAIT.—Frost, with H and S showers on 13th and 15th; frost on the night of 27th. Lapwing seen on 22nd. The month closed cold, with E. wind.

BALLATER.—High winds prevailed throughout the month, but weather open, and out-door work but little interrupted; rainfall under the average; occasional S showers; ground cold and white at the end of the month.

ABERDEEN.—S on six days, auroræ on seven days. A month of mild dry weather; since the 14th of February not one inch of R has fallen. Frequent strong winds; mean bar. (reduced) 29·860, or 0·128 above mean of 14 years; mean temp. 42°·9, or 3°·8 above mean; rainfall 1·87 less than the average. S.W. winds greatly in excees, N.W. also in excess. Estimated pressure a little under the average.

PORTREE.—A cold, wet, and stormy month; from 13th to 17th heavy fall of S, 13 inches deep all over; heavy gale from W.S.W. all day on 12th; the month throughout has been very squally and cold.

LOCHBROOM.—The R during the month has been very constant, but so gradual and uniform that it has not much retarded agricultural operations, and on account of the continual moisture and freedom from frost, vegetation is in an unusual state of forwardness.

SANDWICK.—Temp. of March 2°·3 above the average of last 44 years, and the rainfall below it. Gales on 7th, 8th, 12th, 30th, and 31st, from 40 to 50 miles an hour; auroræ on four nights.

IRELAND.

MONKSTOWN.—The month unusually dry; frost occurred on the nights of 13th and 16th. Prevailing winds in the early part of the month were S.E., S., and S.W., in the latter part N.E., N., and N.W.

DOO CASTLE.—Beginning of month rough and stormy, middle to end fine; tillage fairly advanced.

LECKPATRICK.—Constant R the first half of the month, the latter half very dry and favourable for sowing seeds. S on the 16th.

WHAT ARE THE CAUSES OF FROST BEING SO MUCH MORE SEVERE AT ONE PLACE THAN ANOTHER?

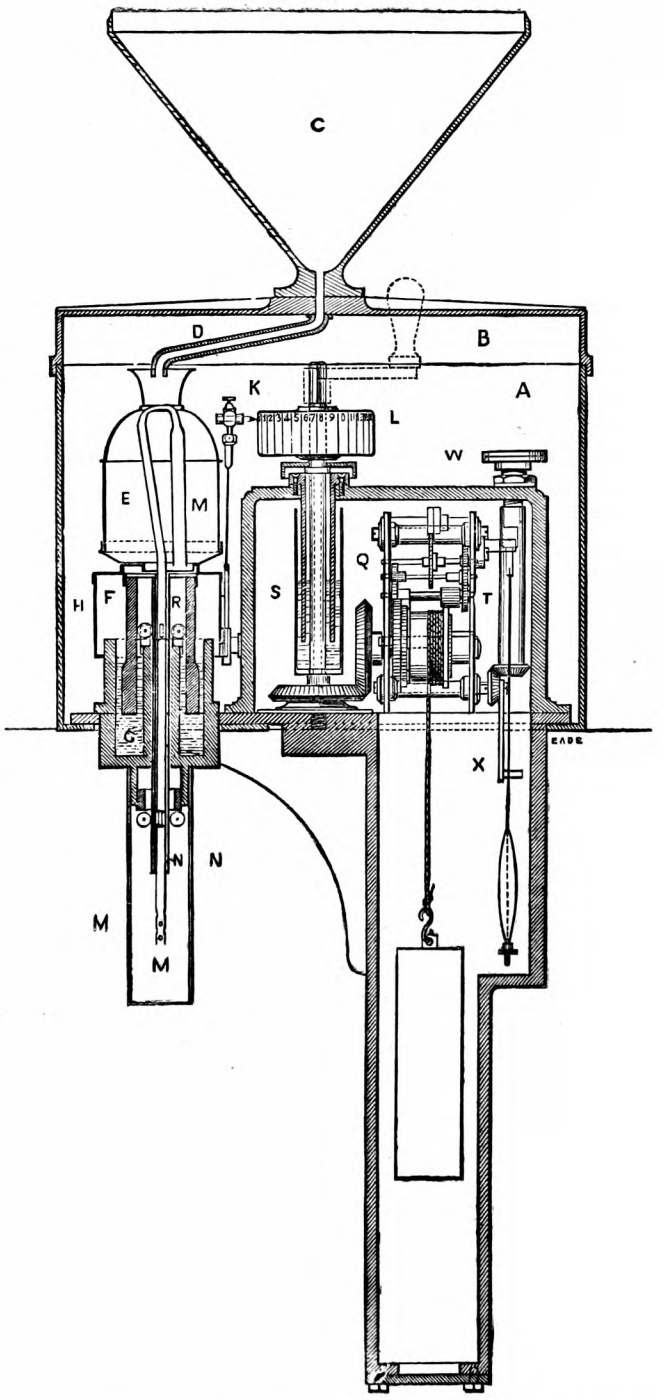
To the Editor of the Meteorological Magazine.

SIR,—Amongst the many questions raised in your useful periodical, there is one to which I have never seen a satisfactory solution given, and that is the cause of the wide differences in the readings of min. thers.; in other words, how are we to account for one place being visited with 10 or 15 degrees more frost than another one less than half-a-dozen miles off. I expect to be told that elevation has something to do with it, and undoubtedly it exercises some influence that way, but not sufficient to make up the discrepancies, neither do I attribute errors in the instruments used as blameable for the whole of it, for there are other tokens

of a severe frost besides those which the readings of a thermometer give, and they are its effects on vegetation, the thickness of ice and other natural results of extreme cold, not the less to be regarded because they cannot well be reduced to figures; and the past winter has given us several examples this way which require explanation; for instance, the lowest point attained by our thermometer here was 13°, or 19° of frost, on the morning of 24th of December, which I believe was also the coldest at other places in the neighbourhood. While at some places not more than 4 or 5 miles off, the readings were down to 3°, and one or two places at zero, and some are said to have been even below that. An error in the instruments used might have been thought the cause of this, were the effects on vegetation not so apparent as to justify the belief that the thermometers are not much in fault, for while our shrubs and trees have scarcely been injured, others are killed to the ground; and I could point to one or two situations of nearly the same elevation as Linton, that were visited with 6° or 7° more frost, and that only a very few miles from us, while as much as 8° difference existed in a situation not more than half a mile from us, but some 100 feet lower. Assuredly there must be causes for this, which have never been sufficiently explained. The only conclusion I can come to on the matter is, that the cold air descends in waves or volumes, and not in a compact uniform body, and has to depend on the wind mixing it with the surface atmosphere, and as there was scarcely any wind at all the night in question, the mixing was only imperfectly effected, and probably cold may have an affinity for cold, and consequently an accumulation of it might visit one place to a greater degree than another. Certain it is we never experience the same disparity in heat. The hottest day in summer rarely presents above 1° or 2° of difference in those places where 8° or 10° have been read the past winter, and I can only attribute it to the greater circulation during the daytime; be this as it may, the matter requires investigating, and I have been looking for each issue of your magazine, the present year, containing some articles upon it; thus I have put forward the above theory, rather as an inducement for others to inform us of the actual cause; at the same time, I may repeat that erroneous instruments are not the only one, for I am not sure but a careful examination of them would make the discrepancy still larger, and assuredly an elevation of some 60 or 70 feet ought not to account for 6° or 7° more or less of frost, and yet this has been exceeded, when the situation in other respects seemed much the same, and I am not sure but 15° or 18° difference has not been recorded in this county within a stretch of less than that number of miles, the injury done to trees and shrubs proving that a great difference did exist, and possibly quite to the extent the instrument pointed it to be. Might I ask for some further explanation on this?

JOHN ROBSON.

Linton Park, Maidstone.



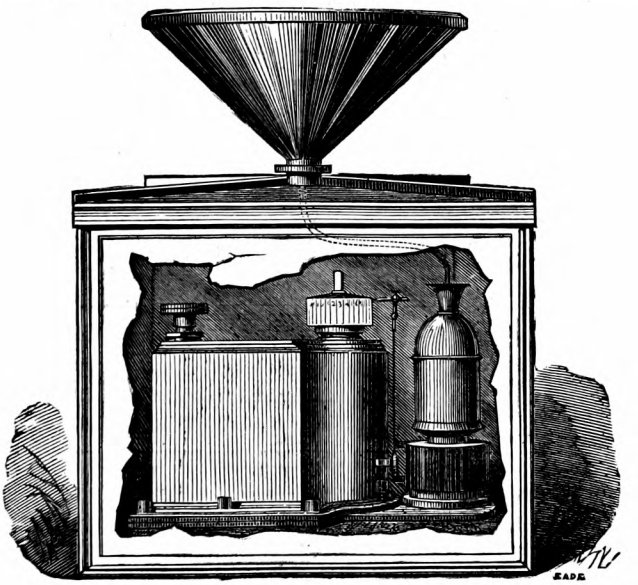
BECKLEY'S SELF-RECORDING RAIN GAUGE.

SYMONS'S
MONTHLY
METEOROLOGICAL MAGAZINE.

LXIV.] MAY, 1871. [PRICE FOURPENCE, or 5s. per ann. post free.

BECKLEY'S SELF-RECORDING RAIN GAUGE.

We are glad to find from several recent communications that the importance of adopting, at several widely scattered stations, self-recording rain gauges is being recognized by observers. In compliance with more than one request, we now reprint from the Report of the Meteorological Committee, for 1869, the full description of the rain gauge adopted by them. Mr. Beckley's mechanical skill is so well known as to create a favourable impression on behalf of any instrument which he designs; in the present case (not having personally worked the instrument) we are not in a position to say whether this impression would or would not be correct.



DESCRIPTION of a SELF-RECORDING RAIN-GAUGE, invented by ROBERT BECKLEY, of the Kew Observatory; made by JAMES HICKS, London.

The instrument is shown in the annexed plate, a section being given of the whole:—

(A) is a cubical box of thin cast iron, 13 inches square and 11 deep, furnished with a loosely-fitted hinged cover (B). The top of the cover is stiffened by four

ribs which meet at a boss in the centre, into which the funnel (C) is screwed. The funnel is also of cast iron, but its interior surface after having been turned is enamelled, in order to prevent rusting. It is provided with a lip to retain the splashes, which is $1\frac{1}{4}$ inches deep, and is turned accurately to a circle of $11\frac{1}{4}$ inches diameter, giving an area of exposure of 100 square inches. A small aperture in the bottom of the funnel opens into a pipe (D), which conducts the water, as it is collected, into the copper bottle or receiver (E); this is supported by a hollow ebonite cylinder (F) floating in mercury contained in the annular vessel or cistern (G). As water enters the receiver the float descends in the cistern, displacing more mercury the further it goes; the relation between the area of the cistern and float being so proportioned that the entrance of equal quantities of water into the vessel (E) shall cause its descent to take place through equal spaces. A cover (H) fixed to the top of the float supports on one side a spring, the upper extremity of which is adapted to hold a pencil (K) which presses against a cylinder (L) covered with waterproof paper, marking on it vertical lines as the float with the receiver rises and falls. When the level of the water in the receiver reaches the neck of the vessel (E), which has then descended to its lowest point, the syphon (M) comes into play, and rapidly discharging the water, enables the receiver to rise and resume its original position, while at the same time the pencil (K) marks a line from the bottom to the top of the cylinder. As the receiver (E) has a capacity of 20 cubic inches this occurs whenever two-tenths of an inch of rain has fallen. The syphon (M) acts on the principle of the intermittent syphon, modified and adapted so as to enable it to act accurately and with certainty in the present case. As the water enters the vessel (E) it rises in the short leg (M) of the syphon, driving the air before it through the long leg (M'M). This continues until it reaches the bend at the top, when it flows down the long leg and brings the syphon into play, and then runs until the vessel (E) is quite emptied (a small depression in the bottom materially assisting it), and the air can enter at the lower extremity of the short leg. The flattened contracted bend of the syphon answers the double purpose of preventing the entrapment of an air-bubble in the bend, and also of ensuring that the vessel shall always be emptied immediately the water in it arrives at a constant fixed height, while at the same time sufficient area is left not to retard the flow of water through it. In order to prevent the retention of a few drops of water by capillary action in the lower extremity of the tube, several small apertures are made at (M); these, by admitting air and also allowing the lateral escape of the fluid, effectually prevent all stoppage from this cause. The action of the syphon as thus constructed is so certain and constant that it is found on experiment that if the water running out of the receiver, when it is discharging itself, be caught in some vessel and returned to the receiver, the syphon will not commence to act until the last drop is poured back. The long leg of the syphon, on issuing from the under side of the receiver (E), passes down a brass tube (NN), through the centre of the mercury cistern guided by rollers (R) fixed to the cistern, which serve to keep the float and receiver perfectly vertical and central. In the experimental forms of this instrument some difficulty was caused by the oxidation of the surface of the mercury in the cistern preventing the moving of the float with sufficient ease and freedom; but a suggestion of Mr. Hicks completely removed this source of annoyance. It consists in pouring a small quantity of glycerine over the surface of the mercury, which by acting in a measure as a lubricating fluid causes the movement of the float to be extremely delicate. The registering part of the apparatus consists of a clock (Q) turning a cylinder (L) at an uniform rate, the pencil (K) marking on the cylinder. The pencil is a piece of ordinary black-lead pencil fixed in a holder capable of being raised and lowered by an adjusting piece. This piece is fastened to the top of a flat metal spring which terminates below in a small brass bar screwed to the cistern cap, and running up and down between two friction rollers (R) to destroy any lateral movement. The cylinder (L) fits easily on the clock spindle, but is capable of being fixed in any position on it, and the paper with which it is surrounded is divided by engraved lines into 24 hour spaces. The clock (Q) is contained in a hermetically closed case, the two places where communication takes place between the interior and exterior being guarded by mercurial stuffing boxes (S and T). S is

the vertical axis supporting and giving motion to the cylinder, being driven round by the clock once every day. By means of a peculiar adaptation of the wheel-work of the clock, a reversal of this motion winds it up, a handle (shown by dotted lines in the figure) being temporarily fitted on to the end of it, which is made square for that purpose. The upper bearing of this axle is formed of a tube which surrounds it loosely for the greater part of its length. This tube is again contained in a larger tube closed at the lower extremity and fastened to the axis. Mercury is then poured into the tube, half filling it, and so preventing the passage of air either into or out of the clock case, but allowing it to expand under varying changes of temperature, whilst at the same time freedom from friction of the axle in its bearings is retained. A similar arrangement at (T) serves to put the pendulum in motion. On turning the milled head (W) on the exterior of the case, movement is imparted by bevilled wheels to a small arm (X), which pressing against the pendulum rod forces it out of its vertical position; immediately the pressure is removed from the head (W) the arm (X) falls back to its original place by its own weight, leaving the pendulum vibrating freely. The clock case is recessed at the bottom to a sufficient depth to allow the weight to fall for one day. The clock mechanism can readily be altered so as to go any number of days, and the time scale can be made of any desired length; but in the present instrument the time scale adopted is that chosen by the Meteorological Committee for their other self-recording instruments.

We can quite understand the desire of the Committee to keep all their curves to a uniform scale, and for ordinary rains the present scale (0·4 inch = 1 hour, and 0·3 inch = 0·1 inch of rain) will answer very well, but with heavy rains, such as several of those quoted on page 93 of *British Rainfall*, 1870, the record would be almost unintelligible. It is satisfactory to find that a more open scale can be adopted by those who desire to be prepared for all emergencies.

SOLAR HALOS ON APRIL 5TH.

CORONÆ, in which the sun or moon are *closely* surrounded by prismatic circles, are very common, in fact occur with more or less distinctness whenever a thin cloud partly veils the principal luminaries. HALOS, or circles of light, at distances of about 10°, 22½°, 45°, and 90°, are occasionally seen, those of 22½° being very frequent. SYSTEMS OF HALOS, such as those engraved in the *Meteorological Magazine*, Vol. V., p. 1, are much more rare. Another modification of these systems is shown in Vol. IV., p. 145, in which we have a nearly horizontal circle passing through the moon,—and still another modification is that described in the following letters and cuttings. It seems to be simply an ordinary halo of 22½° radius, with the addition of a portion of a vertical circle passing through the sun. This vertical circle is called by Kaemtz, the parhelic circle. It is infrequent, except in higher latitudes than ours, but is not, by any means, without precedent, as we proceed to show. We give a few illustrations, which will be interesting for comparison. Figs. 1, 2, and 3, are reduced from Mr. Lowe's "Treatise on Atmospheric Phenomena," which contains a very long chapter on Halos, copiously illustrated. Figs. 1 and 2, represent appearances seen near Thirsk (Yorkshire), on April 19th, 1840, at 7, and at half-past 7, p.m. The observer says:—

The sun appeared to be in the centre of the circle, and the circumference of the circle was almost entirely visible when first noticed. The bow was *prismatic*, and

after the sun had set a clear bright light emanated from the highest part of it. This bright light was, probably, there all the time of the phenomenon, but not apparent on account of the superior brightness of the sun.

Another observer describes (in the same work, p. 88), the appearance at Leeds, which differed from that at Thirsk only in two points, he states (1) that the red rays were nearest the sun, (2) that at 90° from the vertex of the halo there were two parhelia (or mock suns), and that they afterwards extended both internally and externally, but not sufficiently to complete the chord. Fig. 3, copied from the same work, p. 98, shows the appearance as sketched by Mr. Lowe himself, on February 8th, 1845; fig. 4 is from Buchan's excellent *Handybook of Meteorology*; and, lastly, fig. 5 is from the sketch kindly forwarded to us, with several cuttings, and the following letter by the Rev. I. H. Gosset:—

To the Editor of the Meteorological Magazine.

SIR,—I enclose some scraps touching a most remarkable and beautiful sight we had here on April 5th. It was seen for at least an hour-and-a-half by myself and several gentlemen who were playing golf on the Burrows, a large common adjacent to the sea. I concluded it was some kind of parhelion. I regret that I did not watch the phenomenon until the sun set. It must have been about 5.15 p.m. when I first observed it. The sun, as it sank towards the west was surrounded at a very considerable distance by a species of rainbow, the prismatic colours being very apparent; and, as in a rainbow, they were plainer and wider from the sides to the base, but the whole arch was perfect and prismatic above. Its shape was that of a large horse-shoe, or Moorish arch. As the sun got lower, an upward set of rays, quite white, shot up in addition. My barometer (mercurial), at 100 ft. above sea level, stood at 9 a.m., at 30·02, and at 9 p.m. at 29·97, the temp. varied from 50° to 40°. The day was bright, clear, and almost cloudless. Probably you have received other accounts. —Faithfully yours. I. H. GOSSET.

The Priory, Westward Ho! Bideford, N. Devon.

ATMOSPHERIC DISTURBANCE. (*To the Editor of the Standard.*)—Sir,—This afternoon, about an hour before sunset, my attention was drawn by a labourer to a remarkable appearance of the sky, and to some peculiar atmospheric disturbances, the most noticeable of which were currents of alternately cold and warm air. On ascending a hill at 6 30 I witnessed the most extraordinary sunset I ever saw. The sun's rays were not diffused, but concentrated into a column of intensely white light, which was reflected downwards, towards the nadir, when half the sun had set, as though the horizon had been transparent. On each side of the pillar of light was darkness such as is usual about an hour after sunset, amidst which (though the orb had not wholly disappeared) three or four bright stars were seen, not by myself, but by five or six friends at my side. I saw a similar remarkable column of light above and below the moon at rising. In about half an hour parts of a lunar rainbow appeared, the brightest portions of which were the north and south ends of the arc. This was visible for nearly two hours. The barometer continued all the time stationary, at 29·28, but the thermometer fell permanently from 60 to 45 degs.—I am, Sir, yours. J. H.

Poyntington Rectory, Sherborne, April 5.

THE HALO OF APRIL 5th. (*To the Editor of the Standard.*)—Sir,—Will you allow me, through your columns, to offer a short explanation of the vertical halo

seen by your correspondent, the "Rector of Poyntington"? Each ray of the sun, which is not absorbed by a raindrop, either passes through the centre or not. Those rays which *do* pass through the centre proceed afterwards as if the drops were not there; so that the only effect of raindrops upon *this* class of rays is to diminish the number of those rays which have any chance of reaching the eye of a spectator; or, in other words, the sun is less dazzling than usual. The other class of rays, which do *not* pass through the centre of the raindrop, will be best understood by dividing them into groups, each group or "pencil" being cylindrical before incidence on the drop, and, *therefore, conical afterwards.* Now, all the rays of each pencil will have the same absolute intensity, and, although the rays of one pencil will have a different intensity from those of another, this will not embarrass us, for we can consider any *one* pencil by itself. Roughly speaking, the eyes of all spectators are in a horizontal plane; if, therefore, a halo be seen, it must be caused by a maximum number of rays out of each pencil (so far, at least, as this explanation is concerned), falling within a given space in that horizontal plane. A moment's thought will show that this happens at the vertex of the conic section which the horizontal plane makes with the cone. And since the vertex of the conic section is in a vertical plane passing through the sun and the raindrop, therefore the maximum brightness is in the same vertical plane, and this plane cuts the heavens apparently in an upright pillar, or vertical halo. I have spoken of the sun as a point; if it were, the halo would be only a line of light, but each point of the sun causes a similar line of light, and hence the whole sun produces a vertical halo of its own width. If any one finds it difficult to understand what I have said, let him place a terrestrial globe with its north pole towards the sun; then all the sun's rays which fall on the same parallel of latitude belong to the same group or "pencil" of rays, and the smaller the latitude the less will be the intensity of the group if refracted, and the opposite for reflected rays. These vertical halos are now and then seen out of the Arctic and Antarctic regions. I made the following notes:—"Canterbury, March 4, 1861, at 5.30 p.m.—A white halo through the sun of the same breadth, the wind across it. Canterbury, March 27, 1861, at 5.40 p.m.—A white halo through the sun of the same breadth. Bishop Stortford, October 19, 1862, at 6.45 a.m.—A halo of the same breadth and colour as the sun, through the sun, but not that part adjacant to the sun, the part visible being on a dense cloud which had a 'wind edge' (by which I meant that smooth kind of edge which always betokens a strong wind). The weather was very stormy indeed on the 19th, 20th, and 21st, her Majesty being detained at Lacken Palace, near Brussels, as the sea was unsafe." All these are under the heading "Halos vertical." The halos, whether vertical or horizontal, which pass through the sun are always white. Coloured halos, however, both vertical and horizontal, as well as other halos, having the real sun or a vistual sun for their centre, are sometimes seen, and even the ordinary rainbow is sometimes blown (on one side at least) into the upright. The wind in such a case is always nearly at right angles to the direction in which the upright pillar is seen. The same drop sends its rays to us in such a case, not from one point only, but from each point in the long line through which the wind drives it before the eye has lost the impression of its first rays. I could say much more, but lest I should weary your readers instead of interesting them, I subscribe myself your constant reader, J. B. KEARNEY, Bourton, Shrivenham.

A PHENOMENON. Sir,—Did any of your readers see, and if so could they explain, a very beautiful phenomenon that appeared in the western sky a short time before sunset this evening? About 6.20 I was walking towards Stonehouse along the Millbay-road, when I perceived, a few degrees south of the sun, a column of prismatic light, the line of colours being vertical to the zenith.—
Plymouth, April 5th, 1871. Yours truly, S. E. E.

THE SOLAR PHENOMENON ON WEDNESDAY.—The phenomenon in the western sky on Wednesday evening appears to have been seen in West Devon and Cornwall. "P. L.," writing from Collaton, says the phenomenon seemed to him to partake of the character of the halos sometimes seen in the polar regions. There were two short columns of prismatic light, evidently forming the ends of a bow, of

which the remaining portion was faintly traceable. The violet was outside, and the red within. The angle between the two ends of the bow was about 45 degrees. At the same time two lines of yellowish light were observed proceeding from the sun—one vertical, and the other horizontal. There was no appearance of mock suns, by which these halos were accompanied in the polar regions. What he had described continued to be visible for some time after the sun was below the horizon.—The Rev. J. R. Hoare was walking near Trendall, about one mile and a half from Bissick, on Wednesday evening, about six o'clock, when he perceived a perpendicular line of coloured light in front of him, and looking towards the west was an apparent rainbow, turned upside down, the ends being north and south, the bend to the earth. The sky was all but cloudless with the clear, brilliant sunshine usual when N.E. winds prevail in spring. He watched it for about a quarter of an hour, long enough to take a rough pencil sketch of the relative positions of the lines of light, which he had since set on paper in colour.—"R.," writing from Newquay, says he also observed the prismatic column to the south of the sun, but that visible on the north of the sun at the same time was from the point at which he observed it (between Bodmin and St. Columb) by far the most remarkable, the iridescent colours being far more marked and varying from time to time in their degree of intensity. He suggested to his companion, who first pointed out the singular appearance, that it seemed to be of the nature of a halo which was not unfrequently seen to surround the moon, and which was generally supposed to forebode rain.—Our Helston correspondent writes that a beautiful parhelion, or mock sun, was visible for upwards of an hour at Helston on Wednesday afternoon, and at the same time what may be described as a vertical rainbow.—The Rev. R. Mildren, Newquay, says the parhelia were plainly visible there, and answered precisely to the description given of such phenomena in Milner's "Gallery of Nature," and to the representation given, figure 2, page 531.—"J. G.," while crossing from Turnchapel to Plymouth, saw the phenomenon—"a clearly defined circle within the radius of a few degrees around the sun."—"C." writes that the solar phenomenon was also seen at Truro.

SOLAR HALOS.—E. R. Colby, Esq., M.A., Exeter, writes: Many of your readers may have missed the beautiful halo I saw on the evening of April 5th, on the road from Torrington to Bideford, the sun's altitude being about 20 deg., as nearly as I could judge. It consisted of a complete circle, with a vertical column of white light passing through the centre, and its duration was considerable. I mention this circumstance now, particularly because to-day's issue of the *Standard* contains an explanatory letter from a correspondent, in answer to the Rector of Poyntington, enquiring about the phenomenon as seen, same time or nearly so, near Sherborne.

ALTITUDE ABOVE SEA LEVEL.

We regret to state that the proposal on this subject which we made in *British Rainfall*, 1870, pages 58—63, has met with so few acceptances that it is not expedient to repeat the work of 1867. Our practised observers have cheerfully, and in most districts sufficiently, agreed to supply the requisite accurate data, but those observers who do not know the altitude of their stations have been conspicuous by their non-acceptance of a proposal made solely for their benefit, and to add to the completeness of their observations. Possibly in some cases the offer has been overlooked, but we can hardly think this has been the case to the extent indicated by the paucity of applications. However, to meet that possibility, we will not abandon the design until three days after the publication of this number, and should anything like "fifty applications" reach us by May 20th, we will undertake to issue the forms on the 22nd or 23rd.—Could we do more?

THE WONDERFUL SHOWER AT BATH.

To the Editor of the Meteorological Magazine.

SIR,—I have just read the paragraph enclosed, from *Lloyd's* newspaper, of 7th May, the particulars of which you have no doubt received.

As the phenomenon does not seem to have been confined to Bath, I beg to forward a few remarks of what came under my observation at this station. On Saturday, 29th April last, we had almost incessant rain, and the next day at 9 a.m., a gauge, 6 inches above the ground, yielded 0·31 inch, but I was somewhat surprised on measuring the contents of the first gauge, for there appeared to be numerous air-bubbles in the glass measure, such as I have never seen before. I came to the hasty conclusion that the glass was greasy, and washed it, but only to obtain the same result. I soon found that it was of a gelatinous substance, which floated from the bottom of the measure to the top, and though the water was poured steadily into the measure, the foam was several hundredths of an inch; had it not been Sunday, I should probably have examined the substance microscopically. The wind blew with a mean velocity of 12 miles per hour, and a perpendicular rain-gauge (the funnel at 6 ft. moved by a vane, and which registered the amount from eight points of the compass) was as follows:—S., 0·01 in.; S.W., 0·12 in.; W., 0·06 in.; N.W., 0·09 in. The barometer was steady, 29·240 in. all day. On Sunday afternoon, we had a storm of rain and hail, attended by thunder and lightning. The hailstones were of a most prodigious size.—Yours obediently,

JOHN ARNOLD, F.M.S.

Meteorological Observatory, Aldershot Camp, May 9th, 1871.

EXTRAORDINARY STORM AT BATH.—A most violent storm of rain, hail, and lightning visited Bath on Saturday night. The rain descended in torrents, causing the Avon to overflow its banks in the lower districts, especially at Salford, where whole tracts of land were laid under water. The storm was accompanied by a similar phenomenon to that of the previous Sunday; myriads of small annelidæ enclosed in patches of gelatinous substance, falling with the rain and covering the ground. These have been microscopically examined, and show, under a powerful lens, animals with barrel-formed bodies, the motion of the viscera in which is perfectly visible, with locust-shaped heads bearing long antennæ, and with pectoral and caudal fin like feet. They are each an inch and a half long, and may be seen by the curious at Mr. R. Butler's, The Derby and Midland Tavern, where scientific men, on inspecting them, pronounce them to be marine insects, probably caught up into the clouds by a waterspout in the Bristol Channel.

[On receipt of the above we wrote to some of our correspondents at Bath, and have been favoured with the following letters.—ED.]

To the Editor of the Meteorological Magazine.

SIR,—I received your note this morning, and should be glad to know from what newspaper the cutting is taken.* The actual facts are as follows:—On Sunday morning, 23rd April, a gusty wind blew from W.S.W., force about 8; during the morning a quantity of what are described as "myriads of small annelidæ" fell upon the platform of the Midland Railway station here, and created some consternation and

* We do not know in what newspaper it first appeared, but we have seen it in at least half-a-dozen different ones.

speculation amongst the porters and officials. Of course all sorts of stories were told about these marvellous creatures which had "fallen from the clouds," but it was very soon discovered that they were nothing more than the pupa of the common gnat, which had been raised by the gusty wind from the surface of the adjoining river, and deposited upon the station platform. It appears that the same occurrence happened on the following Sunday and Saturday night, but to a less extent.

As to the violent storm described, the writer's descriptive powers have again carried him somewhat beyond the mark. At 8.55 p.m., on Saturday evening, April 29th, a storm of rain, accompanied by hail, set in from W., which lasted five minutes. There were two flashes of lightning, and no more, one a brilliant one, followed by distant thunder. The storm was over at 9 o'clock. At 1.15 a.m., Sunday morning, April 30th, there was another, but slighter, thunder shower. The rain collected at 9 a.m., amounted to 0·105 in. The previous morning (29th), 0·215, and on the 28th, 0·360 in. As to the overflowing of the river as Saltford, not Salford, six miles from Bath, I have not heard of its occurrence, and from the previous low state of the river, and dryness of the land, think it highly improbable that 0·680 in. of rain in three days would cause such an event, which, as a rule, happens only after heavy and continuous rain, or the sudden melting of snow in spring.—I am, dear Sir, yours very truly,

C. S. BARTER, M.B.

27, *The Paragon, Bath, May* 11, 1871.

P.S.—Since writing the above, I find that the water in the river rose 5ft. above its ordinary level on the 20th April; possibly at that date the Saltford meadows may have been partially flooded.

To the Editor of the Meteorological Magazine.

SIR,—I have already sent a statement to the Entomological Society (in consequence of seeing in the *Athenæum* that the subject had been mentioned at their last meeting), of so much as I know respecting the phenomenon alluded to in the newspaper cutting received from you this morning. But my knowledge of it is limited, from the circumstance of my having been far away from Bath at the time the storm happened. On my return home, a few days after, hearing what had occurred, I applied to the party mentioned in the paragraph as posessing some of the worms that had fallen with the rain, requesting to see them. He showed them to me accordingly, and they were still alive and active, in a tumbler of water, but having (he said) already parted with a considerable number to different applicants, he would not allow me to take any away for closer examination at home. I could only, therefore, ascertain so much as was to be learnt by a brief inspection of them with a pocket lens. The statement respecting the size of the worms is greatly exaggerated. They are very small, though distinguishable with the naked eye; and my full belief is that they are *not annelidæ*, as stated in the account you sent me, *nor the larvæ of gnats*,

as stated in another newspaper report of the phenomenon I saw, but infusorial worms belonging to the old genus, *vibrio*, and identical, so far as I could determine without higher microscopic powers than I had about me, with the *Vibrio undula* of "Muller's Animalcula Infusoriæ," which is well described and figured in that work, and the peculiar character of which is to congregate in gelatinous masses, as represented in one of his figures, and as noticed by myself in the specimens I saw, as well as mentioned in the newspaper cutting. There was a squall of wind (so I was told) before the storm came on, and they were, probably, borne upwards, by a gyratory movement of the air, from some shallow pool, or puddles of water, in the neighbourhood, where the worms had been bred. A few other particulars are mentioned in the letter I sent to the Secretary of the Entomological Society, which will probably be read at their next meeting, and, perhaps, appear in the "Proceedings."—I am, truly yours. L. JENYNS.

Belmont, Bath, May 11th, 1871.

To the Editor of the Meteorological Magazine.

SIR,—There is, as you suggest, some small amount of truth in the sensational paragraph from the *Standard*, but mixed up with a large proportion of the marvellous. We had on the 22nd of April, the day on which the phenomenon occurred, no "violent storm of rain, hail, and lightning" as described by the writer; my register of rainfall on that day was only 0·115 in. There was, however, heavy rain on the 18th and 19th, amounting in the two days to 1·163 in., and on the 20th the river had swollen in consequence 59 inches above its mean level, but had fallen to 31 inches by the 22nd. The gelatinous substance which was found scattered over a comparatively small area has been erroneously stated to be larvæ of the gnat, but there can be no doubt that the patches were capsules or eggs of a species of annelidæ which had been drawn up by a gyration of the air, from some contiguous pool, and deposited with the rain.

I remain, yours very sincerely,
CHAS. P. RUSSELL.

Bath Royal Literary and Scientific Institution, May 12th, 1871.

P.S.—I omitted to mention, that we had a thunderstorm on the evening of the 29th, and about 1 o'clock p.m. on the 30th, but I have not heard that the phenomenon of the 20th was repeated.

HAIL ON MARCH 8TH, 1871.

To the Editor of the Meteorological Magazine.

Barometer 9 a.m. (at 32° and sea level) 29·880 in.; dry bulb, 44°·2. wet bulb, 41·3. Weather stormy, unsettled, wind N., average velocity = 14·5 miles per hour, from 9 a.m. to 1 p.m. At 12.26 p.m. a few drops of rain, and hail fell, and again at 12.29 p.m. Barometer, 30·013 in.; dry bulb, 48°·0; wet bulb, 41°·8 max. of day, 52°·0; min. 39°·0.

FRANCIS NUNES.

Heathfield Lodge, Chislehurst.

ERRONEOUS MINIMUM TEMPERATURES.

To the Editor of the Meteorological Magazine.

SIR,—I regret exceedingly to observe in your number for March last, a letter from the Rev. C. Maxwell, commencing as above, and reflecting in most erroneous terms not only upon the action of his own thermometers, but including all other minimum thermometers of every kind.

If standard spirit minimum thermometers are not so sensitive as the mercurial, Mr. Maxwell, as an old observer, ought to know that when used as they should be, they are most trustworthy as well as valuable and excellent instruments.

What a pity it seems that after such extended experience, Mr. Maxwell should appear still to be unacquainted with the proper method of using his instruments, for certainly had he attended to the plain instructions, both verbal and printed, which are given with even the most simple registering thermometers, he would have found an effectual remedy for preventing error, by simply slanting the bulbs of his thermometers, say $\frac{3}{4}$ to 1 inch lower than the upper part, and thus avoiding the error of a lower reading by preventing the vapour of the spirit from forming in detached globules in the stem. Again, had he adopted the well-known plan of comparing his spirit thermometers, from time to time, say monthly or quarterly, by suspending a good mercurial thermometer beside them, of course placing the bulbs close together, and as much as possible under the same conditions, or better still, immersing them for a few minutes in a quart or two of water, for comparison, no such mishaps as those he complains of could have possibly occurred. Indeed, I quite understood that, as advised by me, Mr. Maxwell had the mercurial thermometers for this purpose.

As to "one month's exposure having completely bleached the colour from every instrument," it is always at the option of observers to have their thermometers with either plain or coloured spirit in them, but standard instruments, as is well-known, are usually preferred without this colouring, which is mostly employed in those for popular use, and is well-known to fade on exposure to the sun.

From the further tone of Mr. Maxwell's letter, I should infer that he had entirely overlooked the important effect of radiation, and the difference caused by the bulbs of his thermometers being more or less covered or shielded from the clear radiation of the sky, all of which, as you know, would naturally alter the result.

In conclusion, the mercurial minimum thermometer referred to, though a great scientific achievement, has been always spoken of by me as requiring great care in its use, and with this care, I must say that its action is not only interesting but admirable, as it affords the means of a quick and sensitive corroboration of the true action of the spirit minimum thermometer, a result which I believe had not been hitherto obtained.—I am, Sir, your obedient Servant,

LOUIS P. CASELLA.

Hatton Garden, May 8th, 1871.

THE CAUSE OF THE DECREASE OF RAINFALL WITH ELEVATION.

To the Editor of the Meteorological Magazine.

SIR,—While we are all throwing up our hats for joy at the solution of "the problem which has baffled observers for more than a century," (to quote your own words in *British Rainfall*,) let us be quite sure that we are not jumping hastily to a conclusion. For my own part, I confess that the proposed solution of the problem baffles me not less than the problem itself. Mr. Stow tells us, as the result of his experiments, that the decrease of rainfall with elevation is due mainly, if not entirely, to the difference of angle at which the rain falls at different heights, and this result he considers established by the observation that whereas the upper of two horizontal gauges shows almost always a decrease, the upper of two vertical gauges similarly placed shows with equal regularity an increase. That the rain does fall at different angles at different heights I have not the least doubt: we know that the strength of the wind is in proportion to the elevation, and it is matter of familiar observation that the driving of the rain is in proportion to the strength of the wind, indeed it cannot be otherwise. Now, a vertical gauge, when compared with a horizontal gauge at the same level, is simply a measure of the amount of driving of the rain, that is, of the deviation of the path of the drops from the perpendicular. It is clear, therefore, that whatever relation is found to obtain between the receipts of a horizontal and of a vertical gauge at one foot above the ground, such relation will be modified in favour of the vertical gauge when the comparison is made at an elevation of ten feet. This seems to me to be a proposition to which it would be impossible to refuse assent, though it were placed before one purely as a matter of inference. But do the experiments prove anything more than this? I have no wish to underrate their importance or interest, and am willing to admit that the law just stated, although capable of independent proof, might nevertheless have escaped distinct recognition if the experiments had not been made, but I cannot bring myself to see that the experiments prove anything beyond that law. We knew before that the rainfall received on a horizontal surface decreases as we ascend; we know now (and might have known at any time, if we had chosen to think,) that the deviation of the rain from the perpendicular increases as we ascend. But the link necessary to connect these two things, as cause and effect, appears to me to be still wanting. Suppose, for the sake of argument, that the old-fashioned view were correct, and that the difference of rainfall at different elevations were due to the drops acquiring increased volume in their descent by condensation of vapour. Would it not still be possible to obtain all the results that Mr. Stow has obtained? He says that if that hypothesis were true, the decrease of rain with elevation must affect both horizontal and vertical gauges alike. I submit that this is not strictly logical. There would be a cause of decrease affecting both gauges alike, but in the

vertical gauges there would be also the cause of increase first referred to, and the latter would be equally powerful to neutralize the former, whether the two were essentially identical or altogether independent of each other.

So much for the experimental view of the question. The theoretical difficulties in the way of the proposed solution are to my mind insuperable. Suppose a cloud, exactly a square mile in extent, discharging rain uniformly from every part of its lower surface for the space of one hour. Suppose, in the first instance, that the rain drops fall vertically to the ground. It is clear that the ground watered by the rain will be exactly a square mile in extent, and the fall will last exactly one hour. Suppose, secondly, that the rain drops, having fallen vertically for a certain distance, become suddenly deflected by a current of air to an angle of 45°, which angle they maintain until they reach the earth. The space of ground watered will still be a square mile, and the duration of the downfall will be one hour. That is to say, exactly the same quantity of rain will fall that fell in the first instance, and it will fall in the same time. But what is true of that square mile is equally true of every square foot within that square mile, and of every circle of 8 or 5 inches diameter. And hence it seems to me to follow that the quantity of rain received by a horizontal surface does not in theory vary with the angle at which the rain falls. In other words, the horizontal section of a falling shower being unaffected by any changes in the angle at which it falls, a given surface placed horizontally to intercept it will, so far as the effect of angle is concerned, intercept the same quantity at every point in its course.

GEORGE F. BURDER, M.D.

Clifton, 25th April, 1871.

[Dr. Burder is such a competent critic that it is with no little dismay that we find him sceptical as to the solution of "the problem which has baffled observers for more than a century." We shall doubtless hear next month what Mr. Stow has to say upon the subject, but as our words may be regarded as the text of Dr. Burder's remarks, we may as well state our own opinion at once. We think that Dr. Burder has not clearly realized the problem, and therefore is naturally baffled by the solution. We take the state of the question to be somewhat this :—

FACT OBSERVED.—Since 1765, it has almost invariably been found that rain gauges of the usual shape (*i. e.* whose orifices are horizontal) *collect less rain* if placed on lofty buildings than similar ones on the ground.

INFERENCE.—From the above fact it has been *assumed* that *less rain falls* the higher we rise above the ground.

REAL PROBLEM.—To determine why an elevated horizontal gauge *catches* less than one on the ground.

WHAT WE THINK THE EXPERIMENTS HAVE PROVED.—(1) That there is no sensible decrease in the amount which really falls within the

first 20 or 30 ft. of the earth, although there is a decrease in the amount collected by horizontal-mouthed gauges. (2) That elevated horizontal rain gauges *collect* less because the rain falls at a greater angle with the vertical.—ED.]

RAINY DAYS AND RULE XII.

To the Editor of the Meteorological Magazine.

SIR,—Having been the first member of your Rainfall Parliament to draw your attention to the loophole for misunderstanding that exists between the instructions contained in Rule XII. and the heading "Days on which ·01 or more fell," perhaps you will kindly allow me an opportunity of suggesting a very simple way of filling up this little gap, without interfering with any of the present rules or headings, and yet at the same time answering finally a question which many thought was decided long, long ago, but which still continues to puzzle some observers, and that is,—"What constitutes a rainy day?"

I propose, therefore, with all due deference to the opinions of older and more experienced members than myself, that all observers who, in accordance with Rule XII., enter small quantities between ·005 and ·010 as ·01, be directed in future to place a distinguishing mark—a note of interrogation, (?) as expressing doubt, would, I think, be an appropriate one—on the right-hand side of all such quantities, at the time of entering them in their journals, and to omit all ·01's so marked, when reckoning the number of rainy days, as being less than full one-hundredths; but *not* when calculating the aggregate rainfall of the month.

I need scarcely say, that this slight innovation, if adopted, would not in any way affect the practice of those observers who now read even the smallest quantities to the thousandth part of an inch.

I remain, Sir, yours faithfully,

EDWD. MAWLEY.

Richmond, S.W., May 4th, 1871.

REPORT OF THE RAINFALL COMMITTEE OF THE BRITISH ASSOCIATION.

By the kindness of the Association, copies of the above Report, containing the tables of monthly rainfall in 1868 and 1869, as well as an elaborate analysis of some of the rain gauge experiments, and results of the examination of rain gauges during 1869 and 1870· have been placed at our disposal. We shall have much pleasure in supplying copies to such of our correspondents as may apply for them.

APRIL, 1871.

Div.		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.	Date.	Min. Deg.	Date.	No. of Nights below 32°. In shade	On grass
			inches	inches.	in.								
I.	ENGLAND.	Camden Town	2·84	+ 1·71	·71	18	18	66·0	12†	28·3	7	3	5
II.		Maidstone (Linton Park)	2·80	+ 1·58	·42	17	15	70·0	14	32·0	7§	...	...
,,		Selborne (The Wakes)	4·55	+ 3·05	1·28	18	16	60·5	29	21·0	8	3	5
III.		Hitchen	2·14	+ 1·14	·54	18	17	63·0	13	24·0	8	5	...
,,		Banbury	2·65	+ 1·49	·80	18	17	64·0	14	27·5	7	5	...
IV.		Bury St. Edmunds (Culford)	3·70	+ 2·95	·58	16	15	64·0	26	22·0	8	6	7
V.		Bridport	4·96	+ 3·48	1·05	18	16	61·0	27	30·0	5	2	...
,,		Barnstaple	3·83	+ 1·82	·54	28	18	62·0	14†	33·0	6	...	...
,,		Bodmin	5·82	+ 4·12	·79	20	20	60·0	26	33·0	5	0	1
VI.		Cirencester	3·65	+ 2·36	1·00	18	13	...	...	...	...	...	...
,,		Shiffnal (Haughton Hall)	2·92	+ 1·77	·42	15	18	64·0	14	25·0	8	6	...
,,		Tenbury (Orleton)	2·84	+ 1·30	·63	18	18	64·2	13	25·7	7, 8	4	7
VII.		Leicester (Wigston)	2·76	+ 1·46	·55	19	15	68·0	16	24·0	6	6	...
,,		Boston	2·60	+ 1·63	·47	18	17	64·5	22	29·5	8	4	7
,,		Grimsby (Killingholme)	3·06	..	·58	18	20	61·0	12‡	29·0	8, 9	4	...
,,		Derby	3·72	+ 2·29	·87	28	17	64·0	13	28 0	7, 8	3	...
VIII.		Manchester	3·52	+ 1·76	·51	22	21	62·0	27	29·8	7	3	6
IX.		York	2·76	+ 1·66	·71	18	18	63·0	13	31·0	5, 8	4	...
,,		Skipton (Arncliffe)	3·95	+ ·91	·80	23	16	...	...	...	...	...	...
X.		North Shields	3·79	+ 2·48	·87	18	19	58·0	27	30·6	7, 11	4	7
,,		Borrowdale (Seathwaite)	6·36	— ·54	1·20	23	16	...	...	...	...	...	...
XI.	WALES.	Cardiff (Town Hall)	...	...	...	...	...	...	...	...	...	...	...
,,		Haverfordwest	4·44	+ 2·58	1·00	28	11	66·1	3	32·0	4	1	2
,,		Rhayader (Cefnfaes)	6·15	+ 4·26	·70	18	19	59·0	...	27·0	...	...	...
,,		Llandudno	2·57	+ 1·07	·61	15	15	66·5	14	34·3	8	...	...
XII.	SCOTLAND.	Dumfries	4·55	+ 2·88	·58	19	19	64·0	29	28·0	11	6	...
,,		Hawick (Silverbut Hall)	4·08	...	·82	19	17	...	...	...	...	...	...
XIV.		Ayr (Auchendrane House)	3·34	+ 1·12	·65	22	16	58·0	12‡	27·0	8	6	9
XV.		Castle Toward	5·43	+ 2·93	1·17	18	16	58·0	29	32·0	6	1	4
XVI.		Leven (Nookton)	5·17	+ 3·92	1·04	22	19	59·0	4	26·4	11	9	17
,,		Stirling (Deanston)	4·40	+ 2·65	·65	26	18	61·1	12	24·9	11	12	15
,,		Logierait	2·55	...	·41	16	15	...	...	...	...	...	...
XVII.		Ballater	3·24	...	1·10	19	13	61·5	12	19·0	6	20	...
,,		Aberdeen	5·00	...	1·26	26	21	59·2	12	27·6	6	3	17
XVIII		Inverness (Culloden)	1·96	...	·54	20	17	55·0	12	31·8	6	1	18
,,		Portree	2·10	— 3·17	·49	12	18	...	...	..	...	...	...
,,		Loch Broom	1·41	...	·33	18	11	...	...	...	...	...	...
XIX.		Helmsdale	3·41	...	·78	19	23	...	...	...	...	...	...
,,		Sandwick	1·74	— ·01	·73	14	16	51·0	15	29·3	6	7	15
XX.	IRELAND.	Cork	4·48	...	·79	17	18	...	...	...	...	...	...
,,		Waterford	4·51	+ 2·28	1·04	11	22	60·0	13‖	36·0	4, 5	...	...
,,		Killaloe	4·92	+ 2·79	·51	19	22	68·0	8, 30	29·0	4	1	...
XXI.		Portarlington	3·17	+ 1·15	·48	15	24	61·0	13	31·0	7	2	...
,,		Monkstown	2·68	+ 1·04	·58	18	14	...	...	...	...	...	...
XXII.		Galway	3·44	...	·37	16*	20	63·0	17	36·0	30	...	...
,,		Bunninadden (Doo Castle)	4·18	...	·90	16	18	65·0	12	29·0	8	1	...
XXIII		Bawnboy (Owendoon)	...	...	..	...	...	...	...	...	..	...	..
,,		Waringstown	2·76	...	·52	11	16	66·0	16	28·0	8, 9	4	14
,,		Strabane (Leckpatrick)	3·29	...	·40	27	20	...	...	..	...	...	...

* And 18. † And 27. ‡ And 13. ‖ And 21. § And 8, 11.

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

METEOROLOGICAL NOTES ON APRIL.

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

ENGLAND.

CAMDEN TOWN.—T on 27th.

LINTON PARK.—First 11 days bright and very dry, the remainder mostly dull and showery, but mild, so that vegetation was in a forward state throughout; very slight frosts on the 7th, 8th, and 11th; T on 27th and 30th. Cuckoo heard on 10th, being one day earlier than I have any record of. Apple in bloom on 21st, and hawthorn on 30th, the latter not so early as on one or two former years. Winds mostly S.W. and W., but never high.

SELBORNE.—Swallow on 6th, Cuckoo on 12th, T with R at 3 p.m. 29th, and T from 2 to 3 p.m. 30th.

BANBURY.—Cuckoo first heard on 24th. T on 27th. Aurora on 9th.

CULFORD.—Latter half of the month wet and deficient in sunshine, nevertheless exceedingly favourable weather for the light land in this part of the country. The swallow was first seen on the 20th, the nightingale and cuckoo heard about a week previous to that date. Mean temp. of month 47°·8; T S on 17th, 22nd, and 27th, on the latter day accompanied by H.

BRIDPORT.—First ten days of the month fine, afterwards stormy but mild. Swallow first seen on 15th, cuckoo first heard on 13th; horse chesnut in leaf on the 19th.

BODMIN.—Average bar. of month, 29·85; average temp., 50°·8.

SHIFNAL.—Although the month opened with the much desired R from the N.W., the wind returned to the E. on the 6th, on which night the ther. fell to 27°, and next night to 25°, with frost till the 12th, when the wind changed to W. and S.W., and R fell daily, with one exception (13th) till the 23rd; the genial temperature that came with it, brought on vegetation uninterruptedly to the end. Wood anemone in flower on the 4th, blackthorn on 5th, wild cherry on 8th, pears in blossom on 16th, crabs on 27th; first swallow seen on 12th, white butterfly and willow wren on 17th, cuckoo heard on 20th, first martin seen on 26th, young rooks fledged on 30th.

ORLETON.—Fine growing month, with much R, cuckoo on 15th; sand-martens on 11th, and willow wrens on 17th; bright aurora on 9th. T on 17th and 29th.

WIGSTON.—Brilliant dry weather to the 14th, with frosty nights, since that time very showery and growing; vegetation forward, and everything giving promise of an abundant season. A heavy T S on the afternoon of the 28th.

BOSTON.—Ice half-inch thick on 7th and 8th, wheat in some parts much injured.

GRIMSBY.—Almost as much R fell as in the three preceding months. Grass abundant, but warm weather much wanted. Grand auroral arch at 10.50 p.m. on 9th. Swallows first seen on 16th, willow warbler arrived on 19th, cuckoo heard on 26th, first swarm of bees in this neighbourhood on 27th. Apples began to blossom on 27th. T at 10 a.m., and T and L at 1.45 p.m. on the 28th, when a tree was struck.—*Erratum.* In last month's remarks for Barrow-in-Furnace (*sic*), read Barrow-on-Humber. [We regret the blunder, but those who know Barrow-in-Furness will enjoy the accidental pun.—ED.]

DERBY.—The month, unlike the April of the last few years, was that of our recollection of former years; although no R fell on the first 10 days, we have had continual showers alternating with sunshine ever since, producing a rapid development of vegetation such as we have not lately seen. Fruit trees about a week earlier than last year. Rainfall 1·84 + average of 31 years; Mean temp. 1°·5 in excess.

MANCHESTER.—T S on 22nd at 12.50 p.m., and on 28th at 1.50 p.m.

NORTH SHIELDS.—Rose-coloured aurora on 1st, and again on 9th. Distant lunar halo on 1st; S on 3rd and 9th; T on 27th.

SEATHWAITE.—S on the mountains on 4th, and again on 18th; T on 16th, 17th, and 25th.

WALES.

CEFNFAES.—Cold and stormy weather during the month; wind N.E. or S.E.; frosty nights, and frequent hailstorms; Cuckoo heard on 19th.

LLANDUDNO.—On 7th, at 10.15 a.m., difference of wet and dry 12°; 9th at 9 p.m. very light to N., and streak of white aurora stretching from zenith to S.E., at 11 p.m. the colours most brilliant; streak of aurora on 13th at 10 p.m.; a splendid rainbow forming a complete arch at 6.40 p.m. on 15th; cuckoo heard on 12th; lilac in flower on 18th; apple on 19th; white broom on 21st; hawthorn in full flower in the hedges on the 26th; laburnam in flower on 28th; oak almost in full leaf on 27th; landrail heard on 27th.

SCOTLAND.

DUMFRIES.—With the exception of the 3rd, the first 10 days of the month were dry with frost at night; the rest of the month wet, only two days on which no R fell. On 19th the hills were white with S, and on the 27th there was S on the higher ground, and not quite gone at the end of the month; mean temp. 2°·38 below that of April, 1870; rainfall 2·66 in. + average of previous five years. At the close of the month, vegetation had made good progress, crops looking well; swallows seen on 21st; cuckoo heard on 28th.

SILVERBUT HALL.—A cold, wet month with East winds prevailing. The first nine nights were frosty in succession; swallows first seen here on 24th; hills white with S on the 20th.

AUCHENDRANE.—Aurora on 9th, rivers still have plenty of water; swallow on 18th, and landrail on 30th.

CASTLE TOWARD.—A fine month; scarcely any frosts; but wet from the 11th to the 28th; fruit trees of all kinds flowering most abundantly; grass is plentiful; all kinds of crops are healthy and strong. A smart shock of an earthquake was felt along the Clyde on Saturday the 12th at 7.55 p.m.; the houses here, at Dunoon, Blanmore, and, I am told, as far as Dumbarton, were shaken.

DEANSTON.—Weather dry and cold till the 11th, with frost at nights; sunshine during some days; then wet and cold E. winds; gale on the 19th with rain-sleet, and heavy S on Ochills and Grampians; heavy R towards the end of the month; frost at night and cold E. wind; swallows seen on 28th.

LOGIERAIT.—Cold E. winds with little intermission; S shower on the 18th; cuckoo on 26th; swallow on 28th.

ABERDEEN.—Red auroræ on 1st and 10th; temp. on grass 17° on 6th; temp. in sun (in vacuo) 130·3 on 24th; fog on eight days; S on four days; sleet on two days; T at 4.40 p.m. on 29th, and at 11 a.m. on 30th; the wettest April on record during 42 years; a cold ungenial month; bar., temp. and wind pressure rather below the average; rainfall, and N., N.E., and S.E., winds above the average.

PORTREE.—The coldest April on record; frost from 5th to 11th, and from 17th to 26th; S from 3rd to 7th, and on 19th and 20th; heavy gale from N.E. on 19th; berry bushes, and garden shrubs and trees all frostbitten; early potatoes blackened and cabbages browned by the frost.

LOCHBROOM.—This has been a singularly dry month, and very propitious to the grazier and agriculturist.

SANDWICK.—Very cold month; fine sun pillars on 5th, 7th, and 9th, that on the 5th lasted twenty-five minutes after sunset, and was 20° high; that on the 7th thirty-five minutes, and was 15° high; and that on the 9th lasted fifty minutes.

IRELAND.

MONKSTOWN.—A variable month; frost on the night of the 7th; a humming bird sphinx moth seen about the 20th.

DOO CASTLE.—Fine to 11th; and remainder of month one incessant downpour of R, which has retarded all agricultural operations in this locality; oats have been put in so late as the 1st of May. Four waterspouts were observed to west of Doo Castle on the 16th; a few peals of T also.

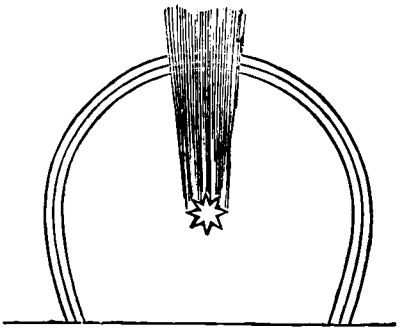


Fig. 1.

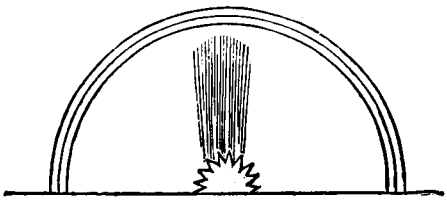


Fig. 2.

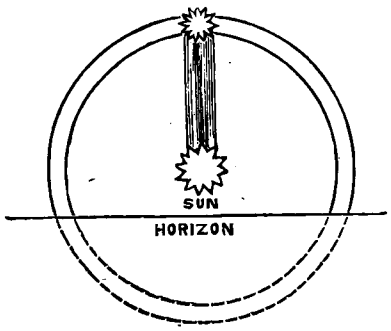


Fig. 3.

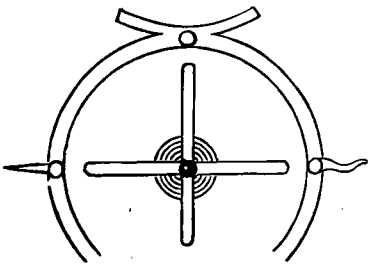


Fig. 4.

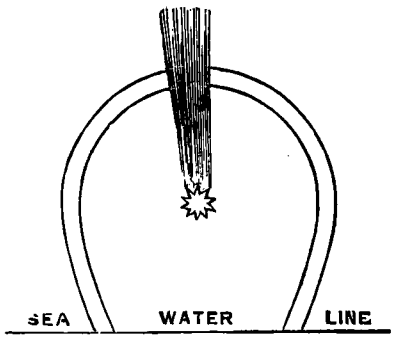


Fig. 5.

DIAGRAMS OF SOLAR HALOS AND PARHELIÆ.

SYMONS'S
MONTHLY
METEOROLOGICAL MAGAZINE.

LXV.] JUNE, 1871. [PRICE FOURPENCE, or 5s. per ann. post free.

THE CAUSE OF THE DECREASE OF RAINFALL WITH ELEVATION.

[Although there cannot be two opinions as to the importance of "settling" this question, we feel it to be undesirable that its discussion should occupy so large a portion of our space in future numbers as in the present. Anticipating a somewhat prolonged correspondence, we suggest to our correspondents that no single letter should exceed one page in length, and that not more than three or at the outside four pages, per month, be devoted to this subject.—ED.]

To the Editor of the Meteorological Magazine.

SIR,—Though I am sorry that so experienced a meteorologist as Dr. Burder should not be disposed to accept the conclusions at which I have arrived, I cannot regret that the subject should be thoroughly discussed. I am not unwilling, therefore, to say a few words in reply, more especially as not only my own conclusions are attacked, but the theory according to which all the results of the Rotherham experiments, as well as mine, have been calculated. That theory rests upon an assumption, which some might call an axiom. The assumption is, that the character of the rain is not altered appreciably by any difference in the angle at which it falls, or, in other words, that when falling rain deviates from its original path, the drops are not brought closer together, or the contrary, nor their size thereby increased or diminished. If this be true, Dr. Burder, it seems to me, must be wrong, since it is impossible to deny that a horizontal gauge presents a smaller area of aperture to rain falling obliquely than to that which falls vertically, and if it be the same rain and not altered in density, the gauge must catch less of it. If it be not true, at least approximately, then the calculations hitherto made from the Rotherham experiments must be cast aside as useless—a bold step to take in the face of the very close agreement between calculation and observation exhibited by the results thus obtained.

I do not assert the exact truth of the assumption, but the theory based on it assigns a cause which seems to account, and account adequately, for the facts, and not to be contradicted by any known

facts. If it has a fault, it is that it is slightly more than adequate to account for the observed decrease in horizontal gauges, showing apparently some *counteracting* cause. But can as much be said of the "old-fashioned" hypothesis? Does it account for the facts—especially the greater decrease in winter than in summer? Does it not assume what can be disproved—viz., that the temperature of falling rain is almost always below the dew-point of the air near the ground? Is the cause assigned adequate, or even nearly so? And if it were true that the rain-drops gain more than they lose till they reach the ground, would not the beginning of rain dry the air near the ground, by depriving it of moisture, and even warm it by the latent heat given out in condensation? I am much more disposed to believe that, on the contrary, the drops lose volume by imparting moisture to the atmosphere, for it is a matter of common observation that when it begins to rain, the air becomes damp and generally cold.

May I now be permitted to doubt whether Dr. Burder's theory be less beset with difficulties than that on which I have relied? In the first place, clouds do not, I fancy, often discharge rain vertically downwards; but let that pass. Next, it would be a still rarer occurrence for these drops to be deflected to 45°, after falling vertically a certain distance. But admitting all this to be possible, though scarcely representing the ordinary processes of nature, what possible kind of force could "suddenly deflect" to an angle of 45° a body falling vertically, and then make it "maintain that angle," falling, that is, obliquely in a straight line? I should be glad to have this explained, as at present it seems to me that a very extraordinary combination of forces would be required, such as could hardly exist in nature, and it is scarcely desirable to prove or illustrate a theory by impossible suppositions. Next, if the drops are not all of the same size, will not the same force of wind necessarily deflect some more than others, and cause the fall to be spread over a wider space and a longer time?

I should like to hear Dr. Burder's explanation of the results of my "Position Series"—all horizontal gauges carefully kept level—if the angle at which rain falls makes no difference to the amount received on a horizontal surface.

I may point out as a weakness in Dr. Burder's theory, that it would hold good for any angle short of 90°, but would suddenly fail at that point; so that if an inch of rain or snow fell with a very heavy gale at an inclination of 88° or 89°, one gauge might catch the whole inch, while another, tipped over by the wind 1° or 2° from the horizontal, would catch nothing at all.

But if Dr. Burder's proof is sound for horizontal gauges, why not for vertical, or indeed gauges at any angle? Suppose a shower to be falling at an angle of 60° from the vertical, when it meets the upper of two vertical gauges. As it descends the angle diminishes, and it meets the lower gauge at an angle of 45°. By parity of reasoning it follows that the vertical section of the shower intercepted by each gauge would be equal, and the upper gauge catch no more than the

lower one. If, therefore, "the quantity of rain received on a horizontal surface does not in theory vary with the angle at which rain falls," neither does the quantity received on a vertical nor any other surface. Certainly the results of my experimental gauges could not in this case have been obtained, and I still think it is "logical" to say that any increase or decrease, from whatever cause, in the density of rain—that is, the amount of it in a given space of air—would affect both vertical and horizontal gauges *in the same way*, proportionately, of course, to the amount which each caught.

On the whole, therefore, I prefer the theory that the ratio of the amount caught by a horizontal gauge varies as the cosine of the angle which the rain makes with the vertical. This gives at first a very slight diminution, only 1½ per cent. in the first 10°, but 6 per cent. for 20°, 13 per cent. for 30°, 30 per cent. for 45°, 50 per cent. for 60°, 100 per cent. for 90°. As the rain falls in summer at a less angle with the vertical than in winter, it is easy to see that the same difference between the angle at which rain falls at different elevations will produce a smaller decrease in summer than in winter in elevated horizontal gauges. This is a point omitted in my paper in *British Rainfall.*

I have thought over Mr. Strachan's remark about the error caused by the oscillation of the vanes to which vertical gauges are attached, but I do not think the error likely to be serious, for several reasons:—(1) The wind itself oscillates, though less than the vane; (2) The greatest oscillations are almost momentary, consequent on gusts of wind, and for nine seconds in every ten, the vane is very nearly true to the wind; (3) It can hardly be supposed that the mouth of a vertical gauge is more than 5° on an average out of the line of the wind's direction, which would, I suppose, diminish the fall not more than one-half per cent.

I fancy the close agreement of Sergeant Arnold's two tilted gauges may thus be accounted for. If the exposure of the 6 ft. gauge is good, the angle of rainfall at 30 ft. will not be very different, perhaps from 5° to 8°. It is likely that the bulk of the rain at Aldershott falls at an angle of about 45°. Now the angle at 6 ft. may be below and that at 30 ft. above 45°, and then no difference could be perceived. But at all times of the year it is probably within 20° or 25° of 45° and generally within 10°. If so, a difference of 5° between the angle at 30 ft. and that at 6 ft. could seldom make a serious difference in the amounts collected by the two tilted gauges. Suppose the angle at 6 ft. 45°, and at 30 ft. 50°, then if the gauge at 6 ft. caught an inch, that at 30 ft. ought to catch 0·996 in.

For a similar reason, in the Rotherham experiments, if the difference between the angle for which the maximum amount is calculated and the angle of the inclined gauge which actually catches most does not exceed 10°, as it seldom does, the gauge ought not to catch less than 98½ per cent. of the calculated amount. In 1870 there was a mean difference of less than 7° between the angles, and the nearest inclined gauge should have caught 0·993 for every inch of (R), the calculated

maximum. If it actually caught some 4 per cent. too much, the difference is not serious—far too small to be due to an incorrect theory.

Apologizing for the length of this letter,

I am, Sir, your obedient servant,

FENWICK W. STOW.

To the Editor of the Meteorological Magazine.

SIR,—Notwithstanding your high authority, and large experience, I venture to uphold Dr. Burder's views against your own on the above subject. Dr. Burder does seem to me to have realized the problem, and I think proves that it is not because the rain falls at a greater angle with the vertical the greater the elevation of the gauge, that a horizontal gauge collects less rain the more it is elevated. I venture to support his argument with a mathematical reason. It is certain that all the rain which falls into a horizontal gauge in the same small period of time was contained at any moment in a cylinder of the same altitude, whatever the inclination of the path of the rain-drops. It is a mathematical truth, that the volume of all cylinders on equal bases is the same, if their altitudes be the same, whatever the inclination of the axes of the cylinder to the bases. Therefore, the quantity of rain which falls into a horizontal gauge in the same small period of time must be the same, whatever the inclination of the path of the rain-drops to the vertical. I have used the expression *small* period of time to avoid the necessity of supposing the force of the wind to be uniform, or the path of the rain anything but a straight line. I believe the true explanation of the decrease in the amount of rain collected by elevated gauges, to have been given in a paper by Mr. Jevons, to which you called my attention, in the *London and Edinburgh Philosophical Magazine*, for December, 1861. This explanation put briefly is, that the gauge, causing an obstruction to the passage of the wind, breaks up the wind into eddies around the gauge; that, as the force of the wind is generally greater the greater the elevation, therefore the eddies produce greater disturbance, and carry away some of the rain which would have fallen into the gauge had the gauge been nearer the ground and the disturbances less.

This theory seems to me to receive some confirmation from Mr. Griffith's Table on page 25 of *British Rainfall* for 1870, in which I perceive that the 5-inch gauge at a height of 20 feet always received less than the 8-inch gauge at the same elevation: the disturbance caused by the eddies of the wind would produce a much larger effect on small gauges than on larger ones.

J. M. DU PORT.

Mattishall, Norfolk, 27th May, 1871.

To the Editor of the Meteorological Magazine.

SIR,—The recent experiments at Rotherham and Hawsker seem to show that generally—

1.—An elevated rain gauge collects less than one near the ground.

2.—At the elevated point the path of the rain is more inclined to the vertical than below.

3.—As the inclination of the rain increases, so does the difference between the readings of the two gauges, not according to any law, but quite irregularly.

For an instance of this irregularity, see *British Rainfall*, 1870, p. 19. Rain falls on Nov. 14th and Nov. 24th at nearly the same angle, but on the first day the elevated gauge records 8 per cent. less than the ground gauge, whilst on the second day the difference is only 2 per cent. Again, on Nov. 23rd the angle of inclination of the fall is about half, yet the difference is 5 per cent. The Rotherham experiments give similar evidence that some other cause must be also at work. Dr. Burder, in your last number, has, I think, demonstrated that the greater or less inclination of the path of the rain, produced by the horizontal force of wind, cannot affect the amount actually falling on a horizontal surface. Gravitation alone causes the fall of rain, and will not be affected by a force acting at right angles to it. The amount actually collected in a rain gauge is another matter, as here out-splashing and eddying of the wind in the mouth of the gauge may produce some effect. Now this effect ought to remain constant so long as the cause remains constant. But this is apparently not the case, as is shown by the instance quoted above from Mr. Stow's experiments. Hence there must be yet another cause at work. May this not be that indicated in the old hypothesis, that rain-drops gather volume as they fall? Indeed, must they not do so, if cold themselves, from being precipitated from a cold stratum of air above, they pass through a warm stratum of air near the earth, which is quite saturated with moisture? and in this case will they not gather more volume the more their fall is inclined, for as the inclination of the fall increases, so does the path of descent lengthen?

In the unusual case of the lower warm stratum of air being not saturated, the inverse process would take place, as seems to have happened in the case mentioned on page 23, *British Rainfall*, 1869, where the higher gauge collected the most rain.

Your obedient servant, P. P. PENNANT.

May 29th, 1871.

To the Editor of the Meteorological Magazine.

SIR,—Is Mr. Stow right, or Dr. Burder? The former, as I think; for if otherwise, whence comes that portion of the low-level rain which was never at a high level? I propose this test:—Put a vertical and horizontal gauge at each level, on a day when the wind is steady—*i.e.*, uniform both in direction and in force, all four gauges having equal apertures.

Let (*a*) be weight of rain which would fall through any of the four apertures at the upper level, if placed at right angles to the direction of the rain.

(*b*) the same at the lower level.

(θ) the angle (supposed constant) made by the direction of the rain with the vertical at the upper level.
(θ') the same at the lower level.
(x) the weight of rain in upper horizontal gauge.
(x') ,, ,, lower ,, ,,
(y) ,, ,, upper vertical ,,
(y') ,, ,, lower ,, ,,

Then whoever is right, the following equations will be nearly true, and would be strictly true, if the wind were perfectly steady, and the instruments accurate and accurately placed :—

$$\left.\begin{aligned} x &= a\ \cos\ \theta \\ y &= a\ \sin\ \theta \end{aligned}\right\} \text{ which give } \begin{cases} a = \sqrt{x^2 + y^2} \\ \tan\ \theta = \dfrac{y}{x} \end{cases}$$

$$\left.\begin{aligned} x' &= b\ \cos\ \theta' \\ y' &= b\ \sin\ \theta' \end{aligned}\right\} \text{ which give } \begin{cases} b = \sqrt{x'^2 + y'^2} \\ \tan\theta' = \dfrac{y'}{x'} \end{cases}$$

If Mr. Stow is right, $a = b$, $\therefore \sqrt{x^2 + y^2} = \sqrt{x'^2 + y'^2}$. Still better would it be to have at each level three gauges—one horizontal, one vertical facing north or south, and one vertical facing east or west—and we could then similarly prove that the square root of the sum of the squares of the weights in the three gauges would be a constant, if Mr. Stow is right.—Yours, &c., J. B. KEARNEY.

P.S. Of course, the above remarks ignore evaporation, the effect of which is greater at the upper level than it is at the lower; both because there is more wind, which promotes evaporation, and also because there is less atmospheric pressure, which hinders evaporation. We might take account roughly of the effect of evaporation, by providing an additional set of gauges at the upper level, to be kept artificially at the same weight of water as the corresponding gauges at the lower level. The vessel out of which the upper level gauges are replenished (positively or negatively) should be weighed immediately beforehand and immediately afterwards. To get a result as free as possible from the effect of evaporation, we must try our experiment in coldish weather, when there is much constant rain, and little wind. Perhaps Mr. Beckley's ingenuity of contrivance, and Mr. Hicks's skilful workmanship, may suffice to furnish us with a kind of compound gauge, having three equal apertures at right angles to each other, and *three separate* compartments for the rain, and yet recording the three weights by *one* machinery. And, meantime, I respectfully suggest to Dr. Burder that he should, in *settled dry* weather, pour equal weights of water into two similar gauges, and leave them as long as the dry weather lasts at two different levels, when I believe he will find that the upper level gauge contains less water than the lower level gauge. To eliminate evaporation altogether seems to me to be a hopeless task, for I cannot conceive of any way of *admitting* water so as to hinder the constant *outflow* (*a fortiori*) of vapor.

To the Editor of the Meteorological Magazine.

SIR,—Although I have scarcely a right to appear again in your Magazine until my first letter has been answered, I hope you will allow me a word of explanation with reference to your editorial suggestion, that I may not have clearly realized the problem under discussion.

The very concise and lucid form in which you yourself re-state the question satisfies me that I have not misunderstood it, at the same time that it shows clearly, in my humble judgment, where the fallacy lies.

As you put it, the "fact observed" is, that horizontally-placed gauges collect less rain at a height; the "inference" or "assumption" is that less rain falls at a height. But can this be legitimately called an "inference" or an "assumption?" What is rainfall if it is not the quantity of rain that falls on the surface of the earth, that is, on a horizontal surface? Suppose Great Britain to be a horizontal rain-gauge, with a wall round the coast at the water-line, representing the rim. If it will make the illustration simpler, suppose the island to be level throughout. Clearly, the "rainfall" of Great Britain will be the quantity of rain that reaches the ground within the wall, irrespective of any consideration of the angle at which it descends. You may, in imagination, tilt up the island with its wall-rim, as you tilt your gauge, to meet the driving rain, and in the one case, as in the other, you will catch a much larger quantity, but it will be no longer the rainfall of Great Britain, that is, it will be no longer the rainfall proper to the area of Great Britain, for it will include a quantity which was destined to fall into the sea, and which would have fallen there, if, by your tilting process, you had not intercepted it. The illustration is on a large scale, and in the tilting does violence to the position of the clouds, whence the rain issues, but, if preferred, a single county may be taken, or a parish, or a square mile, or a field, it matters not. A small area, as a field or a parish, may indeed be naturally tilted, so that with driving rain from a certain quarter, it shall catch more than its share; but this advantage obtained by one field or parish is obtained at the expense of its neighbour on the other side of the slope, and when the rain drives from the opposite quarter the conditions are reversed. In any case, what we want to measure in our rain-gauges is the depth to which the rain would lie on a horizontal surface, if it all lay as it fell; that is, with respect to a tract of country, the depth corresponding to the horizontal area of the tract, and not to its superficies, which may be increased by undulation. This, and this only, is "rainfall" in any intelligible or measurable sense, and the contested "inference" is, therefore, as it seems to me, only a varied expression of the "fact observed."

GEORGE F. BURDER, M.D.

Clifton, 30th May, 1871.

ERRONEOUS MINIMUM TEMPERATURES.

To the Editor of the Meteorological Magazine.

SIR,—In your number for May, it appears that Mr. Casella is annoyed at my remarks upon his Mercurial Minimum Thermometer. This I regret: in a former letter, I stated that I found it most unsatisfactory. I readily admit that it is "a great scientific achievement," the ingenuity of his beautiful arrangement of a supplementary chamber is deserving of all praise, and I believe that the same principle when applied to a mercurial maximum is successful. All that I intended to convey was, that for all practical purposes and for making the usual daily observations, this instrument cannot be recommended for ordinary use. I think everyone that has tried it will come to the same conclusion, and that even Mr. Casella himself would prefer a spirit thermometer to his own delicate instrument. I have used it patiently for a long period, and was often distressed at its inconsistencies. At one time I attached with India rubber bands the tube of an ordinary spirit level to the stem of the thermometer, so as to insure an accurately horizontal position of the instrument, but in the end I did not find it could be depended upon. During all this time there was a spirit minimum alongside for comparison.

As to my acquaintance with the proper method of using minimum thermometers, I am sure I have much to learn on the subject, but having taken some trouble to read all that I could lay my hands on for information, and having purchased several instruments, always from the best makers and at the highest price, the conclusion arrived at is, that spirit thermometers very soon deteriorate, and do not give accurate readings of minimum temperature.

My thermometers are always hung at an angle, the bulb being invariably lower than the upper part of the stem. During the last six weeks, I have firmly screwed to the frame of the minimum in air, a Kew verified mercurial thermometer, so that the two bulbs are quite close to one another. Also, to the grass thermometer I have attached another Kew thermometer, so that when they are laid on the grass, *always in a slanting position*, the two bulbs are nearly in contact. These two couples of instruments are thus plainly under precisely similar circumstances. Every morning the min. temp. is registered, and in a column alongside is placed the difference between the actual temperature of both sets of instruments at the time of observation. The result is, that both minimum spirit thermometers are invariably lower than the corresponding attached mercurial instruments. The error is not uniform, nor does it bear any proportion to the temperature. Are there not grounds here for questioning the trust-worthiness of spirit thermometers? and, also, for the conclusion that we cannot get accuracy until we have a mercurial minimum that can be depended upon. The same ingenuity which has produced the really scientific achievement referred to, ought to overcome the remaining difficulty, and give us observers, what we demand, a *perfect* instrument.

I am, Sir, yours, &c., CHARLETON MAXWELL.

Leckpatrick Rectory, Strabane, May 20th, 1871.

SNOW IN JUNE.

To the Editor of the Meteorological Magazine.

SIR,—On Saturday night the thermometer fell to 35°; Sunday morning, at 9 o'clock, it was 51°, but at 10 a.m. a sharp storm from N.E., of rain, sleet, and snow, reduced it to 41° in a few minutes. It is surprising to me to see vegetation generally bear up so well against such trying weather.—Yours faithfully,

HENRY ST. JOHN JOYNER.

Northwick House, Harrow, Monday, 5th June.

HALOS, &c.

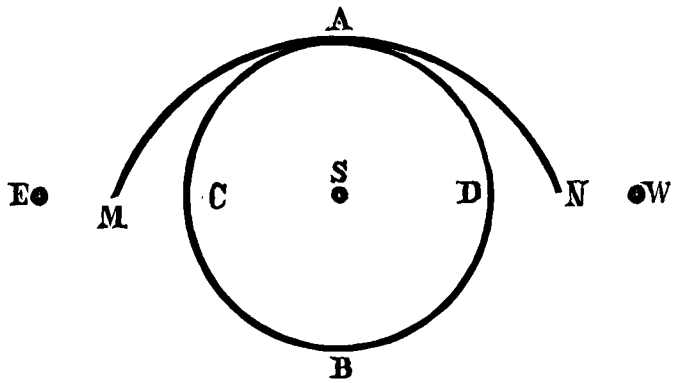
To the Editor of the Meteorological Magazine.

SIR,—I strongly advise everyone who is interested in the subject of halos to buy a copy of the magnificent *Mémoire sur les Halos et les Phénomènes Optiques qui les accompagnent, par* M. A. Bravais, ("Journal de l'Ecole Royal Polytechnique," "Trente Unième Cahier, Tome 18," "à Londres, chez Dulau & Co., 1847.") He adopts the theory that all halos, mock suns, &c., are due to ice prisms, reflecting or refracting the sun's rays. In polar regions, he is no doubt right. In temperate regions, many halos, &c., may be thus accounted for, but, as I think, not all. I have several reasons for my opinion :—

(1) Some phenomena can be accounted for on the supposition of rain-drops, and not on that of ice prisms.

(2) Other phenomena can be accounted for equally on either hypothesis.

(3) These phenomena occur not only in warm countries and in hot weather, but absolutely before the fall and during the fall of *warm* rain. On "2nd April, 1861," for instance, "at 11.47 and 12.15, the S. wind drove the rain from the halo on me; the colors were red and green." This was on Barham Downs. I made no note to that effect, but I remember that the rain was *not cold*. I was formerly curate of Much Hadham and Perry Green, and resided in Bishop Stortford. On "4th May, 1862, returning from Perry Green Chapel,



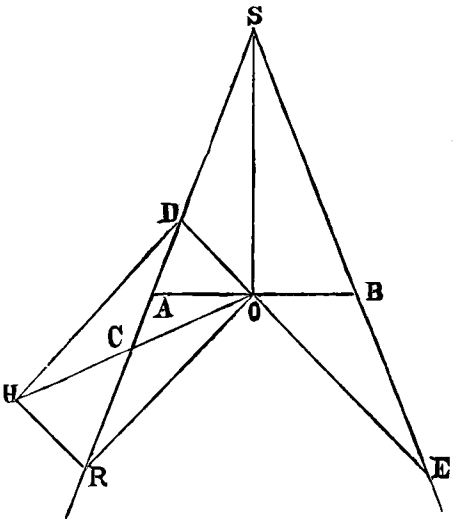
Halos, &c., seen 4th May, 1862, near Bishop Stortford.

I saw the combination of halos and mock suns in the figure, at

1.45 p.m. Colors (*m. s.*) red and green; (*h.*) *r. g.* yellow. A C B D a circular halo about S the true sun; M A N another circular halo touching the former at its highest point A. Two mock suns, E. W., at the same height as S. So far as I could judge E M = M C and D N = N W nearly." The weather (I speak from memory) was *extremely hot*. On "29th June, 1862, at 9.15 to 9.30 a.m., going to Much Hadham, a white horizontal halo through the sun. At first I only saw about one-fourth of it in the north; but when the wind drove the clouds towards the sun, this northern part vanished, and was replaced by a portion on the west, which terminated in the mock sun (3) (23°)" (By this I meant a mock sun at a distance of about 23° from the sun, and in the same direction from it as the figure 3 on the face of a clock is from the centre of the face.) This mock sun was "coloured red and green. The top of the 23° halo round the sun was seen occasionally, also red and green. My children also saw the halo, and said it was white." At Bourton, "28th September, 1868, about 5 p.m., two mock suns, E and W., red, orange; *warm* rain." Bravais's theory would be perfect if we could go up and arrange the ice prisms after our own fancy; putting all those in one region with their axes vertical, all those in another region with their axes horizontal, and all those in a third region with their axes in every possible direction; always supposing that there is a sufficiently large number of ice prisms.

Bravais follows Babinet, and supposes that there are very long and very flat ice crystals, in enormous numbers, in the upper strata of the atmosphere, and that those strata are quite calm, and further that the ice crystals fall slowly and regularly through the air; and he argues that by reason of the resistance of the atmosphere, the axes of the long crystals will be arranged vertically, and those of the flat crystals horizontally. Bravais reasons beautifully and to a certain extent conclusively, moreover he follows up his reasoning by judicious and careful experiments, and he candidly and fully states the views of other scientific men, even when he most differs from them; so that his book of 270 pages is invaluable, nor can anyone expect without it to acquire a sound knowledge of halos, &c. I admire the book enthusiastically, and I shall be extremely happy, for the mere pleasure of doing it, and without any pecuniary remuneration, to translate the whole of it into English, if any one else will pay the expense of printing and publishing it. Without wishing, however, to derogate in the least from a treatise which it would be a high honor to any man to have written, and which it is a great privilege to read, I nevertheless venture to put in a claim on behalf of rain-drops, not as causing all halos, &c., not perhaps as causing the greater number of them, but at least as causing some of them. And, in particular, I claim for rain-drops the power of producing vertical, horizontal, and circumsolar halos, the three white mock suns which have the same height as the sun, and distant from it 90°, 90°, and 180°, and several of the colored mock suns. With your kind permission, I propose to enter more at length into the subject in your pages. Meantime, the following theorem applies as much to horizontal halos as to vertical ones:—

THEOREM.—The base A B of an isosceles triangle S A B is less than any other straight line, D O E, which passes through the middle point O of the base, and is terminated by one side A D S, and the other side produced S B E.



Join S O, make the angle A O R = B O E, complete the parallelogram O H, draw O C H. Then the diagonal H O is bisected in C, and from the triangles A O R, O B E, O R = O E .·. also H D = O E .·. H D + D O = D E, but the two sides H D, D O are greater than H O .·. D E is greater than H O. Again, the angle C A O = O B E, which is greater than the inner and opposite S A B, and S A B is greater than the inner and opposite A C O, much more .·. is C A O greater than A C O .·. also the side C O is greater than A O; but H O = 2 C O & A B = 2 A O .·. also H O is greater than A B; much more .·. is D E greater than A B.

I reserve the application for a future letter.

Faithfully yours,

J. B. KEARNEY.

Bourton, Shrivenham.

THERMOMETER STANDS.

To the Editor of the Meteorological Magazine.

SIR,—Letters have from time to time appeared in your Magazine and other scientific periodicals, complaining of the great discrepancy in thermometrical readings at stations within short distances of each other. Two causes have been assigned for this. One is the probable defect in the instruments themselves; the other, and, in my opinion, the most plausible, is the effect of the sun's rays on the large surface of wood-work presented by the thermometer stand. To obviate this, I would recommend a plan I have for some time adopted, and found to answer admirably. I cover the whole of the exterior surface of that part of the stand exposed to the sun with strong cotton canvas of close

texture, keeping it by means of small strips of wood from half-an-inch to an inch above the wood-work, thus permitting the air to play freely between the wood and the canvas. The result is that on a hot summer's day the stand instead of being too hot to touch, is as cool as though placed in the most perfect shade. The construction of my stand (which I some time since sent you a model of, and of which you were pleased to express your approbation), is much better adapted than the stands in general use, for being thus screened. I think if this simple plan was generally adopted we should have less complaints of discrepancy in readings, and certainly fewer records of temperatures of 98° and 100° (!) in the shade. The stand is also protected from upward radiation by a screen of cotton canvas.

Yours truly,

JOHN THRUSTANS, F.M.S.

Merridale, Wolverhampton, May 16, 1871.

REVIEWS.

Commission Hydrométrique et des Orages de Lyon, 1867. 24$^{me.}$ *Année*. Large 8vo., 218 pages, 2 plates.

THIS useful and interesting volume possesses (in addition to its intrinsic merits, which are equal to any of the previous ones), special claims to notice in the fact that it contains the latest contributions to meteorology of the late president of the Commission, the talented and lamented M. Fournet. In addition to the usual meteorological and rain tables, it contains the daily height of the Rhone at Pont Morand, from 1855 to 1865. Daily meteorological observations at Lyons Observatory, at 9 a.m., during 1867, from which we may take two items: (1) that the annual evaporation only amounts to 19 inches; (2) that the density of every fog is indicated by numbers denoting the distance in mètres at which objects were perceptible. We find that Lyons occasionally has fogs which even Londoners would recognize as such, for there are in the year's tables two instances in which objects distant only 50 mètres (say 55 yards) were imperceptible.

The volume also contains an abstract, by M. Delocre, of observations made during the last two centuries as to the density of snow, and the quantity of water which it will yield on melting. The series is not very extensive, but it contains quantities quite as variable as those given in *British Rainfall*, 1865, the range being from 24 to 1 down to 5 to 1. As with our English observers, the equivalent of 12 to 1 occurs oftener than any other, and the mean is 10·36, which closely agrees with the value assigned in the *Meteorological Magazine* for April, 1867.

Passing two short articles, one on the best means of restoring the French rivers to their original fish-yielding condition, and another on some antiquities dug out of the river at Lyons, we come to one by M. Chacornac, on the influence of atmospheric electricity, or of the currents derived from telegraph lines upon the daily move-

ment of a magnetic needle, which, being short and suggestive, we freely translate :—

"Since I have started a magnetic needle at my residence at Villeurbanne, I have convinced myself that the daily variation far exceeds that ordinarily observed. For a long time I asked myself why the variation here should be 1°, while at other observatories it was only one-sixth as much, or from 9′ to 12′. I endeavoured to account for it, and the following is the result at which I have arrived :—

"Firstly, my needle is of small diameter and powerfully magnetized by the voltaic process. Its length is 13·41 inches, and its diameter ·274 inches (say 1 foot long by $\frac{1}{4}$ inch in diameter), and it is suspended by Gambey's method. It is of steel slightly tempered and highly magnetic. Under the influence of the temperature of a cloudless sky, it immediately undergoes considerable deviations, whilst under a cloudy sky and with a damp atmosphere they are at a minimum. These facts seem to me extremely interesting, and the daily variation being observed by a new magnifying process, I began observing with a second and still lighter needle to see if I could clear up the difficulty. It is well known that in the observatories the magnetic instruments are observed by telescopes from a distance ; in my case, I was close to the needle, and the final result was that the needle of small mass was moved in a jerky manner by the presence of the observer. It was subsequently found that the presence of some persons and their movements affected the needle, even when they were 33 feet distant, whence I conclnde that the presence of observers near magnetic needles is incontestably condemned.

"In searching for the cause of these perturbations, I am led to think that the currents derived from telegraph lines accumulating on the nervous systems of certain persons may, by joining induced currents from Ruhmkorff's coils, give rise to real magnetic disturbances, as I have noticed with myself. The large number of these coils in use, spread throughout the atmosphere a quantity of dynamic electricity, which accumulates on the persons of those towards whom the currents are directed. In conclusion, I may draw attention to the singular fact that currents from telegraph lines should arrive and make themselves felt at Villeurbanne-lès-Lyon, although I am unprovided with an inductive coil.

"As it is easy to repeat these observations at any place where it seems desirable, I have hastened to publish these observations."

Concerning this paper we have only one remark to offer. If some persons are so magnetic as to affect the needles at a distance of 33 feet, should not the admission of strangers to magnetic basements be strictly prohibited? Or is it possible that M. Chacornac forgot the keys in his pocket?

The report concludes with three articles, by M. Fournet, on the characteristic features of the storms of South-West France, written with even more than his usual clearness.

MAY, 1871.

Div.	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.	Date.	Min. Deg.	Date.	No. of Nights below 32° In shade	On grass
		inches	inches.	in.								
I.	Camden Town	·93	— 1·47	·36	8	7	79·0	25	35·0	12	0	0
II.	Maidstone (Linton Park)	1·20	— 1·04	·41	19	8	81·0	26	32·0	12‖	2	4
,,	Selborne (The Wakes)	·21	— 2·27	·09	27	4	74·0	25	28·0	12	3	5
III.	Hitchen	·92	— 1·01	·32	25	9	73·0	25	32·0	13	0	...
,,	Banbury	·98	— 1·24	·57	25	5	77·0	24	32·0	14	1	...
IV.	Bury St. Edmunds (Culford)	1·63	— ·53	·87	27	9	78·0	24	29·0	15	2	7
V.	Bridport	·99	— 1·04	·51	24	5	74·0	24	32·0	12	1	...
,,	Barnstaple	·96	— 1·48	·75	24	5	79·0	25*	38·5	12	0	...
,,	Bodmin	·49	— 1·97	·30	24	5	74·0	29	39·0	11§	0	2
VI.	Cirencester	1·70	— ·58	·74	25	4	...	...	...	...	...	...
,,	Shiffnal (Haughton Hall)	1·18	— 1·08	·66	25	8	74·0	24	33·0	11	0	...
,,	Tenbury (Orleton)	·97	— 1·91	·55	25	5	80·4	30	30·0	11	3	6
VII.	Leicester (Wigston)	1·34	— ·78	·80	25	7	80·0	24	30·0	13	2	...
,,	Boston	1·43	— ·51	·85	25	10	77·7	25	35·0	2	0	1
,,	Grimsby (Killingholme)	1·23	..	·76	25	9	67·5	25	35·5	17	0	...
,,	Derby	1·68	— ·48	1·15	25	10	77·0	24	35·0	17	0	...
VIII.	Manchester	2·08	— ·58	...	...	8	...	...	...	...	...	...
IX.	York	1·31	— ·64	·83	25	8	76·0	24	34·0	17	0	...
,,	Skipton (Arncliffe)	2·03	— 1·32	·57	3	11	80·0	29+	25·0	17	2	...
X.	North Shields	1·59	— 1·05	·56	25	13	66·0	22	29·0	17	1	1
,,	Borrowdale (Seathwaite)	2·63	— 6·91	·91	2	9	...	...	...	...	...	...
XI.	Cardiff (Town Hall)	...	...	...	...	...	...	...	...	...	...	...
,,	Haverfordwest	·53	— 2·19	·20	24	4	76·6	29	32·3	11	0	1
,,	Rhayader (Cefnfaes)	·98	— 1·87	·50	24	10	77·0	...	30·0	...	3	...
,,	Llandudno	1·19	— 1·19	·59	24	6	74·1	24	37·6	13‖	0	...
XII.	Dumfries	1·03	— 1·36	·33	24	10	78·5	29+	28·0	17	...	...
,,	Hawick (Silverbut Hall)	1·06	...	·23	25	11	...	...	...	...	...	...
XIV.	Ayr (Auchendrane House)	·85	— 2·26	·26	3	12	75·0	24	26·0	17	2	7
XV.	Castle Toward	2·44	— ·95	1·09	25	7	...	...	...	...	...	...
XVI.	Leven (Nookton)	1·30	— ·71	·49	25	10	71·0	30	26·0	17	2	15
,,	Stirling (Deanston)	1·10	— 1·55	·39	3	11	75·0	29	25·0	17	3	9
,,	Logierait	·69	...	·14	24	9	...	...	...	...	...	...
XVII.	Ballater	·95	...	·17	17	7	73·0	22‡	28·5	12	4	...
,,	Aberdeen	·79	...	·17	17	12	68·2	22	32·8	17	0	14
XVIII	Inverness (Culloden)	·45	...	·19	18	5	69·9	24	35·4	17	0	...
,,	Portree	2·06	— 3·59	·45	2	19	...	...	..	...	...	...
,,	Loch Broom	1·11	...	·24	16	11	...	...	...	...	...	...
XIX.	Helmsdale	·74	...	·22	29	12	...	...	...	...	...	...
,,	Sandwick	1·12	— 1·14	·29	16	13	60·0	22	31·8	17	1	4
XX.	Cork	·65	...	·34	24	...	...	...	...	...	...	...
,,	Waterford	·71	— 1·54	·19	27	10	72·0	29	37·0	17	0	...
,,	Killaloe	·99	— 2·19	·35	24	12	77·0	29	30·0	1	1	...
XXI.	Portarlington	·63	— 2·57	·11	5	14	74·5	30	32·0	16	1	...
,,	Monkstown	·35	— 1·56	·14	2	6	...	...	...	...	...	...
XXII.	Galway	1·28	...	·47	24	12	76·0	31	36·0	1	0	...
,,	Bunninadden (Doo Castle)	1·42	...	·42	24	11	75·0	8	27·0	1, 17	2	...
XXIII	Bawnboy (Owendoon)	...	...	..	...	...	...	...	...	..	...	..
,,	Waringstown	·48	...	·19	24	7	79·0	22	27·0	16	1	...
,,	Strabane (Leckpatrick)	·68	..	·23	24	12	75·0	22	..	...	...	...

* And 30, 31. † And 30. ‡ And 29. ‖ And 16. § And 12.
+ Shows that the fall was above the average ; —that it was below it.

METEOROLOGICAL NOTES ON MAY.

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.

CAMDEN TOWN.—T S and heavy R from 3.22 to 4 p.m. on 8th, unusually dark at the time; T S from 1.40 to 3.20 p.m. on 27th.

LINTON PARK.—A dry ungenial month, the N. and N.E. winds having retarded vegetation. T, mostly distant, on 8th, 19th, 26th and 27th. Frosts, 12th and 16th, and slight ones on 4th and 5th. Fruit, and many other trees, sadly infested with insects.

HITCHIN.—T on 8th and 27th.

BANBURY.—Strong gust of wind between 3 and 4 p.m. on 8th. [Electric breeze?—ED.] T S on 27th; S on 17th.

CULFORD.—Hail-storm on 1st, and on 27th in a severe T S, during which the L struck and slightly injured the Church of St. John, Bury St. Edmunds.

BRIDPORT.—Very fine but cold month; French beans and potatoes slightly cut by the frost of the 12th.

BODMIN.—Average temp. 2°·8 above the average; average difference between the wet and dry bulb 5°·1; max. diff. 12° on 29th.

HAUGHTON HALL, SHIFNAL.—Very cold for the first three weeks, but, owing to the absence of positive frost, vegetation proceeded quicker than might have been expected; the wheat much improved by the welcome rain of the 25th and 26th. Hollies blossom most abundantly at the beginning of the month; potatoes cut on lower grounds on 11th; hawthorn, a sheet of white, on 18th; oats in full leaf on 19th; seringea blossoms on 28th. Turtle dove arrives on 2nd; orange-tipped butterfly appears on 8th; unusually few queen wasps.

ORLETON.—Very fine and dry, with a low but variable temp. and some frosty nights till the 19th, then warmer to the end with sudden changes from heat to cold. Temp. of month about half a deg. above the average; nearly all the R fell on the 24th and 25th; distant T on 27th.

WIGSTON.—Heavy T S on the 8th, passed over to the N. of us; slight fall of S on the morning of 17th, which continued for three hours; the prospect for fruit is not good.

GRIMSBY.—Polar current scarcely interrupted and nights cold, still the land, both in grass and tillage, is looking remarkably well. Fruit of all kinds scarce. H on 4th; T and L at 7.5 p.m. on 25th; distant T on 27th. Lesser white-throat heard on 6th; garden warbler on 8th. Air very dry on 17th. Old moon visible on 23rd. Monthly rose on 25th.

DERBY.—A very fine month, no frost indicated 5 ft. above ground; refreshing rains, but somewhat below the average. A meteor seen at 9.45 p.m. on 23rd, near the tail of Ursa Major.

ARNCLIFFE.—H on 17th, and hills white with S.

NORTH SHIELDS.—H and T on 26th.

SEATHWAITE.—S on the mountains on the 4th and 17th.

WALES.

HAVERFORDWEST.—The first three weeks cold and ungenial, bright cloudless skies and N.E. winds; the last week bright and very warm, rain much wanted, the driest May during the last 22 years.

CEFNFAES.—Very dry, cold nights and frosts, with wind N.E. and N.W., generally the former. Hills very bare and brown. Hay crops light. Sheep dying of disease in the head.

LLANDUDNO.—On 6th a dense sea fog, from 11 a.m. to 8 p.m. On 24th a heavy shower at 4 p.m.

SCOTLAND.

DUMFRIES.—Drier than usual; the night temp. colder, but day warmer than average, and so the mean is 0°·5 above May of last year. On 17th there was S on the hills and sharp frost, in some places 10° below freezing. Early potatoes cut down. Beech trees and hedges quite brown. T on 26th. Crops looking well.

HAWICK.—A very dry month with much E. wind; hail shower and very keen frost on night of 16th. Cuckoo has not been heard here this season; landrail first heard on 14th.

AUCHENDRANE, AYR.—With bar. pressure and temp. above the May mean, and bar. range below it, the R is the lowest recorded since 1859; the rivers are very low; potatoes, hay, orchards, &c., injured by frost on 17th.

DEANSTON.—Gale of wind from S.E. on 3rd; some R till 6th, then dry and bright; nights cold and frosty, and on 10th, sharp frost, destroying potato leaves, and many young leaves of trees; very dry and bright till the 14th, when, and on the 15th and 17th, some R; sharp frost on 16th and 17th; much E. wind.

LOGIERAIT.—Cold E. winds marked the first part of the month, latterly the temp. has been very high; R wanted; crops looking well; landrail first heard on the 21st.

BALLATER.—R below the average: early part of month dry and parching; sharp frost on the 12th, nipping tender plants; last ten days more seasonable, and vegetation made rapid progress. Cuckoo on 6th, swifts on 25th. Hailstorm on afternoon of 26th.

PORTREE.—Very cold, more or less frost almost every night; gale from S.W. on 3rd. S on 16th and 17th; vegetation backward, trees and shrubs have not got over the frosts of April; fruit trees and bushes are quite brown, and many of them have died.

LOCHBROOM.—The driest May since I have registered, and indeed the driest of any month except March of last year, the difference being ·01. Better weather for tilling the ground the farmer never experienced, nor the hill grazier for his lambs and fleecy flocks.

IRELAND.

MONKSTOWN.—An unusually dry May.

DOO CASTLE.—Month hard and dry; the deficiency of R and prevalence of N. and N.E. winds, have seriously affected vegetation; grazing lands bare of pasture, meadows short and presenting a poor prospect; oats (particularly the late sown crops) in anything but a flourishing condition; potato crop good. Severe frost on 17th; potato tops destroyed.

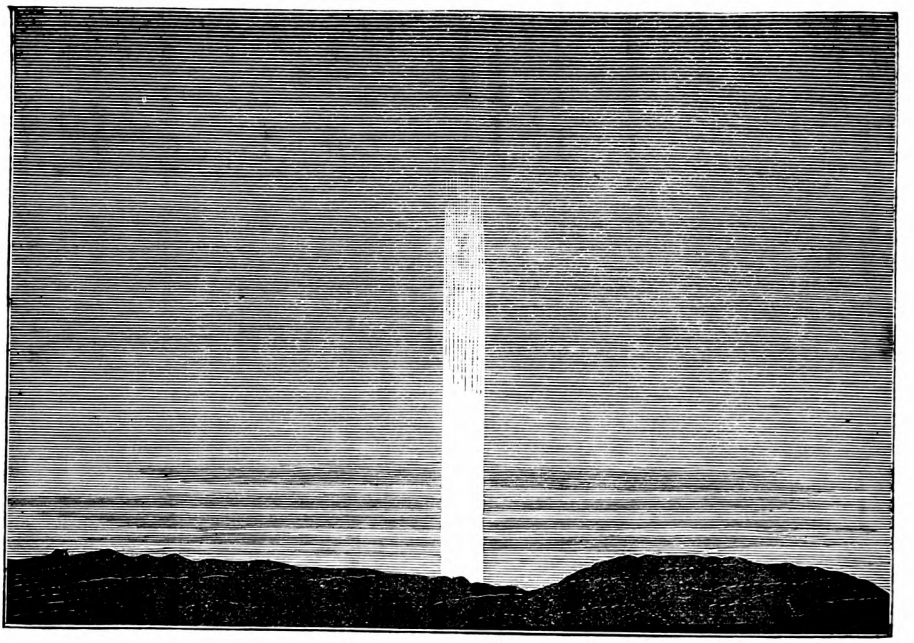
WARINGSTOWN.—Very dry with N.E. winds; R much wanted.

LECKPATRICK.—Driest May ever registered here, during the last 8 years; every month's rainfall has exceeded 1·00 in. except this May, July 1863, and June 1865. The drought has been very injurious to the flax and grass, both hay and pasture. The rainfall for the first five months of the year is only about 1·00 inch below the average.

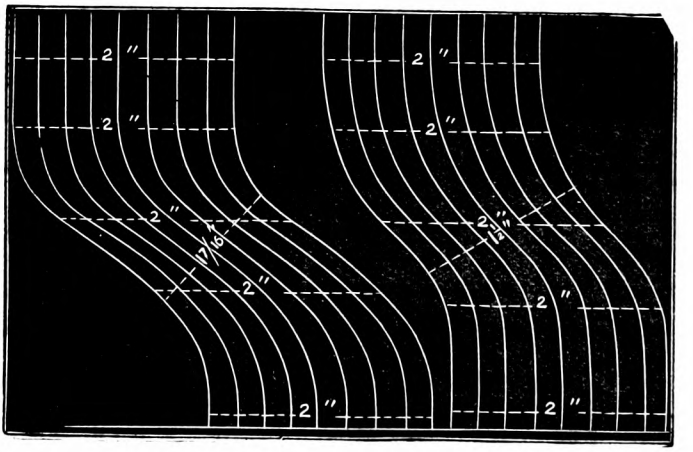
THE SUMMER.

To the Editor of the Meteorological Magazine.

SIR,—When April is very wet we often have a summer rainfall in excess of the average, and when May is very dry we frequently have an unsatisfactory season follow, but when the April rainfall at Greenwich is excessive (say 3 inches or more), and the following month is very dry (say has below an inch of rain), we always have an unfavourable season follow. In 1848 (which was a very bad season), the April rainfall at Greenwich was 3·4 in., and in the following month only 0·4 in. was registered at that Observatory. In 1829, the rainfall at the same station was 4·8 in. in April and 0·6 in. in May, and the summer which followed was very cold and bad. In 1809, according to Luke Howard, the rainfall of April, near London, was 3·8 in. and that of May 0 8 in., and the following summer was very cold and unfavourable. In the present year the rainfall of April at Greenwich was 3·03 in. and the rainfall of May, at the same place, 0·68 in. These are all the instances I can find in the present century with reference to the above rule.—Yours, &c., GEORGE D. BRUMHAM.



Sun Pillar seen near Sidmouth, April 4th, 1871.—(*See p.* 96.)



Diagrams showing that the greater the angle at which rain drops fall the nearer they approach each other; also that a horizontal rain gauge will collect the same quantity whether the rain falls vertically or obliquely.—(*See p.* 93.)

SYMONS'S
MONTHLY
METEOROLOGICAL MAGAZINE.

LXVI.] JULY, 1871. [PRICE FOURPENCE, or 5s. per ann. post free.

WEATHER MAPS.

"Is Old England on the Wane?" the title of a modern song, rises to our mind in sober earnestness after carefully examining some maps and tables recently issued by the War Department of the United States, comparing them with those issued through all her troubles by distracted France, and then reflecting that nothing of the kind is being done in England. We have no desire to write depreciatingly of many good works carried on in this country, but why is the subject at the head of this article utterly neglected?

One reason which may occur to some readers is the expense. We most emphatically deny that that can be a valid argument in a country which is always ready to pay liberally, when it sees a reasonable prospect of money's worth being returned for money granted. And here it may be well to remark that, however true it may be that there are in meteorology, as in most other matters, cases of individual maltreatment, there is no question but that the gross sum, probably £20,000 per annum, paid by the State, is ample, if only it were properly administered. But let us descend to particulars, just sufficiently to show that in asking for a daily map of the weather prevalent in the British Isles, we are asking for nothing in the slightest degree original, difficult, or expensive. Even if it were all three, we should advocate such a publication, but we fail to understand why it is not done when, as we purpose to show, not one of these objections exists.

1. As to *originality*. Passing over the capital organization arranged some 20 years ago, between Mr. Glaisher and the proprietors of the *Daily News*, which merited very much heartier support than it received; we come to Admiral Fitz Roy's daily weather reports, and in 1861 a proposal, by a private firm, to republish his data on a map, a proof of which is now before us. Why the gallant Admiral declined to support the praiseworthy venture, or to adopt a similar course himself, we have no information. Later in the same year, Mr. F. Galton, F.R.S., undertook the great task of mapping the weather of the whole of Europe during the month of December, the result of which was published in his *Meteorographica*, issued in 1863, and from which we must quote one paragraph:—

"A sustained series of publications of this kind, extending over two or three years, would give an extraordinary impetus to the scientific study of Meteorology. They would supply the necessary materials, in a manageable form, for arriving at a general knowledge of the distribution of the various elements of the weather; they would afford means of testing the extant theory of "forecasts," with a rigour impossible at the present time, and they would necessarily improve it."

About this time, also, our neighbours across the Channel added to their daily bulletin a daily map, with direction of wind and isobaric lines.

And then the Admiral died, all the arrangements were altered, the office was placed under a specially-appointed Committee, and three times the previous expenditure was authorized; still nothing was done in this matter, and now from across the Atlantic come weather maps, of considerable excellence, suggesting once more the question, Why have we not a daily weather map of the British Isles?

Having dwelt at some length on the first branch of the subject, in showing that the proposal is by no means original, we have partly anticipated the evidence as to its being neither difficult nor expensive. It is not our duty to show how it ought to be carried out, but no one acquainted with what has been done could fail to accomplish it, both easily and cheaply. As to cost, we should not be at all surprised to learn that the sale of the maps more than covered the expenditure.

PROFESSOR RAULIN ON ALGERIAN RAINFALL.

[TRANSLATION.]

To the Editor of the Meteorological Magazine.

SIR,—I have to reply to the observations on the above subject in page 95 of the *Meteorological Magazine* for 1870.

For Djidjeli the monthly details for 1862 do not, at first sight, lead one to suppose that any numerical error had crept in, to raise the annual quantity so much above the mean, for no month has a larger quantity than had previously fallen therein. However, on looking more closely, it appears that the month of April had a quantity greater by 300^{mm} (11·81 in.) than eight other Aprils, it may not be impossible that this quantity is too large, and that the Algerian copyist wrote 418^{mm} instead of 118^{mm}.

For Bougie the monthly details for 1866 lead to exactly the same result, for the month of April the Algerian copyist may have written 471^{mm} instead of 171^{mm}.

But it is necessary, while admitting these errors, which had their origin in the records of the Ponts et Chausées, to remark that these large annual totals at Bougie and Djidjeli are only three times the respective minima ($\frac{1884·2}{761·5}$ $\frac{1805·1}{622·8}$), confirming that which occurs at other stations, where similar errors are improbable.

I have for each Algerian station the necessary indications of the diameter and position of the rain gauge.—Yours, &c.,

V. RAULIN.

Bordeaux, May 28th.

OBSERVATIONS AT PATRAS.

[The following letter so completely meets our ideas of the details which should accompany notes on local climates, that we gladly avail ourselves of the Rev. H. A. Boys' permission to use it in any way we think fit, and as perhaps our answers to his queries may be useful to others, as well as himself, we also insert them.—ED.]

To the Editor of the Meteorological Magazine.

SIR,—I send you with this note some tables which you may find of use, but before I discuss them, I will say a few words as regards instruments. I brought with me,

1. A Rain gauge, tin japanned, price £1 1s. Negretti and Zambra.
2. A Maximum Registering Mercurial Ther. do., price 8s. 6d.
3. A Minimum do. Spirit do. do., price 3s. 6d.*
4. A do. do. do. do. Pastorelli. price 5s. 6d.
5. A Hygrometer, by Casella, price £1 5s.
6. An Aneroid Barometer, price £4 10s., by Casella, (a pocket size).

These instruments, you may say, are very far from reliable; however, in such a place as Patras, they are quite sufficiently good, because of the danger of breakage and the difficulty of securing proper positions for them. I live in a very large house, built round a court 20 ft. by 30 ft. The outside measurement of the house must be 70 ft. by 80 ft. The walls are 38 ft. high and the roof rises some 12 ft. higher. The house stands not N., S., E., and W., but as nearly as possible N.W., S.E., N.E., S.W. The house has eaves, projecting perhaps 18 inches inside and out. The house has only two stories, is open on S.E. and N.E., has houses opposite it on S.W. and N.W. The only available side is N.E., S.E. being simply a huge blank wall; from the windows on the N.E. side may be seen an amphitheatre of mountains: to the right, at a distance of about 8 miles, the peak of Mount Voidhia, 6000 ft. high, whose last snow will disappear in a day or two; right in front, *i.e.* due N.E., is the whole range of Parnassus, with summits from 7000 to 8000 ft., retaining even now a great deal of snow, and bare, rather from the snow sliding and being blown from its steep sides, than from actually melting. This range is from 30 to 40 miles distant, and includes 40° of the horizon. To the left are other mountains from 3000 to 5000 ft. high, and exactly N. may be seen two or three peaks of Pindus, certainly 7000 ft. high and 40 miles away. The nearer mountains are from 7 to 20 miles distant, and between them and us is the sea. On a window commanding such a view as this I have hung my thermometers, 20 ft. from the ground, with the bulbs an inch from the wall, therefore, as regards the minimum, I have no fear as to its being pretty near the truth. As regards the maximum it is unfortunate that the sun is not off the wall till about ten o'clock; however, it shines so obliquely that it has not yet brought the max. above 93°, when exposed to its full glare, but I generally set a Venetian shutter open so as to shade the thermometer during the early hours, and then set it at 11, 11.30, or 12, and, as the maximum is generally from 2 to

* This is kept in my room, and is not referred to in the tables.

3 in the afternoon, I don't think that the morning sun has any undue influence: the greatest heat is generally the effect of a hot S.E. wind, which invariably hides the sun in a grey haze, though leaving the mountains afore-mentioned distinctly visible. Before quitting the subject of temperature. I will observe that I did not get settled in this house till the end of October, but carried on observations irregularly from my arrival here on September 15, from which I can say that September, October, and November, were almost alike in their temperature, September being unusually cool, and November unusually warm. The winter again has been most unusually mild, the snow never having descended on the mountains within 3000 ft. of the sea, whereas the winter before it snowed in Patras itself by the sea, and remained some days within 600 ft. of sea level. The summer so far has been mild. The month of June on two consecutive days gave us max. 90°, 91°, and min. 67° and 66°, this with a hot wind, otherwise from 80° to 83° and from 60° to 63°. Twice only has the max. been below 80°, and on the second of these days it was the effect of a thunderstorm on the previous evening, which I shall presently allude to. From all I can make out I may expect in July a course of 90° and 70°.

I will now pass on to the rain question. Finding no ground site which combined even moderate fitness and safety, I hit on the expedient of suspending my gauge in the court and drawing it to my own window with pulleys, it is thus fully 18ft. from the ground, the horizontality of the mouth not seriously affected, investigated most readily by the observer, seeing that it comes to him, but it is no doubt far too much shaded by the roof. I have so slung the gauge that it is least sheltered on the S.W., and I draw it nearer to one side of the court or the other as the wind may be. But I fancy that the least angular elevation of the roof is as much as 40°, and the greatest, perhaps, 60°; against this it may be said that inside the court it is still in the strongest gales, and that the rain falls, as a rule, most decidedly unaccompanied by wind. The roof has an excellent water-spout all round, but I cannot give my results as certain. I am rather disposed to think, from my English experience, that my gauge gives under the mark than over, but it is very difficult to say. Still, no doubt, this table will give you a notion of Greek rain. The table explains itself. I may observe that October and November are said to me to have very much more rain usually than they had this time, and December not quite so much. January is usually a dry, cold month, February about the average, but at the end of March and through April there ought to be much more rain than there has been; May had more than usual, and June was graced with a thunderstorm this year, to our great delight. We cannot reckon on any rain from May 1st to end of July, and sometimes from April 1st to September 15th, there is none. You probably know pretty well how much dependence is to be placed on popular reports of weather, but I give you the best information I can get. The autumn rains, and the first part of the January ones, were almost invariably accompanied with thunder and lightning, but nothing

remarkable for noise or brilliancy, nor, fortunately, for danger. As to wind, no satisfactory estimate can be made in Patras; we are near the mouth of a huge funnel, between the mountains that are on each side the strait at the entrance to the gulf of Corinth, consequently weathercocks show either E. or W.; observation of the clouds, hygrometer, and temperature, tell one best what it really is, but I can tell now with tolerable accuracy whether the wind is S.E., N.E., N.W., or S.W. Looking at December, I see no E. at all, at January only four; and since I came only eight of the rainy days have an E. to them. As regards the strength of the wind, I should say there is less of it here than in England, but now and then when it does blow, it blows furiously. On the 1st of January there was a very strong gale, which lasted a day; it almost took one off one's legs. I was out in the worst of it, and was afraid, for the tiles began to fly. The strongest gales are generally from Mount Voidhia, S.E., very hot, and they spread a grey haze over the sky.

Earthquakes need little remark; they appear to be entirely unconnected with barometer or any other meteorologic states, so far as I can see. Patras is, happily, out of the line of the worst. The Ionian Islands and Delphi suffer terribly; near Delphi the shocks are continual, many a day.

BAROMETER.

My barometer, I think, can scarcely be right; it keeps so wonderfully high. My room is only 60 ft. above sea level, and it has shown such averages as this:—November, 30·407 in.; December, 30·227 in.; January, 30·235 in.; February, 30·52 in.; March, 30·464 in.; April, 30·294 in.; May, 30·262 in.; *i.e.*, average of the readings taken daily at 8 a.m. The lowest I have seen was 29·55 in., and the highest 30·86 in. From February 18th to March 16th, it never went below 30·50 in., and was frequently above 30·70 in.; the E. wind blowing all the time. No doubt it is set too high. [Yes, probably 0·60 in.] Curiously, the only other barometer I have seen agrees with it. I have compared it with one ship barometer, which makes it just ·50 too high, and with that in the ship I came out in, which makes it ·20 too high. There is a screw in the back of the instrument,—can you tell me what it is for? [For setting, *i.e.*, rectifying such an error as the above.] Next, as I have frequent opportunities of going up heights, will you give me two or three rules for observing altitudes. [See *Meteorological Mag.*, Vol. I., pp. 52 and 60.] I have walked occasionally to very nearly 2,000 ft. high, and the rules that are good for the first 500 ft. would hardly apply to elevations of 1,500 ft. The barometer is very stationary here, keeping close to the same spot for weeks, then dipping suddenly, and rising again.

HYGROMETER.

I have been utterly unable to get a good place for this. Hitherto I have kept it in my window, looking into the court, whose paved floor is generally kept wet purposely, and in an unduly damp atmosphere. And to make things worse, it became gradually choked with dust, and

I wondered to see such great dampness registered in the dry E. wind of February and March, nor did I discover the cause till the end of April, since then I have washed the cotton wick fortnightly, though it is a perilous operation. The November and December readings may be trusted, with allowance for position of instrument; they are—

November, average reading at 8 a.m., 75·6, greatest 85 (25), least 66 (16),

December ,, ,, ,, 83·7, ,, 93 (17, 18, 31) ,, 72 (1),

May ,, ,, ,, 64·3, ,, 79(8) ,, 53 (27),

June hitherto has varied between 74 (on the 15th), and 58 (on the 7th). I may, perhaps, succeed in getting a better place before long.

[We presume that the above are "degrees of humidity," computed from the Dry and Wet bulb, by Glaisher's tables. Perhaps Mr. Boys will correct us if we are wrong.]

CLOUDS.

I have made notes of these, too, marking against each day 0, 1, 2, up to 10, according to the amount of cloud, 0 representing perfect clearness; 1, 2, clouds hanging on mountains only; 3 up to 7, different degrees of cloudiness over Patras, and 8 to 10, different densities of clouds when the sky is covered entirely all day. The annexed table shows how many days of each sort there have been from the beginning of each month, and the average for each month. This is an unscientific method of registering, but you can take it for what it is worth. I am not acquainted with the proper cloud nomenclature; any hint that you can give me about this I shall be grateful for.

Scale.	Jan.	Feb.	March.	April*	May.	June*
10—8	13	6	1	1	1	0
7—3	16	7	18	11	14	10
2—1	2	10	9	9	14	7
0	0	5	3	0	2	1
	6·3	3·5	3·4	3·5	2·8	2·8

* April omitting 12-20. June only up to 18.

We had a fine Aurora here on Oct. 25th, from 7 to 9. There was an earthquake just before. The day had been rainy, but cleared up well at night. The Aurora was from N.W. to N.E., a deep red, very bright, the finest I ever saw. The people were terrified. Such things are seen here once in about ten years, and connecting it with the earthquake, they said a volcano must have opened. It was a steady red blaze with little or no shooting rays. It was a fine sight to see it along our horizon. Our view of the mountains, with the strong flame-colour behind them, was magnificent.

I hope another year to send you a more complete report, and to have found better places for my instruments. The ground given for our Church is open on all sides, and if I remain here long enough to see Church and house built, I may arrange a proper stand for all the instruments.

If any of your richer meteorological friends are disposed to aid an

English Church in Greece, either on this or higher grounds, I can assure you that subscriptions are really needed.—Yours sincerely,

HERBERT A. BOYS.

Patras, Greece, June 17th, 1871.

Rainfall Table.

Date.	1870.				1871.					
	Sept. 15-30.	Oct.	Nov.	Dec.	Jan.	Feb.	March.	April.	May.	June 1-18.
1...		...	·37	·60	...	...	...	...	...	...
2...		...	·46	·87	·96	...	...	·02	...	...
3...		...	...	·56	·21	...	...	·01	...	...
4...		...	...	·03	·49	...	...	...	...	...
5...		...	...	·02	...	...	...	...	...	...
6...		...	...	·03	·07	·23	...	...	...	...
7...		...	...	·31	...	·17	...	...	...	...
8...		...	...	1·25	·25	·24	...	...	·03	...
9...		...	·46	·72	·54	...	...	...	...	...
10..		...	·33	·14	·60	·36	...	...	...	...
11...		·66	...	...	·39	·74	...	...	...	...
12...		...	...	...	...	·14	...	·01	...	...
13..		...	...	...	·25	·01	...	...	...	...
14...		...	·01	...	·32	...	...	...	·05	·41
15...	...	...	...	...	·18	...	...	...	...	...
16 ..	...	...	...	·02	...	...	...	...	...	...
17...	...	...	...	...	...	...	...	...	...	...
18...	...	...	...	·19	...	..	...	...	.	...
19...	...	...	...	...	...	...	...	...	...	
20...	...	...	...	·04	·57	...	·19	...	...	
21...	...	...	..	·47	·04	·16	·21	...	...	
22...	·33	·44	...	1·41	·68	..	·18	...	...	
23...	...	·01	...	·38	...	...	·44	...	...	
24...	...	·03	...	·32	...	...	...	...	...	
25...	...	·16	...	·09	...	...	...	...	...	
26...	·10	...	...	...	·50	...	...	...	...	
27..	...	...	...	...	·03	...	...	...	...	
28...	...	·04	...	·03	·83	...	·03	...	·08	
29...	...	·56	·10	·21	·35	...	...	...	...	
30...	...	...	...	·20	...	...	·04	...	...	
31...	...	...	...	·08	...	...	·24	...	...	
Total..	·43	1·93	1·73	7·97	7·26	2·05	1·33	·04	·16	·41

Register of Earthquakes.

1870.				1871.					
Sept.	Oct.	Nov.	Dec.	Jan.	Feb.	March.	April.	May.	June.
			4 .						
			5 .			11 .		3 .	
		19 .	6 ...			19 .		4 .	
	25 .	29 .	24 .	22 .		22 .		10 .	
			29 .					18 .	

The figures represent the days of the month on which earthquakes took place, the dots their number, and the size of the dots their severity; the worst shook ground and houses sensibly to the feeling of any one in the streets, as I was.

Temperatures.

	1870.				1871.									
	Nov.		Dec.		Jan.		Feb.		March.		April†		May.	
	Deg.	Day	Deg.	Day	Deg.	Day	Deg.	Day	Deg.	Day	Deg.	Day	Deg.	Day
Average max. temp.	68·3	...	60·3	...	57·1	...	56·3	...	61·7	..	71·0	...	76·9	...
Greatest max. temp.	75·0	3	70·0	28	64·0	13	62·0	22	76·0	20	78·0	21	88·0	14
Least max. temp.	58·0	29	54·0	10	49·0	29	47·0	16	49·0	3	62·0	1	70·0	9
No. of max. between 89 & 80	...		...		...		...		...		...		5	
79 ,, 70	10		1		...		...		4		13		26	
69 ,, 60	19		16		6		9		15		8		...	
59 ,, 50	1		14		24		15		11		...		...	
49 ,, 40	...		...		1		4		1		...		..	
Average min. temp.	49·0	...	44·0	...	40·2	...	40·6	...	44·2	...	51·3	...	56·8	...
Greatest min. temp.	59·0	12	50·0	7	49·0	26	49·0	7	58·0	19	57·0	30	69·5	19
Least min. temp.	40·0	$\frac{29}{30}$	35·0	4	32·0	31	30·0	$\frac{1}{1^{st}}$	30·0	3	43·0	1	47·0	8
No. of min. between 69 & 60	...		...		...		...		...		...		7	
59 ,, 50	14		1		...		...		6		15		22	
49 ,, 40	16		24		15		15		15		6		2	
39 ,, 33	..		6		15		11		9		...		...	
32 ,, 30	..		...		1		2		1		..		...	

† The April register omits any account of the days from April 12–20th inclusive. I was in Athens at the time, but have reason to suppose that the weather in Patras during that time was quite regular, and that the omission scarcely affects the truth at all.

THE DECREASE OF RAINFALL WITH ELEVATION.

To the Editor of the Meteorological Magazine.

SIR,—This question appears to me to be exceedingly simple, and one which, luckily for myself, can be discussed without any knowledge of mathematics or the dead languages. The promoters of the new theory, if I understand them aright, say the amount of rain is the same at (say) 50 feet above the ground as on the surface, but that the reason why a horizontal gauge collects less at 50 feet is owing to the greater angle at which the rain falls at the higher level. The old theory assumed that the amount of rain was less at a given elevation than on the surface of the ground, and that the rain increased in quantity, in some unknown manner, as it fell. Let us apply the test of a little common sense to the subject. We are all agreed, I presume, that no matter how the rain falls, it must reach the earth at last. Now, the most ardent supporter of the new theory must allow that a horizontal gauge, placed on the ground, must catch the same amount

of rain no matter at what angle it falls: then, if on the ground, why not 10, 20, or 50 feet above it, as, according to the new theory, the same amount of rain exists at all elevations? It is no slight satisfaction to find that, on taking this view, I am supported by so great an authority as the late Sir John Herschel. Sir John, in his *Meteorology* (p. 104, sec. 109), says: "Still less can the effect (the decrease of rainfall with elevation) be due to a greater obliquity of fall at a higher than at a lower level, since the same quantity of rain must fall on the same horizontal surface after changing its obliquity as before."

Mr. Stow, in his letter in the last number of your Magazine, says:—"The new theory rests on an assumption that when the falling rain deviates from its original path the drops are not brought closer together." A most amazing assumption, indeed! The real fact is (and it admits of the readiest demonstration) that the greater the angle at which the rain falls, the nearer the drops approach each other. If it were not so, a tipped gauge would *not* collect more than a horizontal one. This brings me to another passage in Mr. Stow's letter, above referred to. He says: "It is impossible to deny that a horizontal gauge presents a smaller area of aperture to rain falling obliquely than to that which falls vertically." No doubt of it; but when the rain falls at an angle, the drops being closer to each other in proportion to the angle, cause the same amount of rain to fall on the smaller area as would fall on the larger area if the drops fell perpendicularly.

Yours truly, JOHN THRUSTANS, F.M.S.

Merridale, Wolverhampton, June 20th, 1871.

To the Editor of the Meteorological Magazine.

SIR,—Do not inclined and vertical gauges register an erroneous rainfall in consequence of their inclined and vertical position? and is not this a fact to be proved by mathematical reasoning? Let us suppose a 5-inch circular horizontal gauge placed at the same elevation with a similar gauge inclined at an angle of 45°: a shower of rain falls at an angle of 45°: as Mr. Du Port stated, in last month's Magazine, a cylinder of rain discharges its volume into the horizontal gauge (the base); during the same period the inclined gauge receives the volume of a cylinder of rain; now the diameter of the inclined gauge is *not* the diameter of the base of the cylinder, but the straight line at right angles to the axis, terminated by the superficies of the cylinder: therefore the base and volume of this cylinder can be proved to be much larger than those of the horizontal gauge, and consequently the inclined gauge registers a larger amount of rainfall than is due to a circle of the ground 5 inches in diameter. Must we not then reject as of no value the comparison of the returns of a similar horizontal and inclined gauge at any elevation?—Yours truly,

G. WARREN.

Merton Villa, Cambridge, June 23rd, 1871.

To the Editor of the Meteorological Magazine.

SIR,—A *tu quoque* is generally a feeble argument; however, I think it will help to clear the way towards the solution of our problem, if I attempt to show that the statement, which Mr. Stow tells us some might call an axiom, is not accurate. The basis of Mr. Stow's theory is that the rain-drops are not brought closer together as the falling rain deviates from the vertical. Now, surely we may consider the rain as falling in straight lines for an appreciable time, though a short one, say while it is falling through a foot. Now, the deviation from the vertical will be caused by the rain-drops being moved through some horizontal space by the motion of the air: it would only complicate matters to estimate this force, even if we could estimate it, and, for all practical purposes, we may suppose this horizontal translation of the rain-drop in a certain time to be that exactly due to the velocity of the wind, which, too, for a small time, we may consider uniform. Now, let anyone take three or four strings, each a foot long, and fasten one end of each to one of three or four equidistant points on a knitting needle, and the other end of each string to a corresponding point on another needle; lay the whole system on a table; pull the needles apart, so that the strings are at right angles to both needles; this will represent rain falling from one needle on to the other vertically: draw one needle aside, say through 3 or 4 inches, keeping all the strings tight, the strings will then represent the path of rain falling obliquely: it is manifest that the whole of the rain which fell directly from one needle to the other will also fall upon this other, whatever be the inclination of the strings to the needle, or, in other words, of the rain to the horizon. It is further manifest that, although the rain-drops in any horizontal stratum at any moment are not drawn nearer together, nevertheless the paths of the rain-drops are, since the distance between two parallel lines is the line perpendicular to both.

To put the matter briefly and on mathematical grounds: the fact, that all parallelograms upon equal bases and between the same parallels are equal in area, is inconsistent with Mr. Stow's theory, and further disposes of his question, on page 70, "why not for vertical, or, indeed, gauges at any angle?" Any person by drawing a diagram may satisfy himself of these two consequences.

The weakness which Mr. Stow thinks he has discovered in Dr. Burder's theory, as to the incidence at 90°, is really a crucial test of its accuracy: it is no more than the physical expression of the fact that the secant of an angle becomes infinite as the angle passes through 90°.

Dr. Burder's clear letter in the number for June ought to be sufficient to convince. I have only ventured to add my mite to the correspondence, because I think I have discovered a mathematical inconsistency in Mr. Stow's communication.

J. M. DU PORT.

Mattishall, Norfolk, July 3rd, 1871.

To the Editor of the Meteorological Magazine.

SIR,—In replying to the letters of Mr. Stow, and others, in your last number, I wish to confine myself strictly to the issue which my first letter was intended to raise. I do not, therefore, propose to enter at all into the question of what is the real cause of the decrease of rainfall with elevation, but simply to show that the cause assigned by Mr. Stow is founded on a misconception. The former question is one of a class that may legitimately admit of difference of opinion; the latter is one on which a very moderate amount of controversy ought, I think, to bring about an agreement.

Mr. Stow objects to my illustration, that it is "impossible," and that the exact thing supposed could not occur in nature. The same objection will apply to a diagram, or to any method by which the component parts of a problem are singled out for separate investigation. I cannot see the force of the objection, and will therefore ask your readers to draw for themselves a very simple diagram on the following plan. First, let a number of vertical lines be drawn at equal distances apart, say, 12 lines at distances of a quarter of an inch. At a certain level, let these lines be all deflected at an angle of 45°, preserving their parallelism. Next take a scale on which is marked off a length of just over 2 inches, and count the number of lines that are included within this space, holding the scale horizontally, at first across the vertical lines, and then across the diagonal lines. In each case it will be found that 9 may be included. Next count the number of diagonal lines that can be included within the same space when the scale is held at right angles to these diagonal lines. It will be found that the number is now increased to 12. Can anything further be required to show that the rain-drops, by falling obliquely, *are* "brought closer together," and that the rain *is* "altered in density," with respect to a receiving surface placed at right angles to the course of the drops? Yet Mr. Stow, in the first paragraph of his letter, seems clearly to state the reverse of this proposition, as the assumption on which his theory is founded.

Again, Mr. Stow, in his fifth paragraph, points out as a "weakness" in my argument, that it involves a sudden diminution in the amount collected from the entire quantity to nothing, when the angle of the falling rain reaches 90°. But if he will so far overcome his repugnance to the kind of illustration, as to follow out the matter with the aid of the diagram above described, only varying the angle, he will find that the result must be exactly that which he considers incredible. But, after all, is the result strange? So long as the rain falls at all, no amount of obliquity will diminish the quantity that falls, but to say that the angle is 90°, is to say that the rain no longer falls.

I will only add, with especial reference to Mr. Kearney's letter, that I cannot see what is gained in this discussion by the use of mathematical formulæ. They seem to me only to obscure the argument, and to render that complex which in itself is perfectly simple.

The real difficulty is so to isolate this particular question from its surroundings as to perceive its simplicity.

GEORGE F. BURDER, M.D.

Clifton, July 9, 1871.

SOLAR HALOS.

To the Editor of the Meteorological Magazine.

SIR,—My attention has been drawn to several communications which appeared in the May number of your Magazine, describing what are there called "Solar Halos." The unusual features in the sky were, by all the observers, uniformly noticed on Wednesday, April the 5th. It seems that though perpendicular bands of light revealed themselves strongly both above and below the sun, they were also and further accompanied by circular, or by horse-shoe-shaped halos, and these bands and halos were visible whilst the sun was still in full brilliancy above the horizon. These appearances differ considerably from a phenomenon which I had the opportunity of seeing on the preceding evening, namely, Tuesday, April the 4th. Mr. Heineken and myself had been out from the morning on Broad Down, about five miles north-east from Sidmouth, examining some tumuli, and towards evening we were returning westward, in full view of the setting sun. I wish to observe that, whilst the sun was above the horizon, nothing unusual attracted our attention. Coming to the brow of Salcombe Hill, a hill 500 feet high, that closes in the eastern side of the valley of the Sid, we descended the steep road at a slow pace, with the drag on the wheel. As soon as the sun's disc had disappeared behind the opposite hill, a column of yellow light stood perpendicularly over the sun's place. It was of the same diameter as the sun throughout its length, thus making its sides parallel. It rose to the height of from 12 to 15 degrees, gradually fading away to nothing at its upper part. As daylight diminished the column grew fainter, but it was discernible for 20 minutes. It continued perfectly steady, with its edges clear and persistent. There were no halos whatever. The sky was clear, or nearly so, with a moderately strong purple haze along the horizon. Remember, this occurred on Tuesday, the 4th: on the 5th, I again observed the sunset, but nothing unusual was visible from Sidmouth Within a day or two, I communicated these circumstances, together with a coloured sketch (similar to the one I enclose),* to Professor Airy, C.B., of the Royal Observatory, Greenwich. His answer was very satisfactory to me, but I have no authority to make quotations from his letter.

P. O. HUTCHINSON.

Sidmouth, May 16th, 1871.

THUNDERSTORM OF APRIL 29TH.

To the Editor of the Meteorological Magazine.

SIR,—A heavy storm of rain and hail, accompanied with lightning and thunder, passed over here on Saturday afternoon, April 29th.

* *See* Frontispiece.

The storm lasted about twenty to twenty-five minutes, during which 0·95 in. of rain fell. The register on the morning of the 30th gave 1·22 in., which is the greatest fall except one during the past eleven years. The road sides on the hills are washed away to the depth of 6 inches. Wind N.W., but calm.—Yours truly,

EDWARD ROBINSON.

Englefield, Reading, May 2nd, 1871.

THE WEATHER IN JUNE.

To the Editor of the Meteorological Magazine.

SIR,—On Saturday, 17th inst., about one o'clock p.m., a thunderstorm passed over the town, and for an hour we had a local deluge. The rain came down in torrents, flooding the streets and many houses. It is many years since we had such heavy rain; my rain gauge measured 0·66 in. in the hour.—Yours truly,

HENRY TUCKER.

Spring Cottage, Lyme Regis, June 21st, 1871.

To the Editor of the Meteorological Magazine.

SIR,—I send you a short account of the weather during the last few days, thinking it may be of interest. The thermometers are by Negretti and Zambra, on a thermometer stand facing north. The rain gauge is 5 inches in diameter, and 2 feet above ground.

1871. June.	Wind.	Temperature at 4 ft		Rain.	Remarks.
		Max.	Min.		
13...	S.E.	62·0	46·0	0·37	
14...	S.	68·0	57·0	0·73	Thunder in the night.
15...	S.	70·5	58·0	0·07	Distant thunder.
16...	S.S.W.	72·0	55·5	0·13	
17..	S.S.W.	65·5	54·0	0·24	Thick fog till 11 a.m.
18...	S.	67·0	51·5	0·11	
19...	S.W.	66·0	52·5	0·26	Thunder in the morning; thunderstorm from 7.45 to 9 p.m.
20...	W.	69·5	52·0	0·73	Thunder in the morning; violent thunderstorm from 1.50 to 5.45 p.m.
21...	W.	65·5	51·0	0·20	Distant thunder.
22...	E.N.E.	58·0	49·0	0·47	
23..	N.E.	58·8	49·0	0·05	

Total rain, 3·36 in. in 11 days.

The thunderstorm of the 20th was very severe. It first appeared in the N.W. about 1 p.m., and from 1.30 to 3.15 was very heavy to the north of us, the lightning being very bright and the thunder loud. After 3.15 till 4.20 p.m. the storm was right overhead, the forked lightning being exceedingly vivid and followed immediately by loud peals of thunder, there being seldom more than one or two seconds between the flash and the thunder. After 4.20 the thunder was farther off, and the last lightning was seen at 5.45. There was very little rain

till 4.20, but after that it rained steadily till 9 p.m. and at times in the night. Total rain at 9 a.m. next morning, 0·73 in.

Yours faithfully, EDWARD C. MORRELL.

Broughton Lodge, Banbury, June 24th.

To the Editor of the Meteorological Magazine.

SIR,—I really think that the cold of this season must be almost unprecedented In March we had 8 days on which the maximum temperature exceeded 55°, but 5 only in April, 13 in May, and in June hitherto only 8 out 26. There was not much wind in the latter half of March and in April and May, but June set in with successive northerly gales, the anemometer registering 900 miles in the 24 hours ending at 2 p.m. on the 3rd, and no less than 1246 miles in the 24 hours ending at 2 p.m. on the 7th, indicating an average velocity of 52 miles an hour—a speed not maintained for a whole day since February, 1870. During the gale the thermometer varied from 41° to 49°, and the cold was intense, making many persons unwell. Trees which were covered with green leaves previously, had nothing green about them after the gale, and those which were partially sheltered were made brown as in autumn. I believe this result is due less to the violence of the wind than to the salt spray with which the air was laden; at all events, the effect of the gale is much less perceptible a few miles from the sea.

Has Mr. Brumham no comfort in prospect for us? I thought he told us lately that a great equality of temperature during spring was a sign of an extreme summer, but I fear I am wrong. The mean of maxima and minima was in February 40°·3, March 44°·1, April 43°·5, May 47·°7, and with Glaisher's corrections these figures become 39°·9, 43°·1, 42°·0, 46°·0. Perhaps the extreme to follow is an extreme of cold, with skating instead of grouse shooting. Horrible thought!

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

Hawsker, June 26th.

P.S.—On Monday, June 19th, the weather was remarkable. Apparently it was fine over the sea all day. On the coast showers fell from 11 a.m. to 4 p.m.—amount, 0·07 in.—and inland there was intense blackness almost all day, and thunder was heard frequently in that direction. I only observed one flash of lightning.

EXTRAORDINARY MIRAGE IN THE FIRTH OF FORTH.

For some time past the atmospheric phenomena at the mouth of the Firth of Forth have been of a remarkably vivid and interesting character, and have attracted a great deal of attention. During the past week especially, scarcely a day has passed without exhibiting extraordinary optical illusions in connection with the surrounding scenery, both at sea and on shore. As an instance of the unusual nature of these phenomena, the whole of the Broxmouth policies, mansion-house, and plantations, were one day apparently removed out to sea. One of the finest displays of mirage, however, occurred on Saturday afternoon. The early part of the day had been warm, and there was the usual dull, deceptive haze extending about half-way across the Firth, rendering the Fife coast invisible. The only object on the Fife coast, indeed, which was brought within the range of the refraction was Balconie Castle on the "East Neuk," which appeared half-way up

the horizon, and in a line with the Isle of May. The most extraordinary illusions, however, were those presented by the May island, which, from a mere speck on the water, suddenly shot up in the form of a huge perpendicular wall, apparently 800 or 900 feet high, with a smooth and unbroken front to the sea. On the east side lay a long low range of rocks, apparently detached from the island at various points, and it was on these that the most fantastic exhibitions took place. Besides assuming the most diversified and fantastic shapes, the rocks were constantly changing their positions, now moving off, and again approaching each other. At one time, a beautiful columnar circle, the column seemingly from 20 to 30 feet high, appeared on the outermost rock. Presently the figure was changed to a clump of trees, whose green umbrageous foliage had a very vivid appearance. By and bye the clump of trees increased to a large plantation, which gradually approached the main portion of the island, until within 300 or 400 feet, when the intervening space was spanned by a beautiful arch. Another and another arch was afterwards formed in the same way, the spans being nearly of the same width, while the whole length of the island, from east to west, seemed as flat and smooth as the top of a table. At a later period the phenomena, which were constantly changing, showed huge jagged rifts and ravines in the face of the high wall, through which the light came and went as they opened and shut, while trees and towers, columns and arches, sprang up and disappeared as if by magic. It is a singular fact, that during the four hours the mirage lasted, the lighthouse, usually the most prominent object from the south side of the Firth, was wholly invisible. The last appearance which the island assumed was that of a thin blue line halfway up the horizon, with the lighthouse as a small pivot in the centre; and the extraordinary phantasmagoria were brought to a close about seven o'clock by a drenching rain, which fell for two hours.—*Scotsman.*

REVIEWS.

Introductory Text-Book of Meteorology. By ALEXANDER BUCHAN, M.A.; F.R.S.E., crown 8vo., 218 pages, 8 plates. Blackwood and Sons.

WE are rather surprised that Mr. Buchan has neither stated on the title page of this work, nor intimated in the preface, that it is to all intents and purposes a cheaper and revised edition of his excellent "*Handy Book of Meteorology.*" Some paragraphs on the more difficult branches of the science are omitted, as, for instance, all those referring to the polarization of the atmosphere; on the other hand, the author's investigations as to the prevalent winds in different parts of the earth's surface are utilized, as are also the recent observations of sea temperature, and some rainfall tables, whence we quote the following paragraph:—

"There is very great diversity in the rainfall of *Australia.* At Somerset, at the north-east point, the annual rainfall is 87 inches; Brisbane, 47 inches; Sydney, 49 inches; Melbourne, 28 inches; Adelaide, 20 inches; and Freemantle, 31 inches. At Deniliquin, on the Murray River, only 12 inches fall annually. The rainfall of this continent is extremely fluctuating from year to year. In *Tasmania* the annual amounts vary from 59 inches in King's Island, to 21 inches in Goose Island. At Hobart Town the average is 27 inches, which is probably the average of the open districts on the east side of the island; on the west much more rain falls. In *New Zealand* the differences are still greater. At Hokitika, in the west, 120 inches fall annually, and at Bealey, 118 inches; whereas, at Christ Church, on the opposite side of the island, the average is only 25 inches. At Southland the annual fall is 44 inches; Dunedin, 34 inches; Nelson, 58 inches; Wellington, 50 inches; Tranaki, 56 inches; Auckland, 49 inches, and Mongonui, 54 inches. In *South Africa* very great differences prevail, the annual amounts being 40 inches at Wynberg; 32 inches at Pietermaritzburg; 30 inches at Simon's Town; 27 inches at Somerset West; 23 inches at Cape

Town ; 19 inches at Alwali North ; 14 inches at Graff Reinet ; 12 inches at Worcester ; 10 inches at Concordia ; and 8 inches at Keerom, Namaqualand; and at all these places the annual rainfall is subject to great fluctuation. In the south of *South America* the annual amounts are 48 inches at Buenos Ayres ; 22 inches at Punta Arenas, near Cape Horn ; 109 inches at Valdivia, and 102 inches at Puerto Montt ; but at Santiago de Chili it is only 17 inches."

While upon the subject of rain, we may call Mr. Buchan's attention to an error of a single figure, transferred from his larger work to page 118 of the present, where he quotes the rainfall at the Stye as 38·9 inches in January 1831, it should be 1851.

The excellent Maps, which have been specially drawn for this work, represent the most recent data as to winds, pressure, and temperature, in a clear and intelligible manner.

Second Annual Report of the Bournemouth Meteorological Society. 8vo., 27 pp., 1870. Offer, Bournemouth.

Third Annual Report of the Bournemouth Meteorological Society. 8vo., 16 pp., 1871. Sydenham, Bournemouth.

WE are glad to find that this Society is continuing in the path of usefulness on which it entered. We do not, however, share the Secretary's satisfaction with the balance sheet ; he has the balance on the right side, *because* the Society have reduced the dimensions of their reports. Ordinarily, we are opponents of quantity, and advocates of quality, but in these reports the quality is such that we should gladly see the bulk of the first one again adopted. Possibly the Society might increase its members and its funds, by accepting non-residents as members, either on the same terms as residents, or on half terms.

When reviewing the first report (*Meteorological Magazine*, Vol. V., p. 11), we objected to the returns of the temperature of the sea, as far too high (the mean for July, 1868, was 70°·1); to this criticism, Mr. Newnham replied, on p. 120 of the same volume. Sea temperatures are not mentioned in the Second Report, but in the third the following remarks are made, and foot-note given :—

"The mean temperature of the sea for the six months, April to September inclusive, was 57°·7 as compared with 63°·3 [63°·5 ?] in 1868. In 1868, however, the air temperature was 2½ degrees warmer than in the corresponding period of last year. The highest reading was 68° against 72° in 1868, and the lowest registration 42½ as compared with 49°.*

We reprint the mean temperatures in part of 1870, adding those for the corresponding months of 1868, and the differences :—

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* The sea temperatures were taken by a "Six's thermometer," made expressly for the purpose by Casella, Hatton Garden. The instrument was fixed at the end of the pier, 4 ft. from the bottom of the sea, and about 4 ft. from its average surface. No continuous registrations were taken in 1869, but in 1868 the instrument then used was a standard "bucket" thermometer, and observations were taken but once daily, consequently the "mean" given in the report for 1870 [1869 ?] was the mean temperature at one hour of the day, which was probably some 3° in excess of the true mean.

	April.	May.	June.	July.	August.	Sept.	Mean for 6 Months.
1870 ...	46°·4	53°·1	59°·1	62°·8	64°·1	60°·5	57°·7
1868 ...	52 ·7	60 ·0	64 ·4	70 ·1	68 ·5	65 ·5	63 ·5
Excess in 1868 ...	6 ·3	6 ·9	5 ·3	7 ·3	4 ·4	5 ·0	5·8

We think that few persons can now deny that our objection was valid; we hope that the Society will resume these observations with every possible precaution, for the important element of sea temperature on the English coasts is, to our English discredit, almost unknown. It is otherwise in Scotland: let Bournemouth set the example, and we believe that other health resorts will follow suit. Bournemouth has taken the lead; it is free from the disturbing influences of any large outflow of fresh water, and in every respect has eminent facilities for maintaining a first position.

The importance which we attach to this subject has induced us to devote so much space to it, that we can at present simply recommend to the notice of our readers an able paper on "Lunar Influence on the Weather," by Mr. Newnham, which is only second in importance to sea temperature.

Quarterly Weather Report of the Meteorological Office. Part IV., October to December, 1869. 4to, 30 pages, 37 plates.

The original degree of accuracy is maintained, and the rate of publication so much accelerated that the arrears will soon be overtaken. Among the miscellaneous tables, at the end of this part, are two which will be especially useful and interesting to many of our readers, and which we therefore reprint.

Extremes of Pressure at Sea Level in 1869.

Observatory.	Maximum.	Date.	Minimum.	Date.	Range.
	in.		in.		in.
Valencia	30·605	Oct. 22, 10 a.m.	28·410	Jan. 28, 7 p.m.	2·195
Armagh	30·677	Dec. 6, 1 a.m.	28·437	,, 28, 11 p.m.	2·240
Glasgow	30·702	,, 6, 9 a.m.	28·340	Dec. 13, 8 p.m.	2·362
Aberdeen	30·686	Apl. 28, 1 p.m.	28·259	,, 13, 10 p.m.	2·427
Falmouth	30·580	Feb. 13, 6 p.m.	28·670	Sep. 11, 11 p.m.	1·910
Stonyhurst	30·666	Dec. 6, 11 a.m.	28·712	Jan. 29, 2 a.m.	1·954
Kew	30·600	,, 5, 11 p.m.	28·751	Sep. 12, 5 a.m.	1·849

Extremes of Temperature in Shade.

Observatory.	Maximum.	Date.	Minimum.	Date.	Range.
	deg.		deg.		deg.
Valencia	82·3	Aug. 27, 3 p.m.	27·7	Dec. 27, 11 p.m.	54·6
Armagh	78·1	July 17, 4 p.m.	20·7	,, 28, 6 a.m.	57·4
Glasgow	79·0	,, 17, 3 p.m.	13·0	,, 28, 7 a.m.	66·0
Aberdeen	78·3	Aug. 25, 2 p.m.	20·0	,, 2, 9 a.m.	58·3
Falmouth	78·4	July 18, 2 p.m.	26·0	,, 26, 11 p.m.	52·4
Stonyhurst	83·2	Aug. 28, 3 p.m.	14·3	,, 28, 9 a.m.	68·9
Kew	88·3	July 22, 2 p.m.	20·3	,, 29, 3 a.m.	68·0

JUNE, 1871.

Div.		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.	Date.	Min. Deg.	Date.	No. of Nights below 32°. In shade	On grass.
			inches	inches.	in.								
I.	ENGLAND.	Camden Town	3·49	+ ·44	·67	19	16	76·0	16	39·0	4	0	0
II.		Maidstone (Linton Park)	2·92	+ ·18	·47	23	17	81·0	15	38·0	6	0	...
,,		Selborne (The Wakes)	3·77	+ ·54	1·05	14	12	71·0	16	33·2	4	0	2
III.		Hitchen	2·43	— ·21	·58	17	20	73·0	16	36·0	4, 5	0	...
,,		Banbury	3·99	+ ·71	·85	20	16	72·2	16	35·5	5	0	...
IV.		Bury St. Edmunds (Culford)	3·30	+ ·72	1·08	17	18	78·0	15‡	34·0	5	0	4
V.		Bridport	2·04	— 1·20	·49	19	11	68·0	17	36·0	3	0	...
,,		Barnstaple	2·43	— 1·69	·50	18	15	75·2	1	38·0	5	0	...
,,		Bodmin	2·81	— 1·23	·90	18	14	70·0	28	40·0	5	0	0
VI.		Cirencester	3·00	— ·38	·65	13	10	...	...	...	...	...	...
,,		Shiffnal (Haughton Hall)	2·31	— ·80	·70	22	15	73·0	16	36·0	3	0	...
,,		Tenbury (Orleton)	3·45	— ·07	·94	22	18	72·7	16	34·0	5	0	1
VII.		Leicester (Wigston)	3·87	+ 1·10	2·00	16	16	77·0	16	35·0	24	0	...
,,		Boston	3·20	+ 1·01	·80	17	17	77·2	16	39·5	25	0	0
,,		Grimsby (Killingholme)	2·79	..	·75	14	15	72·0	16	40·0	25§	0	...
,,		Derby	4·16	+ 1·27	1·66	15	17	70·0	14	41·0	3, 5	0	...
VIII.		Manchester	2·66	— ·68	·52	15*	15	74·0	14	37·0	3	0	0
IX.		York	3·72	+ 1·62	1·39	15	14	70·0	16	40·0	4	0	0
,,		Skipton (Arncliffe)	2·77	— 1·33	·72	15	12	74·0	13	33·0	5	0	...
X.		North Shields	2·54	— ·20	·95	15	13	68·0	30	39·5	5	0	0
,,		Borrowdale (Seathwaite)	2·82	— 7·69	1·22	28	9	...	...	...	...	...	...
XI.	WALES.	Cardiff (Town Hall)	...	...	...	...	...	...	...	...	...	...	...
,,		Haverfordwest	1·50	— 2·15	·50	22	8	71·5	17	35·0	4	0	1
,,		Rhayader (Cefnfaes)	3·73	— ·25	·80	11	11	69·0	...	31·0	...	..	...
,,		Llandudno	2·27	— ·02	·86	15	8	74·4	14	39·4	5	0	...
XII.	SCOTLAND.	Dumfries	2·35	— ·55	·68	15	13	74·0	11	38·0	24	0	...
,,		Hawick (Silverbut Hall)	2·87	...	·81	15	12	...	...	...	...	...	...
XIV.		Ayr (Auchendrane House)	2·13	— 1·22	·48	15	14	75·0	10‖	32·0	9	0	2
XV.		Castle Toward	2·65	— ·84	·78	16	10	...	...	...	...	...	...
XVI.		Leven (Nookton)	2·32	+ ·08	·50	14	14	66·0	18‡	36·0	9	0	4
,,		Stirling (Deanston)	1·87	— 1·05	·46	15	13	71·5	19	35·3	3	0	1
,,		Logierait	2·18	...	·45	16	12	...	...	...	...	...	...
XVII.		Ballater	1·48	...	·40	14	7	68·5	17	31·0	24	1	...
,,		Aberdeen	1·23	...	·58	14	14	65·9	17	39·3	25	0	6
XVIII		Inverness (Culloden)	·92	...	·33	5	11	64·9	12	44·5	24	0	0
,,		Portree	1·33	— 3·45	·27	28	14	...	...	...	...	...	...
,,		Loch Broom	·72	...	·16	30	10	...	...	...	...	...	...
XIX.		Helmsdale	1·07	...	·27	14	15	...	...	...	...	...	...
,,		Sandwick	·33	— 1·21	·12	3	7	67·9	17	40·8	26	0	2
XX.	IRELAND.	Cork	4·22	...	·84	12	20	...	...	...	...	...	...
,,		Waterford	3·74	+ ·75	·50	22	22	71·0	21	45·0	3	0	...
,,		Killaloe	2·75	— ·88	·45	18	20	79·0	27	42·0	26	0	...
XXI.		Portarlington	2·33	— ·92	·45	20	18	71·0	16	39·0	·2	0	0
,,		Monkstown	2·28	— ·33	·54	20	16	...	...	...	...	...	...
XXII.		Galway	3·50	...	·40	13†	19	74·0	1	40·0	5, 7	0	...
,,		Bunninadden (Doo Castle)	3·65	...	·57	17	18	68·0	23	32·0	24	0	...
XXIII		Bawnboy (Owendoon)	...	...	..	...	...	...	...	...	...	...	...
,,		Waringstown	2·64	...	1·04	18	16	78·0	15	37·0	9	0	...
,,		Strabane (Leckpatrick)	2·54	..	·36	15‡	18	...	...	..	...	...	...

* And 22. † And 30. ‡ And 19. ‖ And 16, 17. § And 27.

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

METEOROLOGICAL NOTES ON JUNE.

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.

CAMDEN TOWN.—Early part of the month dull and cold; middle rather wet; finer towards the end. T and L frequent during the month; thunderstorms from noon to 3 p.m. on 19th, and from 1 to 4 p.m. on 20th.

LINTON PARK.—A dull, cold month, with some heavy rain; T S very near and for some hours on 20th, but the rain rather continuous than heavy; several foggy mornings, and cold almost approximating to frost. Winds mostly northerly and bar. high in the early part of the month, but changeable towards the middle. Wheat later coming into ear than in any season during twenty years, except 1860.

SELBORNE.—A cold, ungenial month; much hay spoiled in this neighbourhood by wet; during the whole of May and first five days of June, only ·205 in. of rain fell, the least I ever measured, except in September, 1865, in which month the same quantity fell. Potatoes cut by frost on the 4th; prevailing winds first and last ten days, N. and E. Frequent T S S; coachman and horse near Winchester killed during one, which occurred about half-past one o'clock on the 21st.

BANBURY.—Frequent thunderstorms with hail; unusually cold; max. temp. below 60° on eight days; Sunday, 4th, temp. at noon, 45°, and max. of the day 53° and 57° at 9 a.m. on 5th.

CULFORD.—On 1st, 3rd, 5th, and 26th, the grass quite crisp with frost; the wind from N. and E. on 24 days; the coldest June that I can remember.

HAUGHTON HALL, SHIFNAL.—A cold, ungenial month; prevailing winds, N., N.W., and N.E. Strange to say, mushrooms came up in numbers towards the end of the month, in spite of the cold; swedes and mangold wurzel did well after the rain of the 18th; fruit trees of all sorts much blighted, and infested with aphides, &c. The hawfinches breed here now, and make sad work with the peas. [*Errata last month*—"Oats" *for* "oaks," and "seringea" *for* "seringa."]

ORLETON.—A very cold, ungenial month; much cloud and but little sun, with frequent rough wind; temp. about 4° below the average; cold and dry till the 15th, much rain during the remainder of the month. T on 17th, 18th, 19th, 20th, 21st, and 25th, but no heavy storms here.

WIGSTON.—Mean temp. some degrees below that of which I have any record. A most extraordinary fall of rain on the night of the 14th and during the day of the 15th, measuring 2·75 in. in about 18 hours, more than a third of which fell in two hours in the afternoon of the 15th. A very violent T S on the 20th. Owing to the low temp., the grazing land has been starved.

BOSTON.—Weather dull and cold, with N.E. winds up to the 12th. Much rain, with electrical disturbance of atmosphere, from 14th to 24th. T S S on 15th, 16th, 19th, and 20th.

GRIMSBY.—Cold month, the early part especially so. Ther. in shade did not reach 60° until the 13th. Grass abundant; corn crops, on the whole, indifferent, with a prospect of a late harvest. The polar currents continued till the 28th. High tide in Humber on 6th. T S between 1 and 2 a.m. on 16th; T S with heavy hail on the Wolds on the 19th; T in W. and S. from 4.45 to 5.30 p.m. on 20th. Wild roses began to flower on 19th; wheat in ear on 21st.

DERBY.—The character of the month has been cold and wet, with a few exceptions, with nearly double the usual number of days of E. wind. Mowing has commenced, and the quantity of grass is said to be prodigious.

YORK.—Our rain gauge being small and shallow, the exceedingly violent rains of the 14th and 15th are believed to be imperfectly registered, owing to splashing out of the gauge. Gauges in other parts of this city, of different construction, registered considerably more during those days.

NORTH SHIELDS.—T on 17th, 18th, 19th, 28th, and T S on 30th.

WALES.

HAVERFORDWEST.—A cold ungenial June; prevailing wind, N.E.; vegetation backward, hay crop light, the R came too late to benefit it, and has seriously

interfered with the saving of the scanty crops; great blight of insects on fruit trees. General health good, hooping cough prevailing, small pox cases few and of a mild type.

CEFNFAES.—Month cold and ungenial, the last half especially so.

LLANDUDNO.—A splendid double rainbow on 18th. Hay cut on 5th.

SCOTLAND.

DUMFRIES.—First half droughty and cold, second showery and favourable for vegetation. On low ground potatoes injured by frost on 24th. At the close of the month crops looking well, but two or three weeks later than last year.

HAWICK.—Cold and changeable month, with easterly wind. TS on 19th.

AUCHENDRANE.—The frequency of polar winds has caused a great difference between this June and last. The mills, fisheries, &c., on the river have suffered greatly from want of water. The only TS was on the afternoon of the 20th, with N. wind and small rainfall.

CASTLE TOWARD.—A favourable month for the farm and garden; pasture plentiful and all other crops looking well; heavy TS on 19th and 20th; air much cooler since.

DEANSTON.—Till the 15th very chilly at night, but sunshine and warmth at times during the day, and very dry, only ·130 of rain to that date; TS on 19th and 20th, afterwards chilly night and morning; last week milder and some rain.

LOGIERAIT.—Generally low temperature, with easterly winds prevailing; T on 19th, T and H on 30th.

ABERDEEN.—Rainfall less than mean; winds light and mostly either N.W. or N.E. A cold dry month, day temperature especially low; frequent fogs from 9th to 17th; distant T on five days; much injury done by ground frost on 25th; min. on grass, 27°·4 in.

PORTREE.—Much frost during the month, which blackened the potatoes in exposed situations and young tender garden trees. For the past three months the drought has been unprecedented in this locality; the consequence is that all kinds of crops (except potatoes) are stunted.

LOCHBROOM.—The driest month we ever had; crops and hay are exceedingly short, as the last three months have been dry.

SANDWICK.—This June has been 2° colder than the mean of the previous 44 years, and the driest during that period; the only month that was drier was April, 1852, when there was only ·11 in. of rain. Both the coldness and the dryness were probably owing to the prevalence of northerly and easterly winds. A sun-pillar at sunset on 25th, continuing for 30 minutes.

IRELAND.

DOO CASTLE.—Two-thirds of the month wet. The oat crop, although improved by the rain of this month, will be short, as it fell out of season. T on 11th, 14th, and 16th. Ther. down to freezing point on 24th. None of the heat of summer as yet.

WARINGSTOWN.—Cold, the latter part wet; on the whole a most disagreeable month.

ICE AND SNOW IN JUNE.

To the Editor of the Meteorological Magazine.

SIR,—I see from Mr. Joyner's letter to you that snow fell at Harrow on the 4th; on the following morning my min. at 4 ft had sunk to 37°·7, on grass to 33°, and a thin coating of ice was observed on a pond at a farm close here. So we have both ice and snow in the same 24 hours, within a few miles of London, on a June day.

Yours very truly, FRANCIS NUNES.

Heathfield Lodge, Chislehurst, June 20th, 1871.

NOTE.—In spite of an extra four pages given this month, several reviews and some important articles have to stand over.

SYMONS'S

MONTHLY

METEOROLOGICAL MAGAZINE.

LXVII.] AUGUST, 1871. [PRICE FOURPENCE, or 5s. per ann. post free

THE BRITISH ASSOCIATION AT EDINBURGH.

THE meeting now closing has been in many respects a success, not marked by any startling novelties or the enunciation of any striking meteorological discoveries, but as we hope presently to show, well attended by meteorologists, several of whom had a good account to render of their labours during the past year.

The following is probably an incomplete list of meteorological observers present at the meeting, but it is not easy to render it perfect—

Adams, Prof. J. C., F.R.S....Cambridge.
Ainsworth, T. .....Whitehaven
Backhouse, T. W..... Sunderland.
Ballot, Dr. Buys .....Utrecht.
Bateman, J. F., F.R.S. ...London.
Belcher, Admiral Sir E. ... ,,
Birt, W. R., F.R.A.S. ...Walthamstow
Brooke, C., F.R.S. .....London.
Brown, R. C., jun. ....Carlow.
Buchan. A., F.R.S.E.....Edinburgh.
Colding, Dr. A. .....Copenhagen.
Dowson, E. T. .....Beccles.
Elliot, Sir Walter, K.S.T....Hawick.
Everett, Prof. J. D..... Belfast.
Glaisher, J., F.R.S. ... . Blackheath
Grant, Prof., F.R.S. ..... Glasgow.
Healey, G. .....Windermere.
Herschel, Prof. A.S. .....Durham.
Home, D., Milne.....Milne Graden.
Howden, J. C., M.D. .....Montrose.
Hudson, H., M.D. .. ..Cork.
Janssen, M. J. .....Paris.
Mackeson, H. B., F.G.S., Hythe.
Moffat, T., M.D., F.G.S., Hawarden.
Muirhead, H., M.D., ...Cambuslang.
Pengelly, W., F.R.S. .....Torquay
Redford, Rev. F., M.A. ...Silloth.
Scott, R. H., F.R.S. .....London.
Smelt, Rev., M.A. .....Cheltenham.
Smith, Rev. H. W. .....Kirknewton.
Smyth, J., jun., M.A. ...Banbridge.
Smyth, Prof. C. Piazzi, F.R.S. Edinburgh
Stevenson, T., C.E. ..... ,,
Stewart Balfour, LL.D., F.R.S., Manchtr.
Stirling, J. ... .Kippenross
Symons, G. J. .....London.
Talmage, C. G.....Leyton.
Tomlinson, C., F.R.S. ...London.
Treutler, Dr. .....Kew.
Vivian, E. ..... Torquay.
Whipple, G.M. .....Kew.
Wilson, J.M., M.A.....Rugby.

The first communication of a meteorological nature was the report of the Kew Committee—probably the last, or the last but one, which will be addressed to the British Association, inasmuch as the control of the observatory is now vested in the Royal Society, and its maintenance provided for by the munificent donation by Mr. J. P. Gassiot, F.R.S., of the sum of £10,000. On a future occasion it may be our duty to consider the progress effected by those who are recipients of the large sums now available for meteorological research; for the present we pass on to give a few extracts from the report—

"*Meteorological work.*—The meteorological work of the Observatory continues in the charge of Mr. Baker.

"Since the Liverpool meeting, 113 barometers (including 17 aneroids) have been verified, and 2 rejected; 1320 thermometers and 215 hydrometers have likewise been verified.

"Two standard thermometers have been constructed for Owens College, Manchester, one for the Rugby School, one each for Profs. Harkness and Eastmann, of the Washington Observatory, four for Dr. Draper, of the New York Central Park Observatory, one for Major Norton, of the Chief Signal Office, Washington, one for Mr. G. J. Symons, and three for the Meteorological Committee.

"Three thermograph thermometers have been examined for Mr. Chambers, of the Colaba Observatory, and three for the Meteorological Committee.

"Two standard barometers have been purchased from Adie, and tested at Kew, one of which has been forwarded to the Chief Signal Office, Washington, and the other to Prof. Jack, of Fredricton, New Brunswick.

"Tubes for the construction of a Welsh's standard barometer on the Kew pattern, together with the necessary metal mountings, and a cathetometer, have been made under the superintendence of the Committee for the Chief Signal Office, Washington.

"The Committee have likewise superintended the purchase of meteorological instruments for Owens College, Manchester, and for the Observatory attached to the University of Fredricton, New Brunswick.

"The Kew Standard Thermometer (M. S. A.), divided arbitrarily by the late Mr. Welsh, and employed for many years past as the standard of reference in the testing of thermometers, was accidentally broken on the 3rd of January. Since then a Kew Standard, of the ordinary construction, made in 1866, and which had been compared on several occasions with M. S. A., has been used to replace it.

"Copies of some of the meteorological observations made at Kew during the years 1869 and 1870, have been supplied to the institution of Mining Engineers at Newcastle-upon-Tyne, and the Editor of Whitaker's Almanack, the cost of the extraction being paid by the applicants in both instances.

"A set of self-recording meteorological instruments, the property of the Meteorological Committee, have been erected in the Verification-house, and are now undergoing examination.

"Observations have been made with two of Hodgkinson's Actinometers, the property of the Royal Society, in order to compare them with the actinometers deposited at the Observatory, for reference, before forwarding them to India.

"A series of comparative observations was commenced in April, 1870, of two anemometers erected in the grounds attached to the Observatory, in order to compare the indications of a large and small instrument; but as a discussion of the result showed them to have been greatly affected by the influence of the neighbouring buildings, the instruments were dismounted in January last and re-erected in an open part of the park, at a distance from the Observatory. Three months' observations were made in this position, and as these proved satisfactory, the instruments have been dismounted. The cost of this experiment has been defrayed by the Meteorological Committee. Owing to his duties in Manchester, and to a railway accident, Dr. Stewart has not been able during the last year to devote much time to the Observatory. During his absence the most pressing duties were discharged by Mr. Whipple in an efficient manner.

Dr. CARPENTER, F.R.S., read a paper on the "Thermo-Dynamics of the General Oceanic Circulation"—

Before reading the paper, he mentioned that he had that morning received a letter from the First Lord of the Admiralty, intimating that it had been agreed that, on receiving a formal application from the Royal Society, the Board would be disposed to consider favourably his request for the fitting out of an expedition for deep sea exploration. The paper commenced by laying it down as a rule that the bed of the ocean below 2000 fathoms seldom attained a higher temperature than 32°. Where soundings had been made to the south-west of the Faroe Islands the temperature at that depth was 29°. This could not be attributed to depth

per se, for in the Mediterranean, which must be considered as an inland lake, the temperature at 2000 fathoms was 54°. In the Mediterranean, also, the fall in the temperature took place almost entirely in the first 50 fathoms, while below 200 fathoms, and down to the greatest depths, it remained exactly the same. Out in the Atlantic, on the other hand, and in the same latitude, there was a gradual and regular decrease in the temperature, after getting below the stratum warmed by the surface heat, down to the depth of 800 fathoms. Between 800 and 1000 fathoms there was a sudden fall in temperature of no less than 9°, while below the latter depth scarcely any difference was perceptible. This cold layer Dr. Carpenter attributed to the water chilled in the Polar areas sinking to the bottom by reason of its greater density, and from the same cause flowing southward and northward towards the Equator, while, at the same time, the surface water at the Equator was drawn towards the Poles to supply its place. There was thus at the same time an under-current of cold water flowing towards the Equator, and a surface current of warm water flowing towards the Poles. That the space occupied by the chilled water withdrawn from the surface could not to any extent be supplied vertically—*i. e.*, by lower strata rising from the bottom—he sought to show by the greater ease with which, in a large open area, it could flow in horizontally; and the configuration of the land explained how these surface currents were so much more observable in the North than in the South Atlantic. With regard to the Pacific the case was different, that ocean being almost cut off from the northern polar basin at Behring's Straits, and very little had as yet been ascertained regarding the Pacific currents. After branching out into its fan-like form, the northern half of the Gulf Stream could only be traced for a short distance north of Newfoundland, where its depth is not more than 50 fathoms. How came it, then, that near the Faroe Islands the temperature of the lower strata was only 5° lower than off the coast of Portugal, and the difference between the surface temperatures 16°? He explained it by the existence of a north-easterly stream of warm water flowing from the tropics independently of the Gulf Stream, the current of which, it had been agreed, was propelled by the prevailing trade winds. Dr. Carpenter explained his reasons for differing from Professor Wyville Thomson, who was associated with him in his recent explorations, and whose hypothesis was that the warmer water was supplied by bottom draught, and he closed by reading a letter from Sir John Herschell to himself, written shortly before his death, in which he recognised the existence of surface currents flowing horizontally to supply the place of colder water, as well as of those produced by the wind.

Sir W. THOMSON concurred generally with the conclusions come to by Dr. Carpenter. He pointed out, however, a case, where the supply of water would naturally be vertical rather than horizontal, viz., that of a closed channel or fiord, in which the water heaped up at the head by a surface current propelled by the wind, would form the head waters of an under current running in an opposite direction. These investigations of the deep sea and currents were of the greatest importance to navigation and in the laying of telegraph cables.

The discussion was continued by Professor STOKES, Professor FOSTER, and others, who in general coincided with the views expressed by Dr. Carpenter.

With reference to the influence of the temperature of the ocean currents on the working of telegraphic cables, Sir W. THOMSON mentioned that he had been informed by Captain Sherard Osborne that in laying a cable recently in the Eastern seas, it was found that where it was submerged in shallow water, and therefore in a high temperature, the transmitting power was greatly weakened; and where it crossed a deep portion of the ocean bed, the power was proportionately increased. He mentioned also, as an illustration of the existence of an under current flowing southward in the North Atlantic, that in laying one of the Atlantic cables, a buoy, with a long tail of rope attached, broke loose, and some time after it was found 10° farther south, in spite of the surface current of the Gulf Stream, the hypothesis being that it had been carried there by the cold current, into which the lower portion of the rope was dipped.

M. JANNSEN then read a paper entitled "Observations Physiques en Ballon," which, although long, and delivered with great volubility,

added very little to our previous knowledge of the phenomena of the higher regions of the atmosphere. Most of the observations had been made in balloons the property of M. Godard.

Report of the Rainfall Committee for the Year 1870-71,

Read by the Secretary, Mr. G. J. Symons.

"Your Committee have much pleasure in reporting that the organization under their supervision is believed to be in a generally efficient state. With a staff of observers numbering nearly two thousand, spread over the whole extent of the British Isles, there can, however, be no question that to ensure perfect efficiency and uniformity of observation, a systematic inspection of stations is absolutely necessary. In a paper read before the Society of Arts in 1858, Mr. Bailey Denton appears to have considered that there should be one inspector to about each 200 stations. At that rate we ought to have ten. The Meteorological Committee of the Royal Society also make it a rule to have all their stations inspected each year. On the most moderate computation it is indisputable that at least one inspector of stations is required, the whole of whose time should be devoted to travelling.

"Ever since their appointment, your Committee have felt and acted upon this conviction, but want of funds has prevented them from employing a regular inspector, and obliged them to rely solely upon the unpaid services of their secretary. Even under these adverse conditions, considerable progress had been made with the work, and upwards of 400 gauges had been visited and examined previous to the Liverpool meeting. At that meeting, however, the Association only granted half the sum for which we asked, and we have consequently (most reluctantly) been obliged to stop this important and useful work.

"As an interim measure, and with a view to ascertaining in what districts inspection is most requisite, it has been suggested that a schedule of questions as to the position of their rain gauges should be sent to every observer. The committee unanimously approved of the suggestion, and annex copy of the circular and schedule they are about to issue.

"Another branch of investigation which has been arrested by the same cause, is the relative amount of rain falling in different months, or as we usually have termed it, the 'monthly per-centage of mean annual rainfall.' Several articles upon the subject have appeared in our previous reports, and last year we pointed out that the observations for the decade 1860-69 offered data of completeness unparalleled either in this or any other country, the result of which we had hoped to submit to the present meeting. Excepting in our own reports, we are not aware that the seasonal distribution of rain in this country has received any attention, while on the Continent it has at all times been looked upon as almost equally important with the gross amount.

"Although several short and interrupted sets of observations have

been made in northern Derbyshire, the rainfall of that hilly district has not hitherto been examined with the thoroughness which its importance deserves. We have in previous reports urged the desirability of several additional stations being established, and as no one else undertook the work, our secretary did so, and by the assistance of the observer at Buxton, and Mr. Hazlewood, of Castleton, was enabled to commence several sets of rainfall observations in the district. Some others are still required, which, if our funds permit, we intent to add.

"*Pit gauges.*—In our last report we drew attention to the fact that a gauge of which the orifice was horizontal, level with the ground, but in a small pit or excavation, had at Calne collected about 5 per cent. more than one of which the receiving surface was one foot above the ground. Whence it followed that as a great many rain gauges (the majority in fact) are placed with their apertures a foot above the surface, the records of all these gauges were below what they would have been if placed in a pit as just described. We gave some reasons which appeared to us to prevent the general use of pit gauges, and added the following concluding remark :—'This result appears so startling, that further experiments will be conducted on the subject.' The funds at our disposal have not allowed us to do so, but fortunately the Rev. F. W. Stow, M.A., has tried one pair of gauges mounted in this manner at Hawsker, on the Yorkshire coast, a few miles south of Whitby. The following are the results during 1870 :—

Experiments with Pit Gauges.

	Hawsker, 1870.			Brit. Asso. Report, 1869-70	
Months.	5 in. gauge at 1 foot.	5 in. gauge in pit.	Ratio.	Calne, 1866-7. Mean ratio.	Difference.
January	1·610	1·770	110	113	— 3
February.....	1·995	2·300	115	109	+ 6
March	1·052	1·293	123	107	+16
April	·370	·390	105	105	0
May.....	...	...	...	...	...
June	2·650	2·705	102	102	0
July.....	·920	·977	106	103	+ 3
August	1·887	1·908	101	103	— 2
September ...	·845	·934	110	103	+ 7
October	5·000	5·053	101	102	— 1
November ...	3·043	3·234	106	106	0
December ...	5·230	6·420	123	108	+15
Totals	24·602	26·984	.....	.....	.....
Means	.....	.....	109·3	105·5	+3·8

"Of course it was not to be expected that the results of a single year should agree exactly, with the mean of two other years, still less when the size of gauge used was different, and the locality so opposite as the inland district of Calne, and the rock-bound Yorkshire coast. We therefore look upon it as satisfactory that in only four months out

of eleven do the ratios at Calne and Hawsker differ more than three per cent. In April, June and November they are identical. The Calne results are thus strongly confirmed, and it may be considered as certain, that pit gauges always exceed those at one foot, although the precise amount of excess remains to be determined.

"In our last report we expressed the hope that we should this year be able to state the result of the discussion of all the rainfall registers which were absolutely continuous from January 1st, 1860, to December 31st, 1869. We have the pleasure of doing so in two respects, viz., (1) with reference to their bearing on the question of the existence or otherwise of secular variation of rainfall in the British Isles, and (2) data indicative of the distribution of rain over the country.

"The secular variation of rainfall, or the relative dryness and wetness of different years, and groups of years, is one of the most important and difficult branches of rainfall work. It has been treated in our reports for 1865, and very fully in that for 1866. In the latter, we gave the calculations in detail from which the values from 1726 to 1865 shown on the accompanying diagram were obtained. Referring to that report for full explanation, we have only now to mention that the subsequent years, 1866 to 1869, have been computed in the same manner, and added to the diagram. We may also remark that various observations collected since its publication have confirmed the general accuracy of the curve quite as much as could have been anticipated. On the present occasion we do not intend to discuss the relative rainfall of different years, but the relation of the fall during the ten years 1860-69, to previous decades. For this purpose we have grouped the yearly values in decennial periods, similar to those adopted in our 1867 report.

"Having previously pointed out the peculiarities of the earlier portion of the curve, it is only necessary on the present occcasion to call attention to the last forty years, whence it will be seen that according to this mode of investigation (which is principally based on English returns,) three out of the four decades had a rainfall nearly identical, and the other (1850-59) considerably below them, the deficiency being nearly 7 per cent.

"This result is based on a combination of records, as fully explained in our 1866 report. We proceed to examine how far it is corroborated by individual stations, but are at once confronted by the paucity of stations of which perfectly continuous records for even half a century exist. We therefore confine ourselves to the forty years from 1830 to 1869, for which period we have twelve perfect records at widely separated stations. The mean fall in each decade and in the whole period, and the ratio of each decade to the whole period at each station are given in tables, and laid down on accompanying maps.

"From careful examination of these tables, it appears that the amount of rain which fell in the ten years 1830-39, was very similar to that which fell in the ten following years, the difference being a decrease, but scarcely one per cent. The investigation in our 1866 report shows an increase of 1·2 per cent., and examination of returns ceasing in

1850, and therefore not quoted in either report, show several cases of absolute identity.

"With one investigation leading to a decrease of 1 per cent., another to an increase of the same amount, and a third to identity, we are led to the conclusion that the two decades may be considered to show similar results. This is a much more important fact than it at first appears, and for this reason. While there are only about a dozen registers complete for the four decades, there are 38 which are complete for the last three decades. Now that we have found the relation between the first two decades, the returns for the thirty years are rendered almost as instructive as those for forty years.

"We have therefore compiled another table which differs from the former only in its being for thirty years instead of forty, and in giving observations from thirty-eight stations instead of twelve. The relative rainfall of the three decennial periods therein given, viz., 1840-49, 1850-59, and 1860-69, is shown on the accompanying map by the generally somewhat V shaped curves. We say generally, because at 26 stations out of 38 (2 out of 3), that is more or less acutely the form taken by the curve. Whence of course it will be seen at once that the rainfall of the second decade (1850-59) was less than either that which preceded or followed it. Now if we refer to the curve given by the calculations made in 1865, we shall find an almost identical depression, which strikingly proves the trustworthiness of the method then adopted.

From the above table and diagram the remarkable similarity of the results obtained by the two dissimilar modes of investigation is rendered so obvious, that it is unnecessary to dwell further upon it. We therefore proceed to the second part of our investigation, namely, to consider the distribution of the rainfall of the last decade, during which we have nearly four hundred perfect sets of observations. As each set of observations comprises more than a thousand entries, and the following table contains the result of nearly half a million observations, it is probable that it contains some slight per-centage of errors, but we have no suspicion of the existence of any which appreciably affect the results.

"Before accepting the decennial averages, 1860-69, as data indicative of the distribution of rain over the country, we wish to offer a few prefatory remarks. The difference between the amount collected by any two rain gauges depends on at least four separate and distinct conditions, three of which must be ascertained and corrected before the fourth can be accurately determined.

"The conditions are—(1) Length of series of observations; (2) Correction for secular change; (3) Height of gauges above ground.

(1) Even if there were no other evidence in existence than the large diagram of the fluctuation of rainfall already referred to, we feel that it would sufficiently prove the impossibility of determining accurately the rainfall at any place except by observations continued over a long series of years at that place, or by differentiation from some proximate long continued series,

(2) It does not follow that simultaneous observations even for ten years, giving for example a mean difference between two stations of 5 inches, prove that the rainfall at the one station is greater than the other by that amount—although, if they are not very distant the one from the other, it would probably be a safe assumption. Proof, however, of the existence of risk in the matter is afforded by the fact that although there is great general similarity in the V shaped curves on the map, there are hardly two which are strictly identical.

(3) Before mean results can be given with any pretensions to accuracy and finality, they must be corrected for the elevation of the rain gauge above the ground.

"The above remarks sufficiently show that the mere average of the fall of rain measured during ten or more years does not necessarily give the true mean rainfall at that place.

"Let us take as an example the highest amount recorded in the table and on the map—Seathwaite—which had during the ten years, 1860-69, an average of 154 inches. Many persons would say at once that that was therefore the mean rainfall at that station. It is, however, nothing like it. From the abstract of Table III., it will be seen that the rainfall over England generally during those ten years was 1·5 per cent. above the average; upon which evidence we are bound to reduce the observed mean in that proportion, and then the average becomes 152 in. Even this, however, is not correct, for we pointed out in condition (2), that the same years or groups of years are not similarly wet in all parts of the country. Referring, therefore, to Table IV, we find that at the nearest station to Seathwaite, Kendal, the decade in question was 7 per cent. above the 30 year mean; hence, on the supposition that the Kendal values are applicable to this station, we have to reduce 154 inches by 7 per cent. instead of 1·5 per cent., and hence the probable mean comes out 141·8 inches.

"Now most fortunately we can test the accuracy of this calculation in three ways:—

(1) The mean fall at Seathwaite in the previous decade, 1850-9, was 126·98; from the Kendal observations the fall in that decade was 10 per cent. less than the mean, therefore ($\frac{126·98}{0·90} = 141·09$) we find the probable mean comes out 141·1 from this decade, and 141·8 from that of 1860-69. They thus agree within less than an inch, or one-half per cent.

(2) The fall at Seathwaite has now been continuously observed for 26 years, viz., from 1845 to 1870 inclusive; the mean of the whole 26 years' observations is 140·03.

(3) This value, corrected according to the table in our 1866 report, becomes 141·44, agreeing *exactly* with that indicated by the decades 1850-59, and 1860-69.

"This example proves three points, (1) the great degree of accuracy which is attainable by proper methods; (2) the care requisite to secure it; (3) the serious errors inseparable from the use of mere arithmetical averages without reference to secular changes.

These observations must of course be taken as general results, and

not be construed as having any bearing on the relative rainfall even of proximate stations, the amount of which will vary considerably, according to local circumstances.

"Hence it will be seen that the probable average at Seathwaite is 141 instead of 154 in. as shown on the map, or 7 per cent. less. A similar but generally less correction may be required for other stations. The figures must not therefore be considered as showing the probadle mean fall at the several stations, but only as approximations generally pretty close. The data in our possession, if corrected in accordance with the method explained, would afford more accurate results, but the investigation is altogether beyond our present resources.

"Large tracts of Ireland and even of Scotland are left blank in the present map for want of observers. Much has recently been done to remedy these deficiencies, but there are still many localities where observations are deficient; we shall gladly receive any offers of assistance from those who have residences or property in those parts, and our Secretary will readily advise them as to instruments.

THE DECREASE OF RAINFALL WITH ELEVATION.

To the Editor of the Meteorological Magazine.

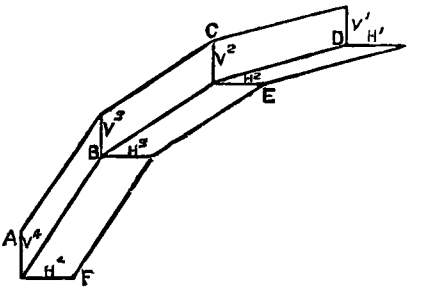
SIR,—I am surprised to find how easily the question is settled. Knitting needles, foot rules, strings, and a few parallelograms, as a mathematical sauce, are the potent weapons of common sense; and just as I was expecting to hear that the complicated problem admitted of no solution at all, owing to the want of facts to go upon, I find that neither facts nor mathematics are necessary, and that all is perfectly simple and obvious. I certainly am constrained to ask, Have not these gentlemen overlooked the difficulties of the problem?

One most important condition has been ignored by all of them—I mean the inequality of rain-drops. I don't suppose any two are exactly alike. If they were all equal, no doubt they would pursue similar paths. But they are unequal: they are differently affected by the resistance of the air, and therefore fall with different velocities, and are deflected by wind to a different extent. No doubt, also, they increase in size as they fall by coalescence. I really think that it is not too much to say, that the great irregularities thus caused render both knitting needles and parallelograms altogether inapplicable to the case.

But of one thing I am sure, that, if these diagrams are applicable to the case of horizontal gauges, they will do just as well for vertical gauges if turned on one side, as hard-hearted masters do with the figures of Euclid to puzzle boys. It certainly strikes me as a somewhat revolutionary doctrine of Mr. Du Port's (if I understand him at all), that parallelograms on equal bases and between the same parallels are *not* equal, if the bases are vertical instead of horizontal. Yet what else can he mean by saying that the properties of a parallelogram dispose of my question, "Why not for vertical, or gauges at any angle"?

I never heard that the properties of a parallelogram would tumble out of it if turned upside down; but I am open to conviction, and if convinced, I promise in future to label my diagrams, "With care, this side up."

It seems, then, that you cannot deny that the angle of rainfall influences the amount caught in a horizontal gauge, and yet think that it stands to reason that it must influence the amount caught in a vertical gauge. To make this perfectly clear, look at this diagram,



where if H_1, H_2, H_3, H_4 are equal, V_1, V_2, V_3, V_4 are not less so. It must influence both or neither. And those who say, "Neither," must find a cause to account for an increase in vertical gauges as well as a decrease in horizontal ones, or else separate and opposite causes, one acting only on vertical, and another only on horizontal gauges.

But I wish to point out to the upholders of the old theory, that if they are ever so little wrong, angle will affect the amount caught. If, in practice, the rain-drops quit ever so little the path which these gentlemen have, without the slightest basis either of fact, or even of thorough theory, mapped out for them, if by any chance they do not separate as they fall quite as much as they ought to do, what is the consequence? Why, a decrease with elevation in horizontal and an increase in vertical gauges. It is quite a mistake to suppose that I have ever maintained the *exact* truth of the much-abused assumption or "axiom." I said that the calculations were made on that assumption: but if it is only roughly true, the calculations will still be approximately correct, and obliquity will still be the cause of decrease and increase, though in that case the decrease and increase will be somewhat irregular, and the amount calculated for a gauge at right angles to the rain will not be the same at all heights. This, I may say, pretty accurately represents the actual facts furnished by my experiments, so far as they are worked out. And I am sure from the very fair and temperate letters of Dr. Burder and Mr. Du Port, that they will agree with me that any clear result of experiments, when fairly ascertained, ought to outweigh any pre-existing theory unfounded upon experiment, even when adopted, long previous to experiment, by so great a man as Sir J. Herschel.

I see that no one has taken up my challenge to explain the results of my "Position Series," on the supposition of the angle of fall not affecting horizontal gauges.

But I had almost forgotten what Mr. Du Port calls a crucial test of the correctness of Dr. Burder's theory. I always like to hear of a crucial test. Well, here it is. The secant of 90° is infinity and the cosine of course nothing. Very good. I haven't the slightest wish to quarrel with infinity or nothing. Therefore the gauge catches nothing. Excellent! Then, after all, the amount which a gauge catches is the "physical expression of a fact" regarding the secant or cosine of an angle. I am delighted to hear it. It is exactly what I have said myself. Now, tell me, does the cosine or secant remain the same from 0° to 89°, and make a sudden rush into annihilation or infinity at the moment 90° is reached? Unfortunately it does not; neither, as I maintain, does the amount which a gauge catches.

I am, Sir, your obedient servant,

FENWICK W. STOW.

Hawsker, July 19th, 1871.

To the Editor of the Meteorological Magazine.

SIR,—With your permission I venture to make a few remarks on the above subject:—

To prove the truth of the theory, that the register of a smaller amount of rainfall by a horizontal gauge, at an elevation, than by a similar gauge on the ground, is the effect produced by the greater strength of wind at the elevation; that eddies around the gauge blow away a portion of rainfall (see *Meteorological Magazine*, No. 65, page 72), I conceive that we want the best plan of so placing at an elevation a horizontal gauge, that it shall be shielded from the wind, and at the same time catch all the rain. There is no doubt but that the ingenuity of those interested in the result will soon obtain this desideratum.

Have we not found the above-mentioned theory supported by the close agreement of the returns of two gauges tipped at 45°, at the elevations of 6 and 30 feet respectively? May it not be that by reason of the wind driving more perpendicularly into the mouth of a tipped gauge, we get rid of the disturbing eddies?—Yours truly,

G. WARREN.

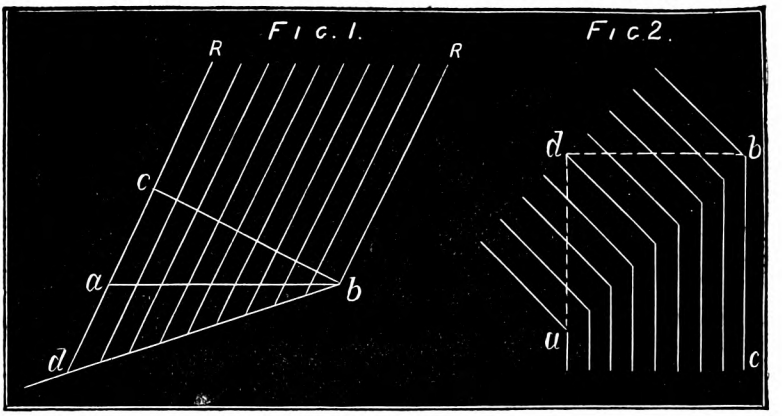
Merton Villa, Cambridge, July 21st, 1871.

To the Editor of the Meteorological Magazien.

SIR,—The correspondence which has been published in the *Meteorological Magazine* respecting the decrease of the rainfall with elevation, calls for a few remarks.

Dr. Burder, in his letter dated April 25th, 1871, supposes a cloud discharging rain uniformly from a square mile of its lower surface, and argues thereon not altogether correctly, in my opinion. If the rain fall *vertically*, the ground watered will be a square mile in extent, but only provided that it be *level*; it will actually be greater than a square mile if it be uneven. If the drops become *suddenly deflected* by a current of air to an angle of 45°, and maintain that direction until they reach the earth, the space of ground watered will be less than,

equal to, or greater than, a square mile, according as the ground slopes, so that the rain strikes it at an angle greater than, equal to, or less than 45°. Fig. 1 illustrates this, R R the direction of the shower,



here drawn at an angle of 22° from the vertical; *b c* rising, *a b* level, *b d* sloping ground; and it is evident that *b c* is less than *b a* and much less than *b d*; also that *b c* is least when the rain strikes it at right angles. Therefore, in order that a rain gauge shall fairly measure the amount of rain deposited on the ground surrounding it, the inclination of its aperture should be parallel with the slope of the ground. But if it be required to ascertain the maximum possible amount of rain that can be collected by a given aperture, that aperture must be kept facing the showers, and this could only be achieved by a rotating tilting gauge—an instrument which is difficult to construct so as to work satisfactorily.

While vapour exists in the form of cloud it is borne along by the air current in a horizontal direction, or nearly so. When condensation occurs, the atoms have an initial horizontal motion, and come under the influence of the wind, a variable force, and of gravitation, a uniformly accelerating force, and the resistance of the air to the descent has also an effect. Under these circumstances there is no more reason to assume that the deflection of the rain takes place in a level plane than in an oblique plane. If, as Dr. Burder supposes, in his letter dated July, 9th, 1871, at a certain *level*, the direction of all the rain-drops be deflected, preserving their parallelism, the drops are brought closer together with respect to a surface placed at right angles to the course of the drops, and a *horizontal* gauge might be expected to collect the same quantity, whether placed in the oblique or the vertical course of the shower. This is a very pretty illustration, but it is deceptive and inconclusive, for we have only to vary the supposition to get a different result. Suppose, instead of the direction of the rain-drops being changed at a *level*, it be changed at an oblique surface, as in Fig. 2, where the change of direction is supposed to take place along *a b*. A horizontal gauge would collect very different quantities in the different courses of the shower. At *d b* it would catch five drops to nine at *a c*.

The force of the wind being generally less near the earth's surface than in the cloud region, while the force of gravity increases as the earth is approached, it seems evident that the drops must have a more oblique path in the higher than in the lower regions of their flight. Nevertheless, this mode of illustration appears to me unsatisfactory, and beset with difficulties.

One point, however, seems, from amid all this discussion, to become clear, which is, that if we wish to measure in our rain gauges the depth to which the rain would lie on a horizontal surface, if it all lay as it fell, we must select such a position for the gauge that its aperture when level, shall have a perfectly clear horizon, there being no elevations to intercept the rain from any direction. As this condition can hardly ever be secured, the next best thing is to attain it as near as possible.

Yours faithfully,

RICHARD STRACHAN.

11, *Offord-road, London, 24th July*, 1871.

To the Editor of the Meteorological Magazine.

SIR,—Since writing my letter of the 24th inst., you have been kind enough to direct my attention to the Memoir on Rain, by Flaugergues, in *Annals of Philosophy*, vol. xiv, which is a translation from the original in *Bibliotheque Universelle*, vol. viii; and I think it right to state that Flaugergues therein shows that the quantity of rain which falls upon a given horizontal surface is porportional to the sine of the angle of incidence of the drops. In this way he accounts for the remarks of Lord Charles Cavendish and Dr. Heberden (*Phil. Trans.* vol. 69), that the quantity of rain which falls upon the same surface at the top of a building is less than at the bottom of it, adding—"The rain at the top of the house, or any other part completely exposed, experiencing without obstruction the whole action of the wind, must assume a direction inclined to the horizon, and reach the rain gauge placed there in that direction, but if the rain is screened from the action of the wind by the building, the drops gradually losing their inclined direction by the resistance of the air, must fall into the rain-gauge placed there vertically, or nearly so."

Mr. Meikle refuted this explanation by an argument similar to Dr. Burder's, founded on the supposition that the deflection vertically of the rain drops takes place in a horizontal plane (vide *Ann. of Phil.* xiv. 312; xv. 270; and xvi. 422). His letters are worth reading if only on account of the animus with which he carried on the discussion with Messrs. Holt and Boase. The latter gentleman effectually non-plussed him by very prudently taking care not to trace all the rain-drops from the same height, although Mr. Meikle affected to treat the notion as a self-delusion.

Verily there is nothing new under the sun! I readily grant priority of idea to Mr. Boase; perhaps Dr. Burder will as willingly yield equal credit to Mr. Meikle?

Yours faithfully,

R. STRACHAN.

11, *Offord-road, N., 29th July*, 1871.

RAINFALL RULES.

Rule I.—We think that the dissimilar results obtained by Messrs. Cator and Stow may be set off one against the other, and that at present no sufficient ground has been shown for altering the wording of this rule, which was intended for all parts of the country, but to which there are of course local exceptions.

Rule V.—Mr. Stow's suggested addition, might, we think, be accepted.

Rule X.—To Mr. Cator's proposed addition to this Rule we entertain the strongest possible objection, except in so far that it raises in a distinct form the question, Is it, or is not, desirable to read to thousandths of an inch?—a question indirectly raised also by Mr. Bicknell. In experimental work, and with the delicate appliances employed for instance by Mr. Chrimes, thousandths of an inch of rain have a necessary individuality, but with ordinary observers we consider their measurement approaches a farce. We are aware that in saying this we are censuring our own private practice, and enlisting the opposition of several first-rate observers, Mr. DuPort (*Meteorological Magazine*, Vol. III. p. 178), Mr. Vernon, id. p. 179; Mr. Bicknell, and Mr. Cator (Vol. VI. p. 27), probably also Mr. Stow and Mr. Mawley.

A proposition of this kind being once distinctly made should, we consider, be fully discussed and settled; we shall, therefore, endeavour so to classify our objections that those who think otherwise may meet each objection separately, and thus avoid discursive remarks.

(1.) *Existing practice.*—By examining 400 returns from different districts, we find that there are

8	returns	giving	readings	to	0·1	inch.
355	,,	,,	,,	,,	0·01	,,
36	,,	,,	,,	,,	0·001	,,
1	,,	,,	,,	,,	0·0001	,,

whence it is evident that not one tenth of the observers do read to thousandths, therefore, the proposed rule would require nine times as many persons to change their practice as the present rule does; which shows that existing practice is against the proposal, by 9 to 1.

(2.) *Scientific authorities.*—All the returns published by the British and Scottish Meteorological Societies, by the Astronomer Royal, the Registrars General of England and Scotland, the British Association (except experimental work), the Weather Reports of the Meteorological Committee of the Royal Society, give the readings to hundredths, and not one of them to thousandths. Hence if we accepted the proposed alteration it would render us the only body professing that degree of minuteness, and break up the present uniformity of practice.

(3.) *Difficulty of reading to* 0·001 *in.*—Owing to its small linear value. It is extremely unusual to meet with a gauge which multiplies the real depth more than 20 times, 10 or 12 is most frequent, but to put our case in the light least favourable to ourselves we take 20 times, which makes each thousandth of an inch represented by a fiftieth of a linear inch. Passing over the question of placing the glass upright by a spirit level (which Mr. Bicknell admits, Vol. VI, p. 27), we come to

the question whether two observers can be found who would agree in their readings to 0·001 in. This point we also pass over, referring our readers for an illustration to the letter by another advocate for 0·001 (Mr. Stow), in our April number, where he says "Rule XII. involves a distinction between ·005 and ·004 which with nine glasses out of ten I am unable to make, owing to the irregularities of the bottom."

(4.) *Records filled up to* 0·001 *imply a degree of accuracy which is not at present attainable.*—By this we mean that there are sources of error, each of which separately exceeds, and all of which together largely exceed, the proposed unit of measurement. We may mention a few: (*a*) very few rain gauges are at present divided with sufficient accuracy, and, therefore, every gauge must be tested to thousandths of an inch, they must be specially constructed to stand this test, or every rainfall reading must be corrected for instrumental error. (*b*) Before a reading of the amount of rain is taken it is diminished by the following causes: (1) the surface of the funnel and of the pipe must be wetted before any will run down the pipe, (2) the collecting vessel, be it bottle or can, must be partially wetted both by the ingress and emptying of the water, (3) the same remark applies to the measuring glass. Now taking an ordinary 5 inch gauge we have for (1) more than 20 square inches, for (2) at least 5, and for (3) 2, giving a total surface of 27 square inches to be wetted before a drop is measureable. How much will it take to wet this area? Would a quarter of a teaspoonful be too much? we think not, but a quarter of a teaspoonful represents three times the proposed unit of measurement; which as pointed out by Mr. Arnold is five drops of water for a 5 in. gauge. If this does not carry the argument far enough, let us for an instant refer to the 1 in. experimental gauges, where a single rain drop of moderate size (weighing one grain) equals six times the proposed unit of measurement.

Rule XII.—Messrs. Mawley, Bicknell, Cator, and Stow, have recently objected to this rule. We accept not the responsibility of its defence; it was altered in December, 1868, in consequence of a discussion in these pages, and it turns upon questions of thousandths of an inch, of which we have just indicated our opinion.

Rule XV.—Mr. Bicknell's objection to this rule is replied to by Mr. Arnold. There are several arguments in favour of Mr. Bicknell's proposal, but our own opinion is at present adverse, and it is so mainly because the loss from a rain-gauge funnel so imperfectly represents the loss from the earth's surface, which of course depends on soil, shelter, slope, crops, &c. Could not the comparison be made?

Mr. Cator says we should state how the snow is to be melted. There is apparently no objection to this; but, as pointed out by Mr. Stow, it is hazardous to put hot water into frosty glasses; we should therefore recommend that the word "warm" be substituted for "hot." We cannot accept, without further discussion, Mr. Stow's proposal to "strike out section 3 of Rule XII. as delusive, sometimes it would not give results correct to the nearest inch of rain." Would Mr. Stow mind giving us an illustration of this, showing also which of the gauges in ordinary use would, under the same circumstances give a correct result?

These rules have been submitted to perhaps the most severe ordeal it is possible to conceive—viz., unlimited criticism by nearly two thousand persons, all of whom are under a sort of mutual obligation to conform to them, and who are, individually and in the aggregate, probably the most competent persons in the world to criticise them. However, the result has been that scarcely half-a-dozen persons have objected to or suggested improvements in any of the rules. Mr. Cator favoured us with a string of suggestions, some of which seemed to us so good that we assumed the responsibility of inserting them in "British Rainfall," 1870 (p. 129), without further discussion. His others, and all the other letters which we have received upon the subject, have been printed in previous numbers of this Magazine. We now contribute our share to the discussion, not with the least wish that it should have any weight beyond that of other observers, or that it should be exempt from that criticism which we have scattered right and left upon some of our most able correspondents and best friends.

REVIEW.

The Geographical Distribution of Heart Disease and Dropsy in England and Wales. By Alfred Haviland, M.R.C.S., &c. Folio, 61 pp. and large map. W. & A. K. Johnston, London & Edinburgh.

THIS work is one the importance of which we do not think anyone is in a position to realize, but, in the first place, it shows that though two of the foremost men in Medico-Climatology, Sir James Clark and Dr. Scoresby-Jackson, have been taken from us, there are other hard and able workers who will worthily follow in their steps.

The work is got up with the accuracy for which the publishers are well known, and being based on the localities of nearly a quarter of a million deaths from heart disease and dropsy, has apparently an unassailable basis of facts. It is beyond our province to discuss the medical aspect of the question, but the coloring of the large (about 40 in by 30 in.) map is so clear and simple that no one can fail to understand the whole argument, or to be able to verify for himself the conclusions arrived at by the author, the bearing on which of meteorology may be imagined from the following paragraphs:—

"I think that the coincident phenomena displayed in the foregoing pages point to some *materies morbi* resident in certain localities, perhaps in all; the only difference being that one district is frequently purged by the beneficial influence of the sea winds, whereas another is sheltered so as to admit of an accumulation; this accumulated air sewage may have either an animal or a vegetable origin, or both; it is impossible to say. All that we know is, that it is coincident with excess of rheumatism, and excess of mortality from heart disease.

"I do not think that the influence of the sea winds on the mortality from heart disease is altogether physical. I incline to the view that there is a chemical element as well in operation. I think that ozone may not play an unimportant part in destroying the material of rheumatism; if so, in the wards and chambers where cases of rheumatic fever lie, we should not only take care that the ventilation is perfect without draught, but that the atmosphere is impregnated with artificially formed ozone; this experiment I feel is worth a trial. I know its efficacy in fever."

JULY, 1871.

Div.		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.	Date.	Min. Deg.	Date.	No. of Nights below 32° In shade	On grass.
			inches	inches.	in.								
I.	ENGLAND.	Camden Town	4·13	+ 2·34	1·23	10	18	80·0	18†	45·8	31	0	0
II.		Maidstone (Linton Park)	2·84	+ ·86	1·02	11	18	84·0	19	48·0	31	0	...
,,		Selborne (The Wakes)	4·43	+ 2·23	1·73	10	16	78·6	17	44·0	10	0	0
III.		Hitchen	3·67	+ 1·77	1·15	10	21	77·0	17	46·0	30	0	...
,,		Banbury	4·07	+ 2·01	·90	10	23	80·0	17	44·0	30	0	...
IV.		Bury St. Edmunds (Culford).	2·93	+ ·94	·60	2	19	80·0	17	45·0	1, 31	0	0
V.		Bridport	3·96	+ 1·85	·48	29	20	74·0	18	47·0	31	0	...
,,		Barnstaple	6·01	+ 3·15	·64	29	21	79·5	18	44·0	5	0	...
,,		Bodmin	5·79	+ 2·68	·63	21	23	66·0	28	52·0	1	0	0
VI.		Cirencester	4·31	+ 1·87	·91	10	16	...	...	...	...	...	...
,,		Shiffnal (Haughton Hall)	3·46	+ 1·29	·49	21	27	76·0	16	43·0	31	0	...
,,		Tenbury (Orleton)	3·48	+ 1·10	·56	21	25	76·2	18	41·5	31	0	0
VII.		Leicester (Wigston)	4·28	+ 2·18	·61	3	27	80·0	16	44·0	9, 30	0	...
,,		Boston	3·55	+ 1·25	·48	3, 21	22	81·3	16	47·0	31	0	0
,,		Grimsby (Killingholme)	3·76	..	·66	30	24	77·0	17	40·0	1§	0	...
,,		Derby	4·68	+ 2·49	1·04	30	27	75·0	16	47·0	31	0	...
VIII.		Manchester	...	...	..	...	...	...	..	...	...	...	...
IX.		York	...	...	...	...	...	...	...	...	...	...	...
,,		Skipton (Arncliffe)	9·22	+ 6·02	1·51	25	30	73·0	17	42·0	1	0	...
X.		North Shields	3·79	+ 1·98	·71	29	27	70·3	16	47·5	26	0	0
,,		Borrowdale (Seathwaite)	12·57	+ 4·43	1·70	7	24	...	...	...	...	...	...
XI.	WALES.	Cardiff (Town Hall)	...	...	...	...	...	...	...	...	...	...	...
,,		Haverfordwest	4·99	+ 1·69	·73	21*	17	70·0	16	47·0	9	0	0
,,		Rhayader (Cefnfaes)	6·04	+ 3·19	·53	28	24	69·0	...	44·0	...	..	...
,,		Llandudno	3·33	+ 1·03	·71	4	19	73·6	14‡	49·0	27	0	...
XII.	SCOTLAND.	Dumfries	3·93	+ 1·68	·60	29	25	71·0	11‖	46·5	12**	0	...
,,		Hawick (Silverbut Hall)	3·02	...	·86	4	20	...	...	...	...	...	...
XIV.		Ayr (Auchendrane House)	3·55	+ 1·39	·44	18	28	74·0	13¶	42·0	29	0	0
XV.		Castle Toward	3·94	+ ·80	·80	14	22	...	...	...	...	...	...
XVI.		Leven (Nookton)	3·90	+ 1·63	·51	29	23	72·0	14	43·0	26	0	0
,,		Stirling (Deanston)	5·35	+ 1·95	·87	29	27	72·0	14	38·0	26	0	0
,,		Logierait	4·06	...	1·17	29	23	...	...	...	...	...	...
XVII.		Ballater	3·13	...	·92	29	15	72·5	16	38·0	12	0	...
,,		Aberdeen	3·06	...	·61	23	20	71·1	17	46·6	25	0	0
XVIII		Inverness (Culloden)	4·02	...	·85	31	17	68·9	14	49·2	31	0	0
,,		Portree	10·73	+ 4·66	1·52	5	26	...	...	...	...	...	...
,,		Loch Broom	3·55	...	·36	16	24	...	...	...	...	...	...
XIX.		Helmsdale	3·45	...	·41	25	22	...	...	...	...	...	...
,,		Sandwick	2·83	+ ·96	·49	8	19	68·0	14	45·8	28	0	0
XX.	IRELAND.	Cork	4·67	...	·65	6	28	...	...	...	...	...	...
,,		Waterford	5·02	+ 1·70	·48	28	26	72·0	19	47·0	26	0	...
,,		Killaloe	6·00	+ 2·81	·68	30	31	79·0	16	44·0	27	0	...
XXI.		Portarlington	5·62	+ 2·08	·62	25	29	72·0	16	46·0	28	0	0
,,		Monkstown	5·63	+ 3 20	·73	10	26	...	...	...	...	...	...
XXII.		Galway	6·20	...	·74	7	29	70·0	19	43·0	1, 15	0	...
,,		Bunninadden (Doo Castle)	5·64	...	·76	6	28	66·0	27	38·0	27	0	...
XXIII		Bawnboy (Owendoon)	...	...	...	...	...	...	...	...	...	...	...
,,		Waringstown	5·07	...	·67	5	26	77·0	19	45·0	10	0	...
,,		Strabane (Leckpatrick)	6·42	..	·81	24	28	73·0	16	..	...	...	...

* And 29. † And 19. ‡ And 15. ‖ And 30. ¶ And 14 § And 10, 30. ** And 26.
+ Shows that the fall was above the average ; —that it was below it.

METEOROLOGICAL NOTES ON JULY.

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.—Dense fogs on 1st, 10th, and 17th; T on 3rd and 5th; very heavy R on 11th. From 13th to 22nd fine and summer like, otherwise the month has been a dull, cold, and wet one for July, retarding vegetation very much; winds mostly S. and S.W., but the greatest fall of rain on one day, 1·02 in., on the 11th, was from the N.E., confirming the current belief, that when rain does come from that quarter, it comes in large quantities. Winds at noon: S.E. 1 day, S. 10, S.W. 12, W. 4, N.W. 1, N. 2, N.E. 1.

SELBORNE.—T in early morning of 3rd, and T and L at 3.30 p.m.; T and L in early morning of 5th, with heavy showers; 2·00 in. in 24 hours of 10th and 11th; T on evenings of 23rd and 29th; prevailing winds, S., S.W., and W. The last two months (June and July) show rainfall amounting to 3·77 and 4·43 = 8·20 in. Much hay spoiled by the wet, and hops ruined by the blight.

HITCHEN.—Heaviest fall in less than 24 hours for many years on 10th and 11th. Hurricane at 5 p.m. on 29th.

BANBURY.—T S on 4th, 5th, and 23rd, with hail on 5th and 23rd. On 5th a chimney struck by L at the top of the town; a man much injured whilst standing under a tree, which was struck about one mile S. of the town.

CULFORD.—T on 5th, 22nd, 23rd, 24th, and 25th, with H on 5th and 25th. A month of growing weather, somewhat deficient in sunshine, and without any high temperatures for the season, the max. being 80° on the 17th. The cuckoo continued to sing until the 9th, this being unusually late, as its notes are seldom heard here after the end of June.

BRIDPORT.—Wet month and low barometer. No rain on St. Swithin's day. Gale on the night of the 29th, accompanied by very heavy H, R, T and L.

BODMIN.—Average bar., 29·91; average temp., 61°·2. This has been a wet, ungenial month, and though the temp. has been only 0°·8 below the average, there has been a remarkable absence of sunshine for July.

HAUGHTON HALL, SHIFNAL.—An ungenial, wet month, not so much from the weight of rain as from the continuous fall, only four days free from it; the nights unusually cold for the season, the ther. exceeding 55° only on three nights, and on the last night only reaching 43°. The prevailing winds were from S.W., shifting occasionally to W. and N.W. No T S. Hay crops good, but badly got in; turnips and mangold wurzel doing well. Not a wasp yet; the hornets, so abundant last year, have disappeared; scarcely a butterfly.

ORLETON.—A cloudy, rainy month, with very little sun, and generally cold and windy. Rain fell almost every day, but rarely in large quantities; the air generally damp; distant T heard on 1st, 3rd, 4th, 5th, 6th, 8th, 23rd, 24th, and 29th, but never loud or near Temp. about 1¼° below the average of the month.

WIGSTON.—The hay harvest has been much retarded by the wet weather, and but little secured in good condition. The pastures very rich, and the prospect of a good crop of turnips and mangolds is favourable.

BOSTON.—Wet and stormy, with very frequent thunderstorms and heavy rains; weather most unfavourable for hay-making operations, but the crops of hay are very abundant, wheat looking very well, and beginning to change colour about the 18th; much hay uncut or standing in cocks during the last few days of the month. Wheat in flower on the 1st; T S S on 4th, 5th, 9th, 22nd, 24th, and 29th.

KILLINGHOLME.—Very cold and wet month; crops of hay much damaged; harvest coming on very slowly; pastures and meadows unusually full of white clover; ther. has only reached 70° on ten days this summer, and 76°, "summer heat," on one day, the 17th.

DERBY.—A month of almost incessant rain, only five days without it, the fall being more than 2 in. above the mean. The deficiency of 1870 is already nearly made up, notwithstanding the almost drought of the spring months; temp. slightly below the mean. The abundant crop of hay being carried, but in most cases in damaged condition.

ARNCLIFFE.—Much T during month; rain excessive, 1·16 in. in 4 hours on 14th, and total nearly three times the average for July; bar. unsteady all the month.

NORTH SHIELDS.—TS on 1st, 2nd, 10th, 14th, 23rd, and 29th; and T heard also on 4th, 5th, 8th, 13th and 26th.

SEATHWAITE.—There were four days on which the fall exceeded 1·00 in.: 7th, 1·70; 14th, 1·40; 17th, 1·29; and 21st, 1·08.

WALES.

HAVERFORDWEST.—Coldest July since 1847; only one day that could be said to be really warm; constantly wet and at times stormy, the evenings chilly, resembling October; nearly every other day wet. Much of the very slight hay crop spoiled; the green crops look well, and the prospects of the corn harvest good, should fine weather set in.

CEFNFAES.—A cold dreary month; nights frosty; lingering hay harvest and crops light, only 5 dry days.

LLANDUDNO.—The month has been most variable, scarcely two days alike, and seldom more than one or two fine days together.

SCOTLAND.

DUMFRIES.—The month has been showery throughout; day temp. 5°·64 lower than July, 1870, and mean of day and night 3°·5. The crops will be two or three weeks later than last year, but are generally good, except where damaged by wind or R. Fruit is very scarce; country looking fresh and beautiful.

HAWICK.—Rainfall much above the average, and notwithstanding the rather cold nights and mornings, the country looks beautiful, and the crops have a most luxuriant appearance. T on 1st, 2nd, 4th, 5th and 11th; TS, with very heavy R, on 4th, when ·86 in. fell in one hour, many of the house cellars in Hawick were completely flooded, and their inmates terribly alarmed; the thunder shower was quite a local one, and did not extend much beyond the radius of a mile.

AUCHENDRANE.—25 days of rather strong equatorial winds, and an amount of cloud beyond the mean, have marked this July as a month of low bar. pressure and range, low ther., weak evaporation, great rainfall, and high humidity; only one moderate TS disturbed this locality, and R and H fell simultaneously in a very peculiar manner.

CASTLE TOWARD.—There has been much difficulty in preserving upland hay, meadow hay commenced cutting; turnips, potatoes and oats look remarkably well. Bedding plants not flowering very well, in consequence of too much damp and too little sunshine. T at 12.30 on 29th.

NOOKTON.—T on 4th, 5th, 22nd, and 23rd; heavy R on 29th.

DEANSTON.—A very wet month; some R every day except 27th and 31st; distant T on 4th, 5th, 8th, and 10th, and on 30th with L; windy on some days in the middle of the month.

LOGIERAIT.—A very wet month, which has been much against hay-making. However, notwithstanding the unusually heavy rainfall for the month of July, it was needed to compensate for the drought of last year, many of the springs which dried up last autumn are scarcely filled yet. T on 11th, and distant T on 29th.

BALLATER.—Rained more or less during the whole month from the 15th; occasional very heavy peals of T on 11th; very heavy R on 29th.

ABERDEEN.—Bar. corrected 29·671, or 0·224 lower than mean of 14 years. Temp. 58°·1, or 1°·2 above mean, chiefly caused by high night temperature. Rainfall 0·855 above average. Winds generally very light, S.W. and N.W. preponderating. A month of rather damp but genial weather. TS on 5th, between 2 and 3 p.m., and on 23rd; T on 8th at 4 p.m.; 11th, between 12 and 2 p.m.; on 22nd, at 7 p.m., very heavy at Inverruie; on 24th at noon; 26th at 10 a.m.; 28th at 12·30 p.m., and on 30th at 2 p.m.

PORTREE.—A very wet month; a heavy shower of R and H on 5th from 1.45 to 2.15 p.m.; rain gauge measured 1·32 inches; all the streams were swollen in a few minutes to a fearful size; all the low lying ground was completely flooded, but no serious damage done to the crops.

LOCHBROOM.—This month has been a contrast to the preceding three, being constantly wet (though the amount of fall was not great), whereas they were remarkable for their dryness; crops look very well, but hay suffers from the wet.

SANDWICK.—July has been wetter and warmer than the mean, and this has

advanced vegetation after the previous protracted drought. I hear there were three waterspouts, but only saw that on the 21st, of which I enclose a sketch, then and for some days after, the rain poured down in some places near, while very little fell at this station; in one parish a great quantity of S fell on the 21st; distant T on 8th and 9th; a waterspout at 2 p.m. [Engraving in our next. ED.], and T at 7 p.m. on 21st.

IRELAND.

KILLALOE.—The rainfall in the present July (6·00) the greatest in 26 years, except in July, 1861, when 6·51 was measured.

MONKSTOWN.—An extraordinarily wet July; T on 8th, 10th, 23rd and 29th, accompanied by very heavy R and H, which lay in drifts for hours.

DOO CASTLE—Incessant R this month; much T and wind, and S.W. winds caused a continual downpour; the month seemed to reserve its strength for the 29th, when the T and L were awful, a flash of L and a single shot (as if a park of artillery were discharged) were simultaneous, and then a peal followed which shook the slates upon the houses, and burst open doors, which kept swinging to and fro. H in some places fell as large as the largest gooseberries, and seriously damaged several fields of oats and plots of cabbages. Where grass was bare the fields were white with the H. No damage to life or property in this locality. Despite all this R the oat crop will be short, and meadows poor. There was too little sun, and the constant rain reduced the temp. very much. The potato crop promised well and looked blooming to the middle of the month, but since then the blight has made fearful ravages; as a rule potatoes will be small. Turf is still on the ground, and will so remain if there be not immediate fine weather.

WARRINGTON.—Constant R, with low temp. Hay crop greatly damaged, other crops looking well. T on 1st, 7th, and 29th.

LECKPATRICK.—Incessantly wet month; R very useful to oats and turnips, but too late for flax and hay.

HOW OUGHT THE MIN. TEMPERATURE TO BE ENTERED?*

Being solely desirous that what is best should prevail, we never think of checking a discussion, however adverse it may be to our own views—thus it was with the above subject. At page 205 of our last volume we wrote—"The minimun temperature indicated by the thermometer when read at 9 a.m. is the minimun of that day, and is always to be so entered." We should not have presumed to write thus positively if the matter were open to doubt, but we only wrote in a few words the spirit of the instructions of the British and Scottish Meteorological Societies, of the Admiralty Manual, and of every book of instructions we have ever seen. Of course it is easy to imagine cases in which the rule will fail, and our January number teemed with them, but the other side of the case was presented in February, and we have only had one letter since. Looking over the whole series of letters, we doubt if any one would arrive at the conclusion that an entire change in the practice of the meteorological world is required, and if not, could we too strongly urge conformity to the existing rules of the various societies? Dr. Burder, and one or two other correspondents, point out the danger of making one extremely cold morning into two from the proximity of 9 a.m. to the epoch of min. temp.—a perfectly valid objection, but hardly sufficient to demand a revolution, especially as most persons who record minima record also the actual temperature at the time of observation, which, of course, throws a great deal of light on the cases he has supposed.

* See *Met. Mag.* for January and February of the present year, since which time this note has been waiting for insertion.

SYMONS'S
MONTHLY
METEOROLOGICAL MAGAZINE.

LXVIII.] SEPTEMBER, 1871. [PRICE FOURPENCE, or5s. per ann. post free

THE METEOROLOGICAL OFFICE.*

THE Report of the Meteorological Committee of the Royal Society, recently presented to Parliament, contains a paragraph which is either of vital moment to the steady progress of meteorology and to that continuity of record which is so striking a characteristic of British observations, or else meaningless. We therefore lose no time in bringing the Report before our readers. Following our usual custom, we shall offer a few brief remarks on the Report in the order in which they arise; the important paragraph to which we desire to call attention being near the end of the Report, will therefore be noticed at the close of this article. The following paragraph rather amusingly illustrates the distinction without a difference between the Hydrographical and Meteorological Offices:—

"The Hydrographic Office of the Admiralty, having expressed a wish to undertake the entire management of the deep sea thermometers, to which allusion was made in the last Report, on the ground that these instruments were essentially hydrographical and not meteorological, the Committee have at once acceded to the request, and no addition has been made to the stock of these thermometers during the year."

We are glad to see promised a thorough discussion of the weather in the Atlantic at the time of the loss of the "City of Boston;" this to our mind is exactly the class of work which the attention of the office should be directed.

We also consider nearly all the changes in the telegraphic reporting stations improvements, especially the substitution of Scilly for Penzance, and the addition of Sumburghead.

Our readers may recollect a short article on "Weather Maps" in our July number. We had not then seen the very primitive effort referred to in the following paragraph in terms with which we by no means agree. We hope that the Committee will see that something more worthy of this country is promptly issued.

"A very important step in advance has been made by the enterprise of Sir W. Mitchell and Capt. Chas. Chapman of the "Shipping and Mercantile Gazette." These gentlemen have proposed to publish daily in that paper, which appears at

* Report of the Meteorological Committee of the Royal Society, for the year ending 31st December, 1870. 8vo, 57 pages, 1 plate. Eyre & Spottiswoode.

3 p.m., a chart of the winds at the principal stations on the coasts. This plan, which was set in operation at the beginning of the year 1871, is calculated to be of great value to the cause of meteorology. It may be hoped that, ere long, the barometrical and thermometrical readings may be given, as well as the wind, but the serious difficulties which are met with in adapting such a chart to the exigencies of newspaper printing, though they have been satisfactorily surmounted by Sir W. Mitchell, are a sufficient reason for proceeding with caution."

The Committee having incurred an enormous expenditure, and bestowed the major part of their attention on the establishment of their self-recording observatories, seem to us rather to over-estimate the utility of the results which they expect to deduce from them. For instance, take the following paragraph with reference to starting another observatory :—

"Such an addition to their system would be, in every way, desirable, and the more so *as it is now universally admitted that the study of continuous automatic records is indispensable for all investigations connected either with climate or with weather.*"

We have italicized words which surely the Committee cannot have fully considered. We have so often expressed our approval for some purposes of automatic registration, that we shall not be misconstrued as condemning its adoption, although we meet the above paragraph with a flat denial. It is not "universally," and we do not believe that it is at all "generally" admitted, that the study of continuous automatic records is indispensable for all investigations connected either with climate or weather." If the term climate had not been so distinctly separated from weather, it might have been supposed to be a *lapsus stylæ*, to which everybody is liable. But as it is, it evidently expresses the settled conviction of the Committee, or at any rate of the writer of the Report.

If automatic records are *indispensable* for all investigations connected with climate, it is evident that Blodget's "Climatology," Mühry's "Klimatologische," Sir J. Clark's "Climate," Scoresby-Jackson's "Medico-Climatology," and scores of other works, are useless. We do not think so.

Again, if they were indispensable, we might at once abandon all hopes of investigating the climates of our health resorts. Take the Isle of Wight: we hold that there are half-a-dozen different climates in that small island: Ryde, Sandown, Ventnor, Black Gang, Newport, and Yarmouth. Will anyone name two of these which are identical? But, if not, are we to start self-recording apparatus at each, and who would undertake to reduce the mass of sheets?

The Committee have wisely provided a supplementary set of apparatus at Kew, for replacing breakages without delay. It would be very useful if they would set the thermometers to work in the temporary shed, and compare them with those outside the Observatory window.

Considerable stress is laid by the Committee on the fact that they are now supplied with returns from some private observers, and they state that they have been entrusted by Her Majesty's Government

with the superintendence of the general system of British meteorology.* We were not aware that this was the case, but if so, it is centralization with a vengeance, and we have yet to learn how far either the Meteorological Committee are able to superintend the general system of British meteorology, or what right Her Majesty's Government possesses over it. We have heard of many changes lately, but it is generally supposed that when things work well, it is undesirable to interfere with them. If this paragraph means anything it means this: that the Committee intend to superintend the British and Scottish Meteorological Societies, the Meteorological Department at Greenwich, the Rainfall Committee of the British Association, as many private observers as they can, and we suppose kindly to control ourselves as well. We thank the Committee for this paragraph, which we submit to the attention of our Parliamentary readers, to the officials of the various societies, and to private observers.

THE BRITISH ASSOCIATION AT EDINBURGH.

(Continued from page 113)

Report by Mr. Glaisher on Luminous Meteors.—MR. GLAISHER read this report, of which the following is an abstract:—The object of the Committee, he said, was, as last year, to present a condensed report of the observations which they have received, and to indicate the progress of meteoric astronomy during the interval that has elapsed since the last report. A valuable list of communications on the appearances of luminous meteors and regular observations of star-showers have been forwarded to the committee in the course of the year. The heights and velocities of thirteen shooting stars obtained by the co-operation of Mr. Glaisher's staff of observers at the Royal Observatory, Greenwich, during the watch for meteors on the nights of the 5th to the 12th of August last, are sufficiently accordant with the velocity of the Perseids, as previously obtained by similar means in 1863, to afford the satisfactory conclusion that the results of direct observation are in very close agreement with those derived from the astronomical theory of the August meteor-shower. On the mornings of the 13th to the 15th of November last, a satisfactory series of observations of the November star-shower (as far as its return could be identified), recorded at the Royal Observatory, Greenwich, and at several other British stations, concurs with very similar descriptions of its appearance in the United States of America, in showing the rapid decrease of intensity of this display since the period of greatest brightness in 1866 and 1867. Notices of the appearance of more than twenty fireballs and small bolides have during the past year been received by the committee. Fourteen of the former were compared to the apparent size and brightness of the moon, and the latter include three detonating meteors of the largest class. Descriptions of some of the largest of these meteors are contained in the report and the accompanying list. No notice of the fall of an aerolite during the past year has been received, although the occurrences of large meteors during the autumn and spring months were unusually frequent. The locality of one of these, which appeared with unusual brilliancy in the south of England on the evening of the 13th of February, can be determined at least

* The exact wording of the paragraph is:—"It is in this direction that they venture to look forward to the most important development of the general system of British meteorology with the superintendence of which they have been entrusted by Her Majesty's Government—a system which was contemplated by the Board of Trade, under the presidency of Mr. Cardwell, so long ago as in the year 1855, but was not brought into practical existence until eleven years later, when in the year 1866 the Royal Society was requested by that Board to make arrangements for taking charge of the Meteorological Department."

approximately, as also the elevation of its flight. A table of the height of sixteen shooting stars doubly observed in England during the meteoric shower of August, 1870 (independently of the observations recorded at the Royal Observatory, Greenwich), appeared in the last volume of the British Association reports. A comparison of the observations made at the Royal Observatory, Greenwich, on that occasion, with those recorded at the other stations, enables the paths of 13 meteors (ten of which are new to the former list), seen by Mr. Glaisher's staff of observers, to be determined; and the heights and velocities of the meteors thus identified are entered in the report. The results are as follows:—The average height of 16 meteors (referred to in the last report) was 74 miles at first appearance, and 48 miles at disappearance; of 13 meteors (given in the present list), 72 miles at first appearance, and 54 miles at disappearance; of 20 meteors (observed in August, 1863), 82 miles at first appearance, 58 miles at disappearance. The present average heights are thus somewhat less than those observed in 1863, but they agree more closely with the general average height at first appearance, viz., 70 miles, and that at disappearance, viz., 54 miles. The average velocity of the Perseids (relatively to the earth) observed in the year 1863, was 34 miles per second, and that of three Perseids in the present list was 37 miles per second; while the velocity which Professor Schiaparelli obtained from the cosmical theory was 38 miles per second. A considerable shower of shooting-stars was also noted on the night of the 20th April last, for which preparations were made, which were attended with satisfactory results. The report, which was very elaborate, also contained a discussion of the new meteor showers noted during the last few years by Professor Schiaparelli, agreeing in many points with previous determinations by the committee from the observations contributed to the British Association, and suggesting considerations of novel and important interest in relation to their probable explanation. The committee, desiring to contribute to the inquiry by continued observations of the principal meteor-showers during the coming year, will provide means of registry of meteors on each of the following dates:—viz., January 2nd and 3rd; April 19th to 21st; August 9th to 11th; October 18th to 21st; November 13th to 21st; and December 11th to 13th, to assist in determining the direction and the hourly numbers of meteors on those days.

On the general Circulation and Distribution of the Atmosphere. By Professor J. D. EVERETT, D.C.L.—The object of this paper was to call the attention of meteorologists to a theory which is jointly due to Prof. J. Thomson of Belfast, and Mr. Ferrel of Boston, U.S.A., and which gives the only satisfactory account of the grand currents of the atmosphere, and of the distribution of barometric pressure over the earth's surface, the irregularities arising from the distribution of land and water being neglected. Independent proofs were also given of some of Mr. Ferrel's results.

A body moving along the earth's surface with relative velocity v (units a foot and second) tends to describe a curve concave to the right of the body in the northern and to its left in the southern hemisphere, the radius of curvature being $\frac{6850\,v}{\sin\lambda}$ feet. The deflection from a parallel of latitude into a great circle is usually negligible in comparison, being represented by the curvature of a circle of radius $R \cot\lambda$, R being the earth's radius.

To keep, therefore, the moving body in a great circle or in a parallel of latitude, requires a constraining accelerating force equal to $\frac{v \sin\lambda}{6850}$ and this formula applies alike to all horizontal directions of motion.

The air over the extra-tropical parts of the earth has a relative motion towards the east, and therefore passes towards the tropics with a force which can be computed from the above formula. If v be the eastward velocity at any parallel, the increase of pressure per degree of latitude is $\cdot0019\,v \sin\lambda$ inches of mercury, and this accounts for the observed increase of pressure from the poles to the tropics, which is roughly ·01 inch per degree.

If any stratum of air have less than the average eastward or westward velocity which prevails through the strata above it, it will not be able to resist the diffe-

rential pressure from or towards the equator which their motion produces. For this reason the lowest stratum of air having its velocity relative to uhe earth kept down by friction, generally moves from the tropical belts of high barometer to the regions of low barometer at the poles and equator. This is the origin of our S.W. winds and of the prevalent N.W. winds of the Southern Ocean.

The tendency of a moving mass of air to swerve to its own right in the northern hemisphere, explains Buys Ballot's law that the wind, instead of blowing at right angles to the isobaric lines, usually makes an angle of 20° or 30° with them, keeping the region of lower barometer on its left. The rotation of cyclones is an example of this law, and the pressure which the spirally-flowing streams exert to their own right in virtue of the earth's rotation, is the main cause of the excessive central depression. The author referred to Prof. J. Thomson's paper (B.A. report, 1857), to Mr. Ferrel's papers, and to *Nature*, July 20, 1871.

Professor COLDING read a portion of a paper, entitled "*Remarks on Aërial Currents*," in which formulæ were given for the velocities of the different particles of a fluid circulating in the annular space between two vertical cylinders, and for the form of the surfaces of equal pressure. The formulæ had been tested in the case of a hurricane at St. Thomas's.

Professor EVERETT read the *Report of the Committee on Underground Temperature*.—The intended boring at the bottom of Rosebridge Colliery has not been executed, recent occurrences in a neighbouring pit having given reason to fear an irruption of water in the event of such a boring being made. Careful observations of temperature have been taken by the engineers of the Alpine tunnel under Mont Fréjus (the Mont Cénis tunnel). The highest temperature in the rocks excavated, 85°·1 Fahr., was found directly under the crest of the mountain, which is just a mile overhead; the mean annual temperature of the crest over it being estimated, from comparison with observed temperatures at both higher and lower levels (San Theodule and Turin), at 27°·3 Fahr. Assuming this estimate to be correct, the increase of temperature downwards is at the rate of 1° in 93 feet, which, by applying a conjectural correction for the convexity of the surface, is reduced to about 1° in 81 feet as the corresponding rate under a level surface. This is about the rate at Dukenfield Colliery, and much slower than the average rate observed elsewhere. The rocks are extremely uniform, highly metamorphosed, and inclined at a steep angle. They contain silica as a very large ingredient. They are not faulted to any extent, and are very free from water. It is proposed to sink two bores, to the depth of from 50 to 100 feet, at the summit and another point of the surface over the tunnel, with the view of removing the uncertainty which at present exists as to the surface-temperature. Mr. G. J. Symons has repeated his observations at every fiftieth foot of depth in the water at the Kentish Town well, between the depths of 350 and 1,100 feet, the surface of the water being at the depth of about 210 feet. The observations which have been repeated are thus completely free from the disturbing effect of seasonal changes. The results obtained agree closely with those previously found, and show between these depths a rate of 1° in 54 feet, which, from the estimated mean temperature of the surface of the ground, appears to be also very approximately the mean rate for the whole 1,100 feet. The soil, from 325 to 910 feet of depth, consists mainly of chalk and marl, and shows a mean rate of 1° in 56 feet. From 910 to 1,100 feet, it consists of sandy marl, sand, and clay, and shows a mean increase of 1° in 54 feet. The former of these is in close agreement with trustworthy determinations made by Walferdin from observations in the chalk of the Paris basin. These are as follows:—Puits de Grenelle, Paris, depth, 1300 feet; rate, 1° F. in 56·9 feet. Well at Military School, Paris, depth, 560 feet; rate 1° F. in 56·2 feet. Well at St. André, 50 miles west of Paris, depth, 855 feet; rate, 1° F. in 56·4 feet. General Helmersen, of the Mining College, St. Petersburg, informs the secretary, that in sinking a well to the depth of 540 ft. at Yakoutsk, in Siberia, the soil was found to be frozen, probably to the depth of 700 feet. The rate of increase from 100 to 540 feet, was 1° F. in 52 feet. A new pattern of thermometer, recently constructed for the Committee, promises to be of great

service—a maximum thermometer, on Negretti's principle, adapted to be used in a vertical position with the bulb at the top. The contraction in the neck prevents mercury from passing into the stem when the instrument receives moderate concussions. Before taking a reading, the instrument must be gently inclined, so as to allow all the mercury in the stem to run together into one column near the neck. On restoring the thermometer to the erect position, the united column will flow to the other end of the tube (that is, the end furthest from the bulb), and it is from this end that the graduations begin. It is set for a fresh observation by holding it in the inverted position, and tapping it on the palm of the hand. This instrument, like that heretofore used, is protected against pressure by an outer case of glass, hermetically sealed.

On Wet and Dry Bulb Formulæ. By Prof. EVERETT.—He said, August, Apjohn, and Regnault have investigated formulæ for determining the dew point, by calculation, from the temperatures of the dry and wet bulb thermometers; but Regnault's experiments on the specific heat of air were not performed till a later date, and all three authors have adopted in their investigations the value obtained by Delaroche and Berard, which is ·267, whereas the correct value is ·237. But when this correct value is introduced into Regnault's formula, the discrepancies which he found to exist between calculation and observation are increased, and amount, on an average, to about 25 per cent. of the difference between wet bulb temperatures and dew point. August and Apjohn erred in assuming that the air which gives heat to the wet bulb falls to the temperature of the wet bulb, and becomes saturated. These two false assumptions would jointly produce no error in the result if the depressions of temperature in the different portions of air affected were exactly proportional to their increments of vapour-tension, and if some of the air were saturated at the temperature of the wet bulb. But it is probable that, when there is little or no wind, the mass of air which falls sensibly in temperature is larger than that which receives a sensible accession of vapour, and that, in high wind, the supposition that some of the air has fallen to the temperature of the wet bulb, is more nearly fulfilled than the supposition that it has taken up enough vapour to saturate it. The effect of radiation, which is ignored in the formulæ, leads in the same direction as these two inequalities, and all three are roughly compensated by attributing to air a greater specific heat than it actually has. The discrepancies above referred to are thus explained.

Dr. APJOHN said it was true his formula was obtained by employing what is now believed to be an erroneous value of the specific heat of air, but it nevertheless gave results conformable to observation. He thought that the erroneous point in his hypothesis probably consisted in the assumption that the film of air which is cooled down to the temperature of the wet bulb is saturated with vapour.

Prof. J. CLERK MAXWELL said there was reason to believe that the rate of diffusion of heat was nearly the same as that of vapour, the difference being about 6 per cent. If the air were perfectly still, the equilibrium of temperature for the wet bulb would depend on diffusion. In all investigations that he had met with, a convective equilibrium was assumed. He thought the action which really occurred was a mixture of the two. The subject was important, not, however, so much for the sake of its application to the wet and dry thermometers, as for its bearing on the conduction of heat in air, a subject of great experimental difficulty.

Mr. C. BROOKE said that Mr. Dines was engaged in experiments on the subject. His own experience had led him to believe that the correction for barometric pressure was not properly applied.

Mr. PENGELLY gave an account of an analysis which he had made of the daily rainfall at Torquay, for the purpose of determining "*the influence of the moon on the rainfall.*" He thought he had detected such an influence. The dry portion of a lunation extends from the first day before the full moon to the first day before the first quarter, and the wet part from the day of the first quarter to the second day before the full moon.

On the Rainfall of the Northern Hemisphere in July, contrasted with that for January. By Mr. A. BUCHAN.—The paper was illustrated by charts, showing the distribution of rain in inches over the greater portion of the northern hemisphere in July. Mr. Buchan described the principles which guided him in drawing lines representing the rainfall of the globe—namely, to reject all places which, being in the immediate vicinity of hills or rising grounds, did not represent the average rainfall of the district; secondly, he drew lines of rainfall for each month separately. The months of July and January were selected, because in these months the greatest effect of heat and cold on the earth's atmosphere and its movements occurred. In July the line of the rainfall passed through the south of Spain, the north of Africa, through Syria, and thence westwards into the desert of Cobi, thus forming the northern boundary line of the rainless region of this part of the globe in July. The map further showed that the greatest amount of rainfall occurred in the centre of the continent of Asia and Europe, taking them both as one continent; and that the line of greatest rainfall passed through the centre of Europe and towards the centre of Asia, to some distance north of the Caspian. In India, the line of the rainfall passed a little to the west of the Ganges, east of which the lines representing inches could not be shown; and the whole of this region was therefore marked by a deep red, to show the rainfall was enormous; and the rainfall was also very excessive in Further India, and in the east of Asia generally. In America the line of the rainfall included California and the neighbouring regions. Very heavy rainfall occurred in the lake district of the north-western sides which sloped eastward—that is, those to the east of the mountains; but the heaviest rainfall occurred in the sides bordering on the Gulf of Mexico, and the whole of the eastern slope of Central America. In the map contrasting the rainfall of July with that of January, there were two sets of lines—blue and red, the red showing those regions at which the rainfall of July exceeded that of January, and the blue those regions where the rainfall was less than that of January. Mr. Buchan showed that where there were prevailing winds blowing into warmer latitudes, the rainfall was not defective, even though those winds came from the ocean, and illustrated his remarks by the summer rainfall of the south of Europe and the north of Africa, and by that of California. The greatest excess of the rainfall in July was in those regions to which the prevailing winds arrived after having traversed a vast extent of ocean, India and Central America. Illustrating this connection, on the western slopes of the British Isles the rainfall in July was less than that of January, but on the eastern slopes it was greater in July. When the prevailing winds blew from the Atlantic eastwards into the centre of the great continent, the rainfall of the hills of this immense tract was greatly in excess in July of what it was in January. Mr. Buchan also pointed out the importance of inquiry in reference to the great movement of the atmosphere, especially the vapour which was condensed into rain, and which must come from some neighbouring surface. The important bearing of the subject on physical geography and climate, and the distribution of vegetable and animal life on the globe, was also pointed out.

On the conclusion of the paper, Colonel Yule remarked that Mr. Buchan had not gone beyond six inches in his calculations, but he wished to state that in the place where his earliest service began—in the district of Assam—there fell, in the month of August, 1841, 30 inches of rain on six days continuously, or 180 inches in all, while the whole rainfall of Edinburgh for a year was about 26 in. During that same month of August the rainfall was 264 inches, or 22 feet. He thanked Mr. Buchan heartily for his paper, and hoped that his maps and observations would be published before long, in a shape in which they could all have access to them.

Dr. BUYS-BALLOT gave a short address "*On the importance of a Telegraphic Meteorological Station at the Azores.*" He spoke of the importance that a telegraphic station in the midst of the Atlantic would have in giving warning of the approach of storms to the shores of Europe. The cable could be laid from the Azores to the Portuguese coast; but it would not be for the interest of Portugal alone, but of all the European nations, and particularly Great Britain, which had

the greatest amount of shipping. He suggested that the Scottish Meteorological Society, which had done great service to meteorological science, should take up the matter, with the view to an international fund being raised to promote the object of his address. He was authorized to say that every encouragement would be given by the Portuguese Government, and the rates would be only £1 per message.

Mr. G. J. SYMONS said he had that morning had the pleasure in Committee of the Section of moving that the excellent proposal of Dr. Buys-Ballot should receive the support of the Association. He considered the merits of the proposal so great, and the expense (£400 per annum, to be divided among all the nations of Europe,) so trivial, that he felt sure it was a foregone conclusion that it must be adopted.

Mr. RUSSELL read a paper "*On the Inferences Drawn by Drs. Magnus and Tyndall from their experiments on the Radiant Properties of Vapour*," in which he agreed in the main with Tyndall's deductions, pointing out, however, that vapour had no power of transmitting its radiant heat into space. This proposition was supported by arguments from natural phenomena.

Mr. W. A. TRAILL described, with the aid of a coloured diagram, a beautiful display of Parhelia, seen by him in County Down, Ireland.

DECREASE OF RAINFALL WITH ELEVATION.

To the Editor of the Meteorological Magazine.

SIR,—Would it be asking too much of Mr. Stow to request him to lay aside his light and flippant style, and answer Dr. Burder's "fair and temperate" objections to his new theory in an honest and straightforward manner? Ridicule is a poor substitute for argument under any circumstances: in a discussion such as the present, I submit it is altogether out of place.

I do not understand Mr. S.'s allusion to the theory "unfounded on experiment" of Sir J. Herschel. I am not aware that Sir John proposed any theory at all on the subject. On the contrary, he states, in his "*Meteorology*," page 105, par. 109, "The real cause" (difference of rainfall with elevation) "is yet to seek, and no more interesting problem can fix the attention of the meteorologist." It certainly did not require the genius of a Herschel to discover the fallacy contained in the proposition that the "decrease of rainfall with elevation is caused by the difference of angle at which the rain falls."

I cannot but consider it a very severe tax on my understanding to be called upon to believe that 30 per cent. of the rain that leaves the clouds *does not reach the earth at all!* Such, if I read him aright, is what Mr. Stow asks us to do. At page 71, of your June number, Mr. S. says, "I prefer the theory that the ratio of the amount caught by a horizontal gauge varies as the cosine of the angle which the rain makes with the vertical. This gives 30 per cent. for 45°, 50 per cent. for 60°," &c. Farther on, he says, "It is likely that the bulk of the rain at Aldershot falls at an angle of about 45°." Now, what I want to know is,—*if* the bulk of the rain at Aldershot falls at an angle of 45°, and *if* a horizontal gauge catches only 70 per cent., *what becomes of the remaining* 30 *per cent.?* To say that it is not collected in a horizontal gauge is, of course, to say that it does not fall at all, for a

garden, a field, or a town, is only a horizontal gauge of larger dimensions. The observations at Calne and Rotherham prove most conclusively that the difference in the quantity of rain collected by two horizontal gauges at different elevations is in proportion to the force of the wind. In what way the wind operates in producing the difference is not yet shown unless the theory of Mr. Jevons, alluded to in your June number, page 72, is sufficient for the purpose.

I believe this theory to be amply sufficient for the solution of the problem, and that the wind, (1) by causing eddies and preventing the rain entering the gauge; (2) by blowing away the rain-drops as they alight on the rim; and, (3) by greatly increasing evaporation, is the sole cause of the difference in question.

Would it not be possible to fill up the rim of a gauge with *sponge*, or some other porous substance, so as to leave a level surface, representing the surface of the ground? The difficulty, I apprehend, would lie in getting the "porous substance" to give the rain up again to be measured or weighed.—Yours truly,

JOHN THRUSTANS.

Merridale, Wolverhampton, Aug. 23rd, 1871.

To the Editor of the Meteorological Magazine.

SIR,—I hope I correctly understand that the debated point in this controversy is, whether "a difference of the angle at which rain falls causes an alteration in the amount of rainfall upon a horizontal surface." This seems to me to be a purely mechanical problem. The case may be stated as follows: Two forces act on the rain-drops, (1) Gravitation, and (2) Wind. The first acts vertically, and alone produces the fall of the rain; the second acts at right angles to the first force, and alone produces horizontal motion. Acting at right angles to the vertical force, wind cannot in the slightest degree accelerate or retard the downward motion of the rain; acting, also, uniformly on neighbouring particles of rain, it cannot alter their horizontal position, *inter se*, and consequently it cannot affect the amount of rain falling on a horizontal surface. The amount of rain received on a vertical surface (or, may I say, in a vertical gauge) will vary directly with the horizontal velocity of the rain-drops, or, as we should say in ordinary parlance, with the force of the wind. And herein is the answer to Mr. Stow's question, why the angle of rainfall should affect the amount of rain on a vertical surface, but not on a horizontal surface? The angle is the product of the wind, a variable quantity, but the cause of the varying amount on the vertical surface. On the other hand, gravitation, the cause of the fall on the horizontal surface, is a constant quantity, and the angle can indicate no change with reference to this cause, simply because it is invariable.—I am, Sir, your obedient servant,

P. P. PENNANT.

August 21, 1871.

To the Editor of the Meteorological Magazine.

SIR,—I quite agree with Mr. Stow that if we are going to try to determine the actual path of a single rain-drop we shall be met with

enormous difficulties; we shall then be plunged into all the intricacies of Hydrodynamics in seeking to determine the path of a body moving in a fluid—a problem in itself difficult enough, and in this case complicated by the fact that the moving body is itself a fluid, and probably changes its size as well as its shape, while the fluid within which the body moves is itself in motion also. I doubt if these variations are very large, but at all events I do not think that I underrate the difficulties of the problem; the point for which I have been contending, however, is something quite different; it is a mere question of geometry. The statement which I have been endeavouring to prove erroneous, is that contained on page 23 of *British Rainfall* for 1871: "The cause of this decline of amount with increase of height is doubtless to be found in the angle at which the rain-drops fall," or, as Mr. Stow more definitely puts it, on page 69 of *Magazine*, "It is impossible to deny that a horizontal gauge presents a smaller area of aperture to rain falling obliquely than to that which falls vertically." It was not to establish any pet theory of my own, for I have none, but to clear the ground for some future theorist, by proving that Mr. Stow's theory was inconsistent with the plain truths of geometry, that I suggested the experiment "with knitting needles and strings, and a few parallelograms as a mathematical sauce," hoping that with "this potent weapon of common sense," I might make evident a geometrical truth which had evidently been overlooked, and which I thought required illustration. The point in dispute, as far as I am concerned, is this: Does a horizontal gauge present a smaller aperture to rain falling obliquely than to rain falling vertically? We cannot advance a step until this is settled; and this question has nothing to do with the equality or inequality of the rain-drops, or with "the great irregularities which render parallelograms inapplicable (?) to the case." I will state the question mathematically, for the sake of greater clearness: Let α be the angle which the rain makes with the vertical, h the very small height through which the rain falls in any small time (the time being small enough for the motion to be considered uniform), l the length of the path of the rain in this time, A the area of the gauge: it is clear that in this small time the rain is contained in an oblique cylinder, which, its base being A and height h, has therefore for its volume $A\,h$: now h cannot vary while the time is constant, and A is constant, therefore $A\,h$, the quantity of rain caught in the gauge is independent of α.

Again, since $l \cos. \alpha = h$, therefore $l \cos. \alpha$ is constant; therefore l varies as sec α, and therefore when $\alpha = 90°$ and sec. α becomes infinite, l becomes infinite too: that is, if it were possible ever to have so violent a wind as that the path of the rain was horizontal, the space through which the rain would be carried by the wind would be infinite, compared with the small space through which it would have fallen by the action of gravity in that short time. This surely accords with the laws of falling bodies, and this I call a crucial test, because it explains a limiting case, which, at first sight, might have been thought to confirm an erroneous assumption.

Now, as to vertical gauges, I am quite ready to admit that if rain were discharged from the vertical face of a cloud, then, whatever the force of the wind, and therefore whatever the inclination of the rain to the horizon, the quantity caught by the vertical gauge would always be the same if the initial horizontal velocity were the same: but everybody, including Mr. Stow himself (page 69), supposes the discharging surface to be horizontal, a supposition doubtless not very far from the truth, though not perfectly exact, and we are all agreed that perfect exactness is not attainable: we try to get as near to the truth as we can. The accompanying diagrams will illustrate my meaning,

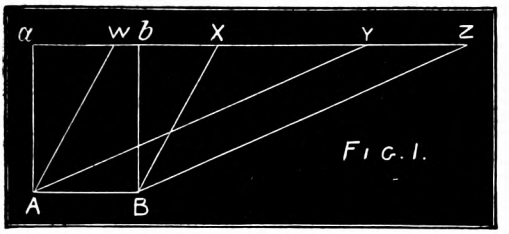


FIG. 1.

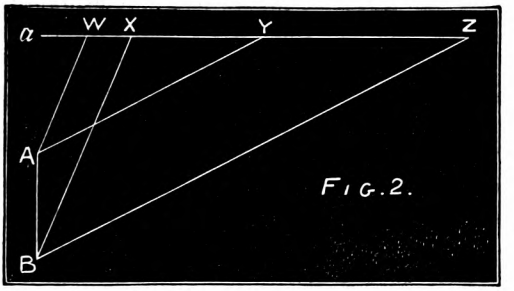


FIG. 2.

when I wrote "the properties of a parallelogram dispose of Mr. Stow's question, Why not for vertical gauges?" A B are the mouths of the horizontal and vertical gauges, *a wb* X Y Z the horizontal discharging surface. In fig. 1, the parallelograms *a* A B *b*, W A B X, Y A B Z, are all equal: in fig. 2, the trapeziums W A B X, Y A B Z, are not equal. The diagram which Mr. Stow supplies does not help me much, for these two reasons, first, that if H_1 H_2 H_3 H_4 were not all equal, as also V_1 V_2 V_3 V_4 then would the figures cease to be parallelograms and, secondly, that we are not concerned with the sides but with the *areas* of the parallelograms.

I have one other little objection to Mr. Stow's language; he calls "the assumption on which his theory is based," pp. 70 and 114, an *axiom*. An axiom is a self-evident proposition — a term hardly applicable to a statement about which so many of us are wrangling, albeit most good-humouredly.

My letter is too long for me to touch upon the "Position Gauges;" nor am I tempted to do so to-day, interesting as those observations are, because these results do not affect the point in dispute.

J. M. DU PORT.

Mattishall, Norfolk, Sept. 1st, 1871.

To the Editor of the Meteorological Magazine.

SIR,—I have been lately chewing the cud over Mr. Stow's paper in the *Annual*, and the letters in the last four numbers of the *Meteorological Magazine*. I am surprised that Mr. Stow's remark, at page 18 of the *Annual*, that "it would be interesting to investigate, both theoretically and by experiment, the path of the rain-drop," has been passed over unnoticed. Of course it would, and if it had only been done, it would have ended the matter one way or other at once. That this should have been neglected, and the argument carried on without such investigation, and upon an assumption or supposition which is, to say the least, a very peculiar one, and, as far as I know, without the authority of facts, seems to me an unscientific method of proceeding.

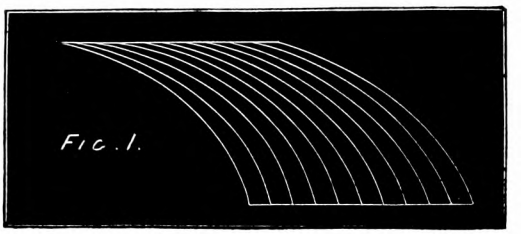
The supposition I allude to, and to which I have seen no objection, is that made by Dr. Burder, at page 64 of the Magazine, in the May number, where he supposes the case of a cloud "discharging rain uniformly from every part of its lower surface."

Now, I confess, I do not know the method of generation of rain-drops from vapour, nor the positions in a given cloud-mass at which such generation takes place. But, if I am to suppose anything, I can far more easily suppose rain-drops generated at many points, at various altitudes in the cloud-mass, than only uniformly at its lower surface. And I think this supposition likely to be true, not only from its seeming to me more probable, but also because the result of such a hypothesis would agree with the facts observed. Let us, then, consider the path of the rain-drop. Now, the rain-drop is a projectile. It is up to the moment of its generation a portion of vapour, travelling with nearly or quite the velocity of the wind at the time. When this portion of vapour becomes a drop its course becomes that of a projectile, projected horizontally with the velocity of the wind for its initial velocity, and subject to the force of gravity. Its path will therefore be a parabola, having the point where the drop is generated for its vertex, and a vertical line through that point for its axis. The velocity of the wind, after the drop starts, will not affect its course unless that velocity be increased or decreased. Any deflection from its parabolic course could be caused only by variation of velocity in the successive strata through which it passes, or by the vertical resistance upwards of the atmosphere. Of these causes and their effects more by-and-bye.

Now let us take Dr. Burder's hypothetical case of "a cloud discharging rain uniformly from its lower surface." I presume the lower surface is supposed perfectly horizontal.

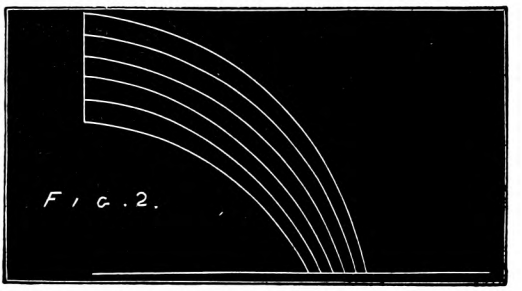
In this case the drops would describe parallel curves, the horizontal distances between them at every point of their fall remaining the same as at the moment of projection, any variation of velocity of wind, and any resistance of atmosphere affecting all their paths alike, as in fig. 1.

Next, let us take another case, which I think we are at least equally



justified in supposing. Suppose a cloud of considerable thickness to discharge rain uniformly from all parts of its mass. Manifestly, if horizontal lines be drawn through it, the drops which start from each such horizontal line will keep their own distances in their downward paths: but how will these several systems of drops affect one another?

Take one vertical line through our hypothetical cloud, and assume rain-drops to be generated at various points of that line. It will be found that the parabolas described by these projectiles will approximate horizontally, and that though in theory they would never actually coincide, they would ultimately become indefinitely near to each other. They would describe the curves represented in fig. 2.



I apprehend, then, that what I have already written justifies the following conclusions:—

1. Rain-drops falling from the same altitude, and under the same circumstances of wind and atmosphere, preserve their horizontal distances throughout unaltered.

2. Rain-drops falling from different altitudes, under the like circumstances, approximate as they fall.

3. The greater the force of wind, *i. e.*, the initial velocity of projection, the longer the path described, and the less the approximation between drops falling from different altitudes, and conversely.

4. Drops falling from different altitudes will be travelling with different velocities when they approach the ground; those starting at a greater elevation travelling faster than those which start at a lesser.

5. On passing into the strata of air near the earth's surface, which are travelling slower than the upper strata, the paths of the drops will be altered, and those drops which travel slowest will be most retarded. The drops which begin to fall at the least elevation will be retarded in the direction of those which had started above and behind them.

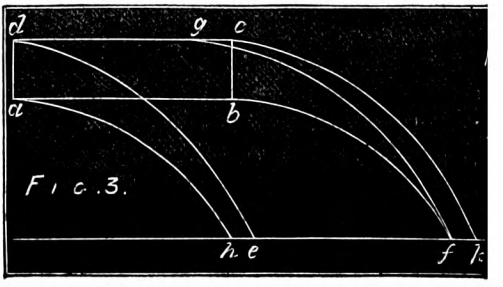
6. The vertical resistance of the atmosphere will affect the paths of

the drops in the opposite direction, tending to lengthen most the paths of the drops which start highest, and to send them forward towards the paths of those drops which had started below and in front of them.

7. Both these last will tend to increase the approximation while the drops are passing through the very lowest and slowest strata, *i. e.*, while very near the ground.

On the theory expressed in the above conclusions, it would happen that if a cloud at rest discharged rain from all points of its mass, or more correctly from many points distributed through all parts of its mass, there being no wind, the same amount of rain would be collected at all altitudes. The drops all falling vertically through a calm air would preserve their horizontal distance, unless there were a sufficient attractive force between the falling drops to render the shower gradually denser towards its centre. In every case, however, of a cloud discharging rain while in motion, the rain-drops in any given horizontal space in the air would be more numerous near the earth's surface than higher up.

Taking a hypothetical volume of cloud in motion, say one mile square and a quarter of a mile thick, and discharging drops, not only from its under surface but from points in various horizontal planes within its mass, it is clear that while each system of drops starting from one plane would cover its own square mile of ground, the whole rainfall from such a cloud must cover a greater space than one square mile. There would be many such systems of drops falling at the same time, and the space covered by the shower, from the line marked by the drops falling from the *hindmost lowest horizontal* edge to that marked by those falling from the *foremost highest horizontal* edge, would be a mile wide, but more than a mile long, and this increase of space would be dependent on the velocity with which the cloud was travelling. Between these two limits there would be a space a mile wide, but not a mile long, in which the shower would be uniformly dense at each horizontal line drawn through it, but diminishing in density from the surface of the earth to the upper surface of the cloud, where it would vanish altogether. In front of and behind this space of uniform horizontal density, would be other spaces in which the horizontal density would be less and also variable, greatest near the volume of constant density, and thinning out before and behind to the few drops with which such a shower would begin and end. *See* fig. 3.



This theory seems to me to account for the facts observed, but it depends of course upon the supposition that when it rains the drops are not discharged from the lower surface of the clouds, but are generated at and discharged from points at different altitudes in the cloud mass. Perhaps somebody "up in a balloon" will notice whether the rain ceases at the moment of passing through the under surface of a cloud, or continues to start as long as there is any cloud for it to fall from.

T. E. CRALLAN.

Hayward's Heath, Sept. 5th, 1871.

To the Editor of the Meteorological Magazine.

SIR,—What surprises me most in this discussion is to find how complicated a simple question may become through the exercise of misdirected ingenuity. This "simple question," be it observed, is not the general question of the cause of the decrease of rainfall with elevation, but it is the question of the soundness or unsoundness of Mr. Stow's solution of that problem. It is necessary to bear this distinction in mind. The general question is full of difficulty. The particular question of the soundness of Mr. Stow's theory is, I still maintain, an exceedingly simple question. To my mind it takes this form: Given a certain quantity of rain to fall over a certain area, can you, by altering the inclination at which it falls, increase or diminish its quantity? In other words, the quantity being the same, can it be different? To settle a question of this kind, mathematics are superfluous, and experiments are worse than useless. Considerations respecting the size of the rain-drops are equally irrelevant. I do not forget that at the outset of the controversy it was maintained that the quantity of rain at the higher elevation is not really less than at the lower, but that the receipts of a horizontal surface, at the higher level, are not a true measure of the quantity falling there, by reason of the inclination at which it falls. I am willing to hope, however, that this position has been abandoned as untenable. Sir John Herschel, when he wrote, with evident reference to a theory identical with Mr. Stow's, "Still less can the effect be due to a greater obliquity of fall at a higher than at a lower level, since the same quantity of rain must fall on the same horizontal surface after changing its obliquity as before," committed himself to no rash proposition which later investigations might disprove, but stated a truth which will hold good to the end of time, any number of experiments notwithstanding.

Mr. Stow's diagram and connected argument are extremely clever, and, *as an exercise*, worth confuting, but this I leave to Mr. Du Port, who is more immediately concerned. I will only remark that when Mr. Stow insists that whatever mathematical principle applies to a horizontal gauge must equally apply to a vertical gauge, he ignores the very important fact that the normal course of the rain is to *fall* and not to pass horizontally. If the average path of the rain were parallel with the earth's surface, sometimes inclining upwards and sometimes

downwards, and if the mouth of the gauge were kept constantly to face the rain, then the same law would hold good for vertical gauges which is now true of horizontal gauges. But, as matters are, it is only by a kind of accident that any rain at all falls into a vertical gauge. The destination of rain is not a vertical surface, but a horizontal surface—the surface of the earth.

Mr. Strachan's criticism on one of my former illustrations is ingenious, but does not touch my argument. I purposely supposed the deflection of the rain-drops to take place on a level plane, to avoid complication. It is quite true, as Mr. Strachan says, that if we suppose the deflection to take place on a plane which is not level, we get a different result. We may, indeed, in this way get any result that we please. We have only to suppose a slanting shower and a vertical plane of deflection, and we shall find the whole body of the shower concentrated into a single sheet of water. But evidently this is a great deal more than altering the inclination, and my argument remains intact, that the inclination of the drops cannot, *per se*, affect the quantity which falls on a horizontal surface.

It will scarcely be a satisfactory conclusion to this controversy if nothing more should come of it than to show that Mr. Stow's solution is erroneous. That I take to be the first and most urgent business, but it may be hoped that we shall not rest there. Sir John Herschel has pointed out what seems a fatal objection to the theory of the condensation of vapour by the falling drops. But how about the *coalescence of spray?* By "spray," I mean particles of rain too fine to fall, and only likely to reach the earth through being licked up by the larger drops in their descent. The idea is not free from difficulties. In the first place, it would be necessary to show the probable existence of this spray. Then, granting its presence, whence does it come? In so far as it may be produced by the clashing of the drops, *inter se*, the objection may be raised that the drops would gain by accretion no more than they lost by dispersion. But the spray may be caused by the impact of the drops upon terrestrial objects, and if we may only suppose that the portion of rain, which falls in a gauge, suffers less than the average loss from this cause, we seem to have at least some promise of an adequate explanation. An analysis of existing records of rainfall at different elevations, might be so conducted as to show the probability or otherwise of the theory I have suggested. If there is any truth in it, then I should expect to find, first, that the elevation differences are greatest with heavy rain; secondly, that they are increased by wind; and, thirdly, that they diminish in ascending. Writing in haste, I have no time for reference, and this letter is already too long.

GEORGE F. BURDER, M.D.

Clifton, Sept. 6, 1871.

AUGUST, 1871.

Div.		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.	Date.	Min. Deg.	Date.	No. of Nights below 32°. In shade	On grass.
			inches	inches.	in.								
I.	ENGLAND.	Camden Town	·85	— ·79	·62	17	7	90·0	13	46·2	5	0	0
II.		Maidstone (Linton Park)	1·09	— 1·62	·94	18	7	93·0	12†	49·0	5	0	...
,,		Selborne (The Wakes)	2·29	— ·89	·90	17	8	85·0	13	40·5	2	0	0
III.		Hitchen	·62	— 1·73	·26	17	8	82·0	13	45·0	27	0	...
,,		Banbury	·75	— 1·38	·21	25	7	84·0	13	42·0	28	0	...
IV.		Bury St. Edmunds (Culford)	·29	— 2·15	·25	17	3	86·0	12	43·0	4, 26	0	0
V.		Bridport	·80	— 1·79	·35	17	6	83·0	13	43·0	27	0	...
,,		Barnstaple	1·75	— 2·44	·67	17	7	86·0	11†	49·0	1, 27	0	...
,,		Bodmin	2·66	— 1·20	·98	17	13	79·0	14	52·0	27	0	0
VI.		Cirencester	2·78	— ·06	1·86	13	5	...	...	...	...	...	...
,,		Shiffnal (Haughton Hall)	1·49	— 1·38	·54	17	7	79·0	6, 11	41·0	22	0	...
,,		Tenbury (Orleton)	1·29	— 1·59	·43	13	8	84·8	12	40·2	22	0	0
VII.		Leicester (Wigston)	·88	— 1·31	·30	19	9	89·0	12	40·0	21	0	...
,,		Boston	·98	— 1·31	·79	17	5	84·0	12	47·0	22	0	0
,,		Grimsby (Killingholme)	1·26	...	·80	17	4	82·0	12	47·0	22§	0	...
,,		Derby	1·35	— 1·25	·74	17	8	82·0	10†	42 0	22	0	...
VIII.		Manchester	1·60	— 1·90	.	...	11	...	..	...	...	...	...
IX.		York	1·03	— 1·68	·32	17*	7	82·0	10	44·0	22	...	...
,,		Skipton (Arncliffe)	2·86	— 3·08	·67	20	9	...	...	...	...	0	...
X.		North Shields	·96	— 1·89	·45	20	6	76·0	10‡	45·0	22	0	0
,,		Borrowdale (Seathwaite)	9·10	— 4·98	2·85	21	14	...	...	...	...	...	...
XI.	WALES.	Cardiff (Town Hall)	...	...	...	...	...	...	...	...	...	...	...
,,		Haverfordwest	2·18	— 2·70	·70	17	*8	79·0	14	39·0	27	0	0
,,		Rhayader (Cefnfaes)	2·97	— 1·69	1·00	16	7	81·0	...	40·0	...	..	...
,,		Llandudno	1·24	— 2·58	·43	17	11	83·4	8	46·6	22	0	...
XII.	SCOTLAND.	Dumfries	2·54	— 1·34	1·15	20	10	79·5	14	43·0	22	0	...
,,		Hawick (Silverbut Hall)	2·10	...	·73	20	9	...	...	...	...	...	...
XIV.		Ayr (Auchendrane House)	5·15	+ 1·18	2·36	20	14	76·0	30	40·0	22	0	0
XV.		Castle Toward	...	...	...	...	...	...	...	...	...	...	...
XVI.		Leven (Nookton)	2·32	— ·67	1·30	20	9	77·0	10	40·0	20	0	0
,,		Stirling (Deanston)	4·12	— ·50	·84	20	13	75·2	9	37·8	22	0	1
,,		Logierait	3·28	...	·82	20	11	...	...	...	...	...	...
XVII.		Ballater	1·98	...	·76	20	7	76·5	12	36·5	20	0	...
,,		Aberdeen	2·60	...	·88	20	11	73·7	10	43·9	22	0	3
XVIII		Inverness (Culloden)	1·82	...	·60	19	10	71·0	7	49·5	...	0	0
,,		Portree	5·70	— 1·75	1·33	24	20	...	...	...	...	...	...
,,		Loch Broom	3·44	...	·66	24	18	...	...	...	...	...	...
XIX.		Helmsdale	2·20	...	·92	24	15	...	...	...	...	...	...
,,		Sandwick	2·93	— ·78	·85	24	17	70·6	10	41·8	16	0	1
XX.	IRELAND.	Cork	2·05	...	·38	16	10	...	...	...	...	...	...
,,		Waterford	3·57	— ·38	·94	14	19	75·0	14	47·0	22	0	...
,,		Killaloe	2·81	— 2·12	58	19	17	82·0	9	40·0	22	0	...
XXI.		Portarlington	1·97	— 2·53	·62	20	19	77·0	10	45·0	27	0	0
,,		Monkstown	1·13	— 2 08	·35	17	9	...	...	...	...	...	...
XXII.		Galway	3·64	...	·96	19	19	75·0	13	52·0	9, 20	0	...
,,		Bunninadden (Doo Castle)	2·41	...	·52	19	19	70·0	6	36·0	4	0	...
XXIII		Bawnboy (Owendoon)	...	...	.	...	...	...	...	...	..	...	...
,,		Waringstown	2·47	...	·85	17	12	82·0	9, 12	42·0	14	0	...
,,		Strabane (Leckpatrick)	2·49	..	·44	20	16	76·0	8,9	..	...	...	...

* And 18. † And 13. ‡ And 11. § And 26.

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

METEOROLOGICAL NOTES ON AUGUST.

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, dry, warm, sunny month, favourable to the harvest, and more especially to the hops and fruits. Very little T, but frequent fogs in mornings, followed by hot sunny days. A rather high wind on the 24th, otherwise the month generally calm. Heavy steady R on night of 17-18th and following day, when almost all the R of the month fell (0·94 in.) Bar. generally high; winds mostly S.W. and W. A fine month in every respect.

SELBORNE.—L at night on 11th, 12th, 13th, 14th, and 24th; T on 13th and 24th; fogs in early morning, followed by fine and hot days, on 7th, 8th and 9th; min. temp. on 21st, 60°; heavy shower with H at 6 p.m. on 4th; between noon on 17th and noon on 18th, 1·561 in. of R fell; fine harvest weather from the 26th; winter oats cut on 5th.

BANBURY.—A fine warm month; harvest commenced in second week; considerable quantity of wheat not cut, and a good deal more not carried, at the end of the month, chiefly owing to the scarcity of labour; distant T and L on 13th.

CULFORD.—A month of very dry and warm weather, with a high bar. and S.E. winds; T has not been heard here during the month. From the 9th to the 13th excessively hot; the rainfall of the entire month was only ·29 in., ·25 in. of which fell on the 17th.

BRIDPORT.—Harvest began on 7th; shooting stars seen on the 9th, and on 10th counted 20 between 10 and 11 p.m., mostly disappearing quickly, leaving a slight train; one very brilliant one seen in the S., about 10.30 p.m. Distant T and L on 13th, 14th, and 15th. On the 13th heavy T clouds gathered in the E., and for a short time the L was vivid and T heavy, but very little R fell here, whilst in the neighbourhood R fell very heavily, flooding the rivers here; and three miles distant turnips were washed out of the ground into the high road; heavy S.W. gale on 24th; gale on 20th.

BODMIN.—On the 14th, during a heavy TS, which lasted with little intermission for 12 hours, there fell at 10 p.m. ·60 in. of R in 10 minutes, by far the heaviest fall every witnessed here in so short a time.

CIRENCESTER.—Great TS on 13th, 1·86 in. of R falling.

HAUGHTON HALL, SHIFNAL.—The month opened with a sudden change, from clouds and R to sunshine. Fine harvest weather till the 16th, when R fell heavily again for two days, but without injury to the grain, and with much good to the swedes and green crops, of which there is not a failure, and all growing fast. From the 6th to the 13th inclusive great heat, averaging 77°. The nights of 5th and 22nd very cold, 42° and 41°; fog on morning of 7th and 12th; TS on 13th and 17th, with heavy R on the latter, and dark as night at 10 a.m. Winds variable throughout the month. Harvest all cut but not gathered by the end; wheat barely an average, but ears well filled; oats and barley excellent. Sirex Gigas, a formidable hornet-like insect, captured on 8th; wasps in great numbers on 20th; peacock butterfly first seen on 23rd; red admiral butterflies in numbers on 28th, feed on apricots and sap exuding from an oak. Few mushrooms, the crop having sprung in June.

ORLETON.—A beautiful harvest month, bright, dry and very hot; temp. about 3°·5 above the average of the month; T on 13th, 14th, 16th and 17th. Great TS from 7.30 p.m. to midnight on 13th; rough winds on 20th and 24th.

WIGSTON.—The weather of this month, taking it as a whole, has been very favourable for harvest work, and but little corn in the Midland counties that was not ripe at the end. Wheat is expected to be below the average, barley and oats above.

KILLINGHOLME.—A very fine month for the harvest; wheat harvest began generally on the 21st; the yield is likely to be deficient; potato disease more prevalent than for several years past, other root crops excellent. Shooting stars on 9th, 11th and 12th. TS and heavy R on 17th; high wind on 20th, 24th, 25th and 26th; fog on 9th and 31st; gossamer on 9th, 30th and 31st.

DERBY.—The rainfall about half the mean, and has scarcely at all interferred with the vigorous harvest operations; temp. about 3° above the mean; such weather coming after the wet early summer months, has marvellously promoted the growth of shrubs. Sad report of the extent of the potato disease.

MANCHESTER.—The fall for August unusually small.

YORK.—Severe TS on 18th.

NORTH SHIELDS.—Fine month; aurora on 24th.

WALES.

HAVERFORDWEST.—Very hot fine month, splendid weather for the crops; the first 19 days the temp. much above the average; heavy TS on 13th, 14th, and 15th; 13th, TS and R during the night, intense heat and threatening appearance of the sky towards 4 p.m.; about 7 p.m., sky of ominous blackness, vivid L and continuous T for three hours; the most terrible storm occurring here for many years, several cattle killed, a man struck with blindness, mows of corn set on fire; the display of L, forked and sheet, of the grandest description; storm proceeded from N.E. to S.W.; storm renewed on succeeding night, thought by some to have been more severe than the first one. L almost entirely forked; only ·09 in. of R fell in the second storm in this locality; in places a few miles distant it fell in torrents; the storm was general throughout the county.

CEFNFAES.—Occasional TS during the month; wind N.W. and S.E.; weather unsettled during the last half. Potato disease very general.

LLANDUDNO.—Barley cut on 1st; on 9th, cutting hay in one field and wheat in the next. L on 12th, 13th and 14th; T S at 6 p.m. on 17th: thick fog over the sea and hills from 3 to 5.30 p.m. on 18th.

SCOTLAND.

DUMFRIES.—With the exception of slight showers on the 1st and 3rd, the first half of the month was fine. From 16th to 26th the weather was unsettled; excessive R and storm on 20th; on 24th a violent storm; T on 17th; temp. at night higher, but by day 2°·8 lower than last year, but mean nearly the same, being 61°·5. Harvest commenced on 7th; corn crops good; potatoes abundant, but some diseased; fruit very scarce.

HAWICK.—A fine harvest month; very stormy on 23rd, 24th, 25th and 26th, fruit is a comparative failure here this season; wasps very numerous and very annoying; harvest is now pretty general, and the crops are such as to gladden the hearts of the husbandman.

AUCHENDRANE.—In 24 hours ending at 9 a.m. on the 21st, the rainfall was 2·36 in., the greatest amount measured here since 1865, and in the week ending on the 26th, the amount measured was 3·47. The largest flood in the river was on the 21st; there was also another smaller one on the 25th. The great equatorial storm reached its height here on the evening of the 24th, but it seems to have been felt earlier in the day on the Scandinavian and eastern coasts of Scotland.

DEANSTON.—First three days showery, then dry and hot till the 17th, 18th and 20th, which were wet and cold; heavy R on 23rd and 24th, with gale of wind from W.S.W. on latter day; then to the end of the month very fine harvest weather; much grain reaped, but very little carried to stack yards.

LOGIERAIT.—With the exception of seven wet days, a fine harvest month. Temp. high. Potato disease very general.

BALLATER.—Very little R has fallen, weather very favourable for harvest purposes; crops look well. Brilliant aurora on 24th.

ABERDEEN.—A month of fine warm weather, during which the crops have advanced with unexpected rapidity. Fog on 6 days. Aurora on 18th, 21st, 23rd, 24th, and 27th.—*Erratum*: In last month for "Inverruie" read "Inverurie."

PORTREE.—Wet and squally month; heavy gale on the 24th, from S., accompanied with heavy R. Potatoes much diseased. Harvest began on the 18th, and is now general over the country, and fully an average crop.

LOCHBROOM.—This has been a particularly fine month; farm operations are much advanced, some have the crops cut and half stacked; the harvest is considerably earlier than usual. There is no sign of the potato disease in this locality,

and, with a steady and profitable herring-fishing, things look well for the poor man.

SANDWICK.—Auroræ on 13th, 21st, 23rd, and 26th. Gale, 50 miles an hour, from 5 till 8 a.m. on 25th. Sea roaring on 31st August. Has been a fine month, 2° warmer and slightly drier than the average.

IRELAND.

GALWAY.—Severe T S on 29th, much damage done by it.

DOO CASTLE.—A good month for farming operations. The oat crop, after all, a pretty good one; but I regret to say the potatoes are a failure. T S on 29th, some damage done, and I see, by the papers, some lives have been lost.

WARINGSTOWN.—A fine warm month; considerable progress made with harvest, although the third week was very wet. Crops, on the whole, very good in this district.

LECKPATRICK.—First half of month dry. On the whole a good harvest month.

THE HEAT OF AUGUST.

To the Editor of the Meteorological Magazine.

SIR,—I beg to forward to you the readings of various thermometers during the hot period which prevailed from Aug. 9th to the 15th. The shade maximum of the 13th and 14th are the highest readings which have ever been registered here since the present series of meteorological observations were commenced in 1851, and such a high shade temperature for August has not been observed since the year 1856, when the maximum thermometer in shade registered 81°·1.

Date.	9 a.m.		Self-Registering Thermometers.		
	Dry Bulb.	Wet Bulb.	Max. in Air, in shade.	Solar Black Bulb (in vacuo.) At 4 ft.	On Grass.
Aug. 9	74°·3	66°·6	79°·5	134°·5	144°·7
,, 10	77 ·6	68 ·8	80 ·1	127 ·8	138 ·0
,, 11	74 ·9	65 ·6	76 ·0	126 ·5	141 ·5
,, 12	76 ·2	68 ·0	80 ·2	128 ·0	141 ·8
,, 13	80 ·9	71 ·4	84 ·0	130 ·0	143 ·0
,, 14	74 ·9	68 ·4	85 ·1	133 ·5	145 ·0
,, 15	70 ·2	63 ·8	78 ·2	128 ·6	142 ·2

Yours obediently,
WM. J. HARRIS, F.M.S.

Worthing, Sept. 2nd, 1871.

THE EXPERIMENTAL RAIN GAUGES.

Owing to the unexpected speedy removal of the Rev. F. W. STOW, from Hawsker to a locality where he will be unable to continue to observe the above instruments, they are now offered, on loan, to any person or persons who may have facilities for, and be desirous of continuing in any form the experiments for which these instruments have been constructed. All communications on the subject should be promptly addressed to Mr. SYMONS, 62, Camden-square, N.W.

NOTE.—Although this number contains four extra pages, several valuable notes are unavoidably postponed.

SYMONS'S

MONTHLY

METEOROLOGICAL MAGAZINE.

LXIX.] OCTOBER, 1871. [PRICE FOURPENCE, or 5s. per ann. post free

DEW-POINT AND OTHER HYGROMETERS.

THE investigations as to the amount of evaporation from a water surface, resumed by Mr. Dines in 1869, have led to some rather unexpected results, and suggest, nay demand, prosecution at the hand of some person with more leisure time. We, therefore, with Mr. Dines's permission, will endeavour to place before our readers a *résumé* of part of what has been done, hoping thereby to induce one or more of them (there is work for several) to continue the enquiry.

A balance, capable of weighing with extreme accuracy, was arranged with a small vessel of water in one of the pans (A). A very delicate thermometer was suspended from the A end of the beam, so that its bulb was just immersed in the water. Weights were placed in the other pan B, until the water, &c., was exactly counterpoised. If the water in the vessel evaporate, weights must be removed from B to preserve the equilibrium; if it be cold enough to condense vapour from the air it will become heavier and weights must be added to B. It was found that if the water were hot it evaporated rapidly, and gradually less until the immersed thermometer was at a temperature *below* the dew-point temperature as computed by Mr. Glaisher's tables. And, conversely, it was found that if the vessel were filled with pounded ice, condensation occurred, A became heavier, and weights had to be added to B. Condensation, however, always ceased some 3° to 4° below the computed dew-point temperature. These results lead to three alternatives:—(1) That there is some error in the experiments. (2) That there is some error in the hygrometrical tables. (3) That the dry and wet bulb thermometers do not enable us to ascertain the dew-point correctly.

The second phase of the investigation is so clearly and concisely given in the *Proceedings of the Meteorological Society*, for March 1871, that we reproduce the note *verbatim*.

"While making some experiments connected with evaporation (see *Proceedings of Meteorological Society* for November 15, 1870), it was found that when the difference of the dry and wet-bulb thermometers amounted to 8° or 9°, evaporation commenced from the surface of water at a time when the thermometer immersed in the water showed a temperature of from 3° to 4° below the temperature of the

dew-point as obtained by calculation; but on repeating the experiments in air saturated with moisture, when the dew-point temperature could be obtained direct from the thermometer, the dew-point temperature, and that of the water when evaporation commenced, agreed with each other. As no satisfactory reasons have been assigned for this discrepancy, I made other experiments, as follows:—small globes and cylinders, both of glass and metal, were used, the substance of which was made as thin as possible; these were filled with iced water; a thermometer, with the bulb 1½ inch in length, was inserted in the water, the stem of the thermometer passing through the centre of the stopper; the whole was then suspended from the beam of a delicate balance. The outsides of the vessels were, of course, immediately covered with condensation, the amount of which was only occasionally noted, the one object of the experiments being to determine the exact temperatures of the water at the time when condensation ceased upon the surface of the vessels, and the moisture deposited upon them commenced to evaporate; that time was clearly shown by the stationary position of the index-rod attached to the balance, just previously to its commencing a retrograde movement. If the thermometer immersed in the water at the time this change took place fairly represented the temperature of the outside of the vessel, it would, without doubt, give also at the same time the true dew-point temperature. Every care was taken with the covering and supply of moisture to the wet-bulb thermometers; and as an additional precaution two sets of dry and wet-bulbs were used, the differences (8° to 9°) of which did not vary much from each other; but those which gave the widest readings, and consequently the lowest dew-point, were taken. Whether the vessels used were larger or smaller, of glass or of metal, or whether the moisture upon the outside was allowed to accumulate almost in drops, or the film of moisture so thin as to be scarcely weighable, the results were nearly the same; condensation ceased and evaporation commenced from the surface of the vessels at a time when the water inside the vessels was 3° to 4° below the temperature of the dew-point as obtained by calculation.

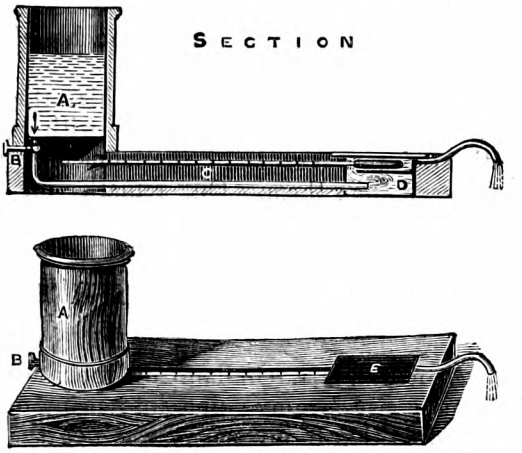
"It will be objected to these experiments that the thermometer placed in the water does not give the true temperature of the outer surface of the vessel from which the evaporation takes place; I fully admit the force of this objection; but does it not apply with equal force to both Daniell's and Regnault's hygrometers as at present used?

"There are, however, these differences in the method of operation; in one case the ether in which the thermometer is immersed is gradually cooling, whereas in my experiments the water is gradually getting warmer; again, in one case the eye is used to determine the time at which condensation begins; in my experiments a delicate balance is substituted for the eye; but I can see no reason in these differences why the results should vary so greatly. I have not compared the results obtained by the wet and dry-bulb hygrometer with those of Daniell's and Regnault's; this has been done by others, and found to agree very nearly; and I have therefore no reasons to conclude that the factors given in Table I. of Glaisher's Hygrometrical Tables are incorrect, as far as their agreement with Daniell's and Regnault's hygrometers are concerned.

"The experiments noticed in this paper have been made at night by artificial light, and therefore under some disadvantages; as the summer advances, I hope to repeat some of them by daylight, but, judging by former experience, do not expect it will alter the results. I cannot at present see my way out of the difficulty; and as the importance of a correct determination of the dew-point temperature cannot be overrated, I have taken an early opportunity of calling the attention of the Society to these experiments, with the hope that some one with more favourable opportunities than myself may be induced to take up the question."

We now come to the third and last phase of the inquiry, viz., to the consideration of the arrangement, designed by Mr. Dines, for ascertaining the dew-point by direct observation, and to which the maker, Mr. Casella, has given the name of "Sensitive Hygrometer." Sensitive,

indeed, is it beyond all comparison, and we are inclined to think as correct as it is sensitive. Let us explain its construction:—A is a



small zinc-lined wooden reservoir, which is to be supplied with water at a temperature a few degrees below the probable dew-point; B is a tap for regulating the flow of water from A, through C to the chamber D. The black horizontal line in this chamber represents a partition inserted to secure thorough mixture of, and equability of temperature in, the water, at the instant of its passing the bulb of the thermometer and being discharged by the outlet pipe. E is an extremely thin sheet of black glass, and it is assumed that the temperature of its upper and under surfaces (perhaps 0·015 inch apart) are nearly the same. The lower one is in contact with the water, and the latter, as will be seen, circulates around the thermometer bulb. Independent of actual trial, it seems difficult to believe that the temperature of the thermometer bulb and of the glass slab can differ more than 0°·2 or 0°·3, and this is confirmed by experiment. The mode of observation is thus explained in Mr. Casella's descriptive paper:—

"In using this instrument, water of a little lower temperature than the dew-point is required, well water being frequently found sufficiently cold for the purpose, or it may be cooled by adding a little ice. Fill the reservoir A with water, as above, then turn the tap B attached to the pipe C, that the water may flow through the small chamber D, and cool the thin black glass E, with which it is covered. Immediately the dew appears upon the surface of the glass, turn off the tap B, and observe the attached thermometer, which will then indicate the temperature of the dew-point. When this is known approximately, but greater accuracy is required, the tap B should be slightly turned off, so as to allow the water in D to pass very slowly as it approaches this temperature, so as to cool down gradually. By using a piece of wash-leather to dry the glass, successive deposits of dew may be rapidly obtained, when the dew-point will be found sometimes to vary considerably in a short time, the dew upon the glass appearing and disappearing several times in a minute.

"Should any obstruction occur in the pipe, it may be easily removed by blowing through the outlet."

To ourselves the special charm of this instrument is its extreme

sensibility, and the perfect control which the observer possesses over it. While it is essentially an apparatus for experimental research, its moderate price, and interesting indications, will commend it to all those who are interested in the more delicate branches of meteorological inquiry.

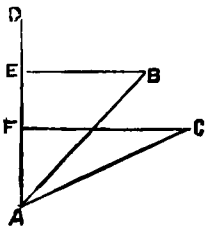
As we indicated at the commencement of this article, our special desire is to secure thorough comparison of this with other Dew-Point instruments. with Dry and Wet Bulb thermometers, and with the Dew-Point as deduced from them. Our remarks on these subjects must be deferred till our next number.

THE DECREASE OF RAINFALL WITH ELEVATION.

To the Editor of the Meteorological Magazine.

SIR,—Mr Strachan and Mr. Crallan, by their admirable letters, have obviated the necessity for my going into many of the details of the question. The objection to my theory was not that it was improbable, but impossible. Both these gentlemen have in different ways shown that decrease *may* be due to difference of angle, and, further, that the presumption of probability is against the objectors. Mr. Crallan has shown that if no part of the decrease in elevated gauges is due to the effect of change of angle, it is necessary to suppose, with Dr. Burder, a perfectly horizontal discharging surface devoid of thickness. Mr. Strachan has shown that it is necessary to suppose the rain to be deflected in a perfectly horizontal plane, and I may add *simultaneously* deflected, so that no gusts or irregularities in the wind can on any account be allowed.

Now, I submit that these suppositions are unlikely to be realized in nature. That a cloud possesses thickness and discharges rain from various heights is so obvious, that it is scarcely necessary to prove it by the experience of mountain walks in wet weather, especially as the clouds are not unfrequently obliging enough on the sea-coast to descend very nearly to the sea-level during a fall of rain, as happened here only a few days ago. Taking into consideration the thickness of a cloud, we may consider the rain near the ground to consist of two components—that discharged from a horizontal and that discharged from a vertical surface. The drops from the former will diverge as they approach the ground, *but preserve the same horizontal distance ;* and those from the former will approach each other, *but preserve the same vertical distance.* The former therefore should affect vertical and not horizontal gauges, but the latter should affect horizontal but not vertical gauges. The increase in vertical gauges should be due to the former, the decrease in horizontal gauges to the latter. If each cloud were as high as it is long, and discharged rain uniformly from all parts, these two tendencies in the mixed rain would just counteract one another, and therefore the density of the rain would be, as at first I supposed it to be, the same at different heights above the ground. This state of things is represented in fig. 1.



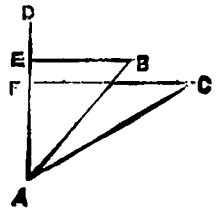
Let A B, A C, represent the amounts received in gauges the mouths of which are at right angles to the path of the rain, at the heights of 1 ft. and 10 ft. respectively. A B, A C, are therefore measures of the density of the rain at those heights.

Let D A B, D A C, be the angles which the path of the rain makes with the vertical at the same heights; E A, F A represent the amounts caught in horizontal gauges; E B, F C, the amounts caught in vertical gauges.

Then if A B = A C, the relation between these amounts is—

$$E A^2 + E B^2 = A F^2 + F C^2.$$

Certainly, I see nothing monstrous in such a supposition (which although exaggerating, as I doubtless did, its importance, I *avoided* calling an axiom), but it must be given up. The results of the experiments show that A C is always greater than A B. The real state of things is correctly represented in fig. 2, from which it is obvious



that the increase in vertical gauges is much greater than the decrease in horizontal gauges. I need hardly point out how this result confirms what Mr. Crallan has written, since it is highly probable that the length of a cloud is generally much greater than its height.

I am much obliged to Mr. Du Port for his explanations. By the "aperture which a gauge presents to falling rain," I mean the area of a section (made at right angles to the axis) of the cylinder which may be supposed to contain the rain. The area of this section would evidently decrease as the rain fell more obliquely.

I will add a few remarks, if you have space for them, on some of the theories started or favoured by your correspondents.

(1) Evaporation is a real cause of decrease with elevation, but it cannot be the principal cause for two reasons:—First, its effect was eliminated in the experiments at Calne, Strathfield Turgiss, and Rotherham, by conducting the water from the elevated gauges by means of pipes into bottles or other receivers on the ground. Next, it

would make the decrease immensely greater in summer than in winter, which is the exact reverse of the fact.

(2) Eddies.—No doubt a gauge, like any other obstacle, may cause eddies in the wind, but these eddies can only be formed behind or at one side of the obstacle, and cannot affect the rain which falls from in front and above. If the eddies spoken of are *in* the gauge, they would have the effect of placing the rain into the pipe, an effect which I have witnessed in the case of light snow.

But I think it very likely that the fall near the ground is, in certain situations, considerably increased by the wind rushing downwards in gusts and bringing the rain almost vertically into the mouth of the gauge. Here, however, the effect, though irregular, is still the result of a change of angle in the path of the rain.

(3) With regard to the wind blowing away rain-drops which alight on the rim, I cannot see why it is not as likely to blow them in as to blow them out.

(4) "Coalescence of spray."—I feel difficulty in believing in the existence of bodies not acted upon by gravitation, and as elevation differences are always small in heavy rain, when this theory would require them to be greatest, no more need perhaps be said.

Mr. Pennant's letter refers apparently to bodies falling *in vacuo*, while acted upon by some horizontal force, since he takes no account of the resistance of the air.

Lastly, let me remind your readers of some of the conclusions arrived at by the Rainfall Committee of the British Association in their report for 1867-8. The Committee includes some of the highest authorities on meteorological matters.

"The ratio of the fall on the ground to that at 25 ft. above it, bears a nearly constant relation to the angle of fall."

"The relation of these results to their cause, wind, is shewn," &c., "and the accordance would doubtless have been more complete if," &c.

My only comment on this is, that the force of the wind is not an exact measure of the decrease with elevation, because it is not an exact measure of the angular deflection, which depends also on the weight of the rain-drops.

It cannot then be denied that there is a relation between angle and decrease with elevation; and the step from this to my theory—that when rain is deflected by wind it is spread over a somewhat larger area than when it falls vertically, and therefore that less falls on the same horizontal surface in proportion as the angle with the vertical is increased—is not a long one.—I am, Sir, your obedient servant,

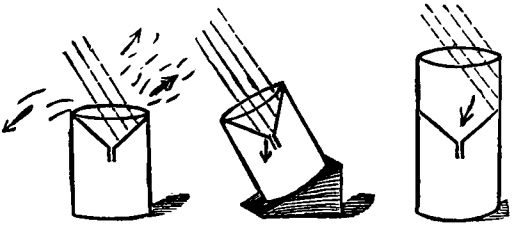
FENWICK W. STOW.

Hawsker, Sept. 26th, 1871.

To the Editor of the Meteorological Magazine.

SIR,—It appears to me that there is a *vera causa* for the decrease of rain-fall with elevation, which would go far to reconcile Mr. Stow's theory with Dr. Burder's physical law, that equal quantities of rain fall upon

equal horizontal surfaces, whether the drops arrive in an oblique or perpendicular direction. It is simply this :—the "surface" of a rain-gauge on which rain falls is not the same thing as the area of the orifice or funnel, it is not horizontal or nearly so; if it were, the loss from splash would be very great. But the sides of the funnel of all good gauges slope at an angle suitable for the reception of rain drops at their average inclination at the level of the ground, the drops, therefore, fall on an inclined plane, and glide from it into the receptacle prepared for them.



How is it, however, with the same, or a similar rain-gauge when exposed to showers at higher levels, while the rain falls, say, at an average angle of 45° ? In this case the drops strike upon the sides of the funnel at right angles, or nearly so, and that with some violence. Consequently, there must be a considerable amount of splash, and a corresponding loss of water. If a rain-gauge, then, at an elevation of 20 or 30 feet were to be inclined at an angle of 40° or 45° in the direction of an approaching shower, it would, probably, be found to receive more rain than one set horizontally. A like result would follow if the walls of a gauge, set in the ordinary manner, were carried up a sufficient height above the funnel to direct the drops downwards into the receptacle. Very possibly other causes may assist in producing the full results.—I am, Sir, &c.

J. PARK HARRISON.

Ewhurst, Surrey, Oct. 4, 1871.

To the Editor of the Meteorological Magazine.

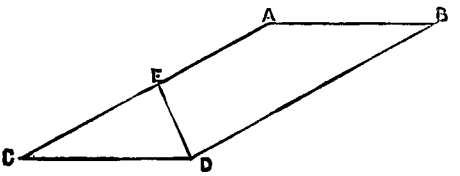
SIR,—I expect the majority of your readers who have carefully followed the correspondence on this subject must have come to the conclusion that Dr. Burder is right, and Mr. Stow wrong.

It has not, I think, been sufficiently borne in mind that hitherto rainfall has invariably been defined as the amount of rain falling on a horizontal surface; until this is clearly understood and admitted we can never agree.

Mr. Stow's pertinacity about vertical gauges is amusing. No one, I take it, would be so infatuated as to deny that the nearer at right angles the surface of a gauge meets the rain, the greater will be the amount collected. All we contend for is, that inasmuch as we cannot tilt up our fields to meet the rain at right angles, neither must we so tilt up our rain gauges.

Mr. Du Port's argument and diagram in your last number appear to me to prove the fallacy of Mr. Stow's conclusions as to vertical gauges beyond all question.

It is, I think, easily shown to what extent inclined gauges give erroneous results. During a shower falling at an angle of 60° with the vertical, let us imagine, at a short distance from the ground, a square, horizontal surface, whose side is A B.



The rain which falls on A B_2 would, if not interrupted, fall to the ground between the lines A C and B D, and cover C D_2. Now if we interpose an inclined surface, as E D, at right angles to the direction of the rain, we find that the whole of the rain due to C D_2 is intercepted by the rectangle E D, D C ; and since E C D is an angle of 30°, E D is half D C, the rect. E D, D C is half C D_2, and therefore collects twice as much rain as is due to its *horizontal area.* The greater the obliquity of the shower, or in other words, the greater the disparity between E D and D C, the greater will be the excessive horizontal area monopolized, so to speak, by the rect. E D, D C, and the greater the *excess* of rain intercepted by it. If, therefore, we wish to measure the amount of rain due to C D_2, by a gauge inclined at right angles to the rain, we should take, say a 5 in. gauge, reduce the area of its receiving surface in the proportion of the rect. E D, D C : C D_2, and then the amount of rain collected, if measured in the proper glass for a 5 in. gauge, would tell us the true horizontal rainfall of C D_2. If the rain falls vertically, the rect. E D, D C becomes identical with C D_2, and at whatever angle it falls, the argument holds good. I should feel inclined, therefore, to state it as a general law, that—"The ratio of the amount of rain collected by a gauge whose receiving surface is kept at right angles to the showers, varies as the cosecant of the angle which the rain makes with the horizon." Of course we are all aware that at present we have not succeeded in constructing a gauge whose surface shall always meet the rain at right angles ; all I wish to prove is, that such gauges are theoretically incorrect.

The fact that the rain-drops do not travel in straight lines seems to me to be just as inimical to Mr. Stow's theory as to any other, and I cordially concur with Dr. Burder that horizontal rainfall can only be fairly measured by horizontal gauges.—I am, Sir, yours, &c.,

REGINALD BUSHELL.

Hinderton, Neston, Cheshire. Oct. 4th.

P.S. Will you allow me to suggest, that if any limit is to be put to this discussion, you should declare beforehand what that limit is to be, and then adopt some means of *dividing* upon the question? It

would at least be interesting to know the opinion of the majority of your readers.

[We agree with Mr. Bushell that it will be most desirable to ascertain the general opinion upon the points at issue, but before a verdict there must be the summing up. Although conscious that we are not capable of discharging this duty so well as could be wished, we intend to attempt it in our next issue.—ED.]

THE SEPTEMBER RAINS.

THE fall of rain during the last eight days of September was so heavy as to claim full examination, we have therefore drawn up, from some of the many returns with which we are favoured, the following tables.

The rainfall of September, 1871, is noticeable for two features, one to a considerable extent dependent on the other: the first is, that the monthly total is at many stations greater than before recorded, and even in the longest registers very few equal to it are to be found. Let us take two illustrations: at Cobham the record goes back to 1825; the fall last month was 4·72; during the forty-six years there have only been two Septembers in which the fall has been greater, viz., 1826, = 5·17, and 1839 = 5·74. At Haughton Hall, Shifnal, the fall has been 5·27, and during thirty-seven years this has only once been equalled, viz., in 1866, when 5·40 fell. Of the stations quoted in our usual table the relative excess has been greatest at York (2·84 times the average), Orleton, Shifnal, and Selborne; at Manchester it only just exceeded the average, and in Scotland was far below it.

A few words as to the last eight days will appropriately close this brief notice.

Sept. 23.—A fall of about half-an-inch over the greater part of England, and of between 1 in. and 1½ in. in the South Eastern counties.

24th.—Very little rain, except in the Northern counties. The entry for Linton Park must surely belong to the 23rd.

25th.—About half-an-inch at most English stations; less in the North, and considerably more in the South Midland counties.

26th.—The average fall nearly the same as on 23rd and 25th, but rather heavier in the West and South-West of England than on previous days. A heavy but somewhat local fall in the South of Ireland.

27th.—The average fall rather heavier than on any of the preceding days, especially in Yorkshire and the North of England.

28th.—About one-tenth of an inch fell at most stations; more is reported from one or two isolated ones, but we believe that this is solely through failure to comply with Rule IX.*

29th.—At the majority of stations this was the day of much the largest fall; it reached an inch at most English stations, and 2 inches at several, although as it happens only two such cases are quoted in the following table.

* "The amount of rain measured at 9 a.m. on any day is to be set against the previous one; because the amount registered at 9 a.m. of say 17th contains the fall during 15 hours of the 16th and only 9 hours of the 17th."

30th.—For this day rain was recorded at nearly every station, but its amount was not considerable.

At Ballachulish, Argyle, no rain fell during the eight days.

Rainfall during the period September 23rd—30th, 1871.

		SEPTEMBER.								TOTALS.	
Div.	Station.	23rd	24th	25th	26th	27th	28th	29th	30th	Mnth	8 dys.
I.	Regent's Pk. (R. Bot. Soc.)	·96	...	·67	·32	·76	·11	1·16	·47	5·17	4·45
,,	Camden Square	·97	...	·68	·34	·75	·04	1·22	·44	5·28	4·44
,,	Hampstead (Squire's Mt.)	·73	·02	·63	·30	·59	·20	1·08	·44	4·86	3·99
,,	Harrow(Northwick House)	·46	·01	·64	·39	·42	·06	1·07	·07	4·20	3·12
,,	Winchmore Hill	·81	...	·79	·31	·58	·08	1·07	·46	4·93	4·10
II.	Guildford (Guildown)	1·00	...	·38	·44	·71	·02	1·05	·81	5·53	4·41
,,	Dorking (Denbies)	1·76	·03	·45	·43	1·24	·12	1·02	·76	6·41	5.81
,,	Cobham (Pyports)	·95	·01	·53	·29	·40	·01	1·16	·63	4·72	3·98
,,	Croydon (Tanfield Lodge)	1·63	·03	·26	·20	·80	·05	·90	·46	5·01	4·33
,,	Balham	1·00	...	·63	·22	·96	·02	·83	·53	...	4·19
,,	Maidstone(Linton Park)...	·13	1·38	·04	·47	·33	·79	·23	·15	4·44	3·52
,,	Riverhead, Sevenoaks	·72	...	·49	·40	·75	·06	1·00	·39	4·71	3·81
,,	Margate (Acol).....	·90	...	·68	·13	·24	·07	·42	·17	3·28	2·61
,,	Chiselhurst	·87	·01	·62	·22	·72	·03	1·23	·30	4·77	4·00
,,	Beckenham (Parkside) ...	1·65	·01	·63	·24	·53	·03	·97	·46	5·35	4·52
,,	,, (Fox Grove) ..	1·62	·01	·63	·22	·58	·03	·91	·43	5·19	4·43
,,	Eltham Green	1·47	·01	·67	·20	·60	·03	1·21	·50	5·57	4·69
,,	Worthing.....	·91	...	·34	·21	·16	·05	·60	·30	3·07	2·57
,,	Pevensey	·94	...	·37	·34	·30	...	·28	·13	3·13	2·36
,,	Hastings (High Wickham)	1·31	..	·62	·58	·53	...	·36	·18	4·50	3·58
,,	Osborne.....	1·28	·32	·26	·21	·06	·70	·48	·06	...	3·37
,,	Lymington	·81	...	·58	·66	·18	·09	1·07	·48	5·82	3·87
,,	Selborne	·88	...	·58	·58	·66	·06	·68	1·06	6·44	4·50
,,	Strathfield Turgiss	·42	...	·64	·61	·19	·06	·70	·41	4·20	3·03
,,	Wantage	·82	...	1·17	·56	·32	·14	1·50	·20	...	4·71
III.	Hitchin	·72	·15	·47	·30	·27	·15	1·38	·26	4·40	3·70
,,	Great Missenden	·60	...	1·10	·53	·50	·55	·75	...	...	...
,,	Banbury	·70	·03	·54	·66	·42	·09	1·60	·16	5·41	4·20
IV.	Ramsay (Wix).....	·44	·02	·54	·42	·33	·18	1·31	·26	...	3·50
,,	Bury St. Edmds. (Culford)	·45	·13	·21	·22	·35	·11	1·65	·43	4·40	3·55
,,	Diss	·34	·07	·14	·25	·33	·11	1·60	·18	3·67	3·02
,,	Brandon (West Tofts).....	·43	·08	·12	·24	·60	·15	1·56	·29	4·32	3·47
,,	Norwich (Thorpe)	·47	·17	·05	·19	·89	·12	1·99	·26	5·07	4·14
,,	Swaffham	·52	·16	·04	·24	·27	·19	1·34	·35	3·99	3·11
,,	Hillington	·48	·20	...	·20	·24	·20	1·33	·33	3·64	2·98
V.	Chippenham	·62	...	·89	·67	·38	·07	1·04	·29	5·93	3·96
,,	Bridport	·25	...	·32	·70	·41	·16	·91	·66	4·50	3·41
,,	Shaftesbury	·35	...	·57	·79	·41	·10	·69	·21	4·31	3·10
,,	Dartmoor Prison	·89	·03	·84	·70	1·94	·28	1·00	·86	9·65	6·54
,,	Tavistock (KilworthyHill)	·31	...	·29	1·04	·46	·11	·74	·62	5·73	3·57
,,	Okehampton.....	·62	·01	·82	·54	·53	·16	1·27	·50	6·51	4·45
,,	Holsworthy (Court Barn)..	·31	..	...	·33	·78	·67	·11	1·50	5·26	3·70
,,	Barnstaple	·39	...	·30	·33	·27	·81	·95	·24	4·37	2·61
,,	Bodmin.....	·36	·05	·59	·98	·70	·10	1·28	·67	8·52	4·73
,,	Crewkerne (Bincombe) ...	·60	...	·46	·66	1·08	·10	1·24	·38	5·80	4·52
,,	Taunton (The Castle).....	·58	...	·72	·43	·56	·08	·75	·17	4·97	3·29
VI.	Cirencester (The Firs).....	·56	...	·55	·81	·97	·11	·98	·20	5·60	4·18
,,	,, (Further Barton)	·63	...	·65	·95	·70	·16	1·27	·27	6·70	4·63
,,	Ross (Archenfield)	·38	...	·70	·66	·59	·11	1·66	·10	6·62	4·20

		SEPTEMBER.								TOTALS.	
Div.	Station.	23rd	24th	25th	26th	27th	28th	29th	30th	Mnth	8 dys.
VI.	Orleton	·46	·05	·28	·42	1·16	·07	2·02	·28	7·25	4·73
,,	Shifnal	·51	·06	·04	·60	·85	·02	1·36	·13	5·27	3·57
,,	Shrewsbury (Monkmoor)	·24	...	...	·53	·83	·01	1·43	·07	4·42	3·11
,,	Henley-in-Arden	·37	·38	·37	·73	·55	·06	1·54	·17	5·75	4·17
,,	Bickenhill Vicarge	·61	·07	·20	·70	·52	·04	1.54	·37	5·64	4·05
VII.	Wigston	...	·15	·33	...	·50	·60	1·45	·23	4·50	3·26
,,	Boston	·39	·15	...	·19	·63	·07	1·03	·27	3·79	2·73
,,	Killingholme	·39	·57	·02	·26	·73	·02	1·23	·23	6·12	3·45
,,	Derby	·58	·22	·01	·38	·74	·01	1·25	·20	4·92	3·39
VIII.	Neston (Hinderton)	...	·15	...	·23	1·09	·01	1·16	·07	3·95	2·71
,,	Manchester	·05	·18	...	...	1·20	·04	·47	·13	3·82	2·07
IX.	Tickhill	·25	·16	...	·16	·76	·05	1·37	·20	5·23	2·95
,,	York	·03	·62	...	·06	1·90	·01	·65	·23	6·60	3·50
,,	Arncliffe	·35	·32	...	·06	1·30	·04	·32	·55	6·04	2·94
X.	Darlington (Gainford)	·54	·81	...	·14	1·63	...	..	...	...	...
,,	N. Shields	·31	·72	...	·09	1·08	·03	·27	·22	4·01	2·72
,,	Grasmere (High Close)	·13	·29	...	·03	·15	...	·08	·71	3·73	1·39
,,	Seathwaite	·62	·18	·28	...	·34	...	1·08	...	5·53	2·50
XI.	Haverfordwest	·08	...	·15	...	1·00	·06	2·54	·74	7·48	4·57
,,	Cefnfaes	·05	·10	1·00	...	...	·40	1·10	·40	4·15	3·05
,,	Wrexham (Trevalyn Hall)	·04	·09	...	·18	1·64	·03	1·43	·13	4·80	3·45
,,	Llandudno	·08	·89	...	·33	·25	...	·84	·07	3·59	2·46
,,	Beddgelert (Pen-y-gwyrd)	·25	·25	·50	·25	...	·25	·25	·25	5·00	2·00
,,	Carnarvon (Plas Brereton)	...	·44	...	·10	·17	·02	·57	·30	3·14	1·60
XII.	Dumfries (March Hill)	·27	·56	...	...	·07	...	...	·33	2·63	1·23
,,	Hawick (Silverbut Hall)	·12	·18	·02	·03	·29	·02	·04	·09	1·95	·79
XIV.	Glasgow (Cessnock Park)	·07	...	...	...	·08	...	·06	·12	1·52	·33
,,	Ayr (Auchendrane)	·13	...	...	...	·04	...	·03	·06	2·08	·26
,,	Patna (Hole House)	·12	...	...	...	·05	...	...	·24	2·45	·41
XV.	Castle Toward	·39	·11	·01	...	...	...	...	...	1·61	·51
,,	Ballachulish	..	...	...	...	...	...	...	...	2·67	...
XVI.	Leven (Nookton)	·03	·03	·02	...	·21	...	·03	...	1·44	·32
,,	Deanston	·02	·01	...	...	·04	·01	·01	·28	1·90	·37
XVII.	Aberdeen	·40	·03	·01	...	·08	·15	·01	·06	2·17	·74
,,	Ballater	·05	...	...	...	·40	·33	...	·35	3·46	1·13
XX.	Cork (Queen's College)	...	...	...	1·89	·31	...	...	·46	4·59	2·66
,,	Fermoy (Glenville)	..	...	...	1·57	·43	...	...	·52	4·77	2·52
,,	Killaloe	..	..	·01	·30	...	...	...	·50	2·02	·81
XXI.	Portarlington	·02	·01	...	...	·50	·03	...	·02	1·60	·58
,,	Monkstown	..	·05	...	1·07	·24	·01	·03	·13	3·41	1·53
XXII.	Galway	·13	·03	...	...	·27	...	·12	·39	2·18	·94
,,	Ballinasloe	...	..	...	·61	·01	...	...	·41	1·66	1·03
,,	Doo Castle	...	·01	·10	·16	·05	...	·40	·30	2·21	1·02
,,	Waringstown	·52	·30	..	·09	·15	·08	·30	·17	3·36	1·61
,,	Leckpatrick	·30	·03	...	...	·03	·02	·02	·30	2·39	·70

SOLAR THERMOMETERS.

To the Editor of the Meteorological Magazine.

SIR,—I take the opportunity afforded by the recent very hot weather to send you some account of my Solar Thermometers. The maxima temperatures in sun, given in the table, are from a thermometer, "*in vacuo*," having the bulb and part of the stem blackened. The non-exhausted thermometer in the next column is of similar construction,

except that the air is left within the jacket, there being no occasion for the doubtful process of exhaustion. Thermometers constructed on this principle would, I think, from what I can judge, be far more reliable in every respect than the vacuum instruments.

The bright-bulb thermometer in the next column has an unblackened mercury bulb, enclosed in a non-exhausted jacket, and should give us an idea of the actual temperature within the jacket, without the influence of the receiving surface of the bulb when blackened. See *Meteorological Magazine*, Vol. III., page 18, on the results of a bright-bulb thermometer in the sun, compared with one in the shade.

I have for some little time been trying a solar thermometer, constructed from an idea of Mr. Pastorelli's, precisely similar to the non-exhausted one, only that the air is admitted at both ends of the instrument through two small orifices. The general result is readings lower by a few degrees than the thermometer with air within the jacket; but the wind appears to exert very little influence indeed, and the difference on the whole is remarkably uniform, as will be seen from the annexed simultaneous readings during July.

Mr. Stow has however, I am glad to find, adopted the excellent plan of sending round a Solar thermometer, as a standard of comparison, to all his observers, to test their instruments by, so this is, indeed, another great step towards comparing the sun temperatures of the different localities, and I for one at any rate shall be most anxious to do all in my power to forward this object. I only hope that we shall soon hear that something like a systematic comparison of the different stations has been begun, for it is now considerably more than a year since we had a line from Mr. Stow, in the Magazine, on the results of the different observations sent in.—Yours, very truly,

FRANCIS NUNES.

Heathfield Lodge, Chislehurst, Kent.
August 28th, 1871.

Thermometers at 5 ft.; Max. in Sun.

Days.	Ther. with air at both ends.	Non-exhausted.	Days.	Ther. with air at both ends.	Non-exhausted.
	deg.	deg.		deg.	deg.
July 1.....	119·0	119·2	July 17 ...	119·2	119·2
,, 2.....	88·7	89·5	,, 18.....	116·3	116.2
,, 3.....	115·2	115·7	,, 19.....	123·0	123·8
,, 4.....	108·4	109·3	,, 20.....	108·0	109·3
,, 5.....	114·0	114·0	,, 21	115·0	116·0
,, 6.....	112·7	112·0	,, 22.. ...	109·8	111·0
,, 7 ...	118·8	119·0	,, 23.....	117·7	118·6
,, 8.....	115·7	116·3	,, 24	110·0	110·0
,, 9	116·8	119·3	,, 25.....	114·3	114·8
,, 10.....	118·5	120·3	,, 26.....	116·0	116·5
,, 11.. ...	108·7	109·0	,, 27.....	119·3	120·0
,, 12.....	110·2	111·0	,, 28.....	106·5	107·3
,, 13.....	102·7	103·8	,, 29.....	117·7	118·0
,, 14.	116·7	116·5	,, 30	108·3	109·4
,, 15.....	120·7	122·2	,, 31... ..	113·8	114·3
,, 16	122·7	127·0			

Thermometers at 4 ft.					On Grass.
Shade.		Sun.			
Day.	Max.	Vac. Black Bulb Max.	Non-exhausted Blk.Bulb Max.	Non-exhausted Bright Bulb Max.	Vac. Black Bulb Max.
	deg.	deg.	deg.	deg.	deg.
1...	78·1	136·3	118·3	86·8	147·0
2...	83·8	142·0	124·7	93·8	150·0
3...	83·7	136·8	121·0	92·0	150·2
4...	72·1	128·5	111·3	83·0	139·3
5...	77·3	134·5	117·2	87·7	148·0
6...	80·3	131·2	118·5	91·7	145·5
7...	81·8	136·5	121·5	93·8	148·0
8...	81·0	133·5	118·5	93·0	147·0
9...	85·8	137·8	123·3	96·7	151·5
10...	89·4	136·5	123·2	97·3	148·2
11...	91·7	139·0	127·7	101·2	150·7
12...	91·0	138·4	126·0	100·2	146·5
13...	91·1	138·3	125·5	101·5	147·0
14...	84·6	134·5	121·3	96·3	145·0
15...	81·4	131·3	117·5	93·0	143·0
16...	83·0	128·8	116·8	92·5	140·5
17...	86·3	137·0	123·0	95·5	149·2

REVIEW.

Quarterly Weather Report of the Meteorological Office, with Pressure and Temperature Tables for the Year 1870. Vol. II., Part I., January to March, 1870. Quarto, 55pp., and 18 Plates.

We consider this number worthy on the whole of special praise, but to some parts we strongly object.

Foremost among the improvements is that indicated by the following paragraph :—

"In this volume the Committee are glad to be able to supply some information which might with advantage have been given in Vol. I. In the table for the five-day means, the height of the thermograph bulbs at each of the observatories is stated, but as this information gives no idea of the exposure of the screens, it has been resolved by the Committee to give views of each of the screens, with such explanations as may be required to give as correct an idea as possible of the value of the thermometrical and anemometrical observations published by them, and the local influences which may exert an effect in each case."

Regretting, as we always have regretted, and shall regret, that the bad precedent of Kew was taken as a type for placing the instruments, (*e.g.*, thermometers close ,to stone walls, and anemometers on lofty buildings,) we think that the Committee could hardly have improved upon the engravings and information they have supplied.

The "Quarterly Journal" is even more interesting than usual.

The Appendix contains two useful sets of tables. The first gives the mean monthly pressure at fourteen of the telegraphic reporting stations, between 1866 and 1870, and is (although it does not say so)

a modified continuation of a discussion published in the twelfth number of Admiral FitzRoy's Meteorological Papers. The results are satisfactorily accordant, especially considering that Admiral FitzRoy's values were all deduced from less than three years' observations, and some of them from less than a twelvemonth, while those now before us are based on five identical and consecutive years. Under these circumstances our readers will probably agree with us that the following figures are very satisfactory :—

Mean Pressure at Sea Level at the undermentioned Stations.

Period of Observation.	First Table. Various, between 1860 & 1863.	Second Table. Jan., 1866, to Dec., 1870.	Difference.
	in.	in.	in.
Nairn	29·775	29·811	+·036
Aberdeen	·800	·823	+·023
Leith	·834	·854	+·020
Scarborough	·885	·902	+·017
Yarmouth	·940	·941	+·001
Ardrossan	·820	·872	+·052
Holyhead	·913	·896	—·017
Valentia	·918	·915	—·003
Penzance	·966	·979	+·013
Plymouth	·962	·982	+·020
Portsmouth	·952	·968	+·016
London	29·958	29·961	+·003

The Appendix also contains a discussion by Mr. Gaster, of the returns of rainfall at the same stations during the same period. The telegraph stations being generally in the business centre of the various towns, there is naturally more difficulty in getting a suitable position for the rain gauges than for any other instruments. The Notes as to the position, or rather positions, for there were several removals, of the gauges go far towards increasing the value of the returns. The abstracts are drawn up in a very complete and useful form, which may often be copied with advantage.

One feature in the results is worthy of special notice, as exactly the reverse of what has been elsewhere obtained—viz., that at nearly all the stations, irrespective of position and of total fall, the winter months have the largest per-centages. We presume that this is an accidental circumstance, occurring through the averages being based on the short period of five years.

Another feature worth notice is the rainfall at Yarmouth. It is rather a singular fact that Mr. Symons has never published any returns from that town, but we have an impression that in some of those eccentrically compiled tables of mean annual rainfall upon whose failings Mr. Symons comments with such evident gusto, we have seen Yarmouth put down as 28 or 30 inches, and in the table now before us it is 29·81 in. Does this seemingly concurrent testimony indicate that the fall at Yarmouth really is nearly 30 inches? Because, if so,

the fact is very strange that with a level country, and a remarkably uniform mean rainfall of 23 or 24 inches, we seem to have an increase of 25 per cent. on reaching the coast at Yarmouth. Mr. Scott evidently mistrusts his Yarmouth observer's care in daily measurements, but if the observer neglected to empty his gauge regularly the effect would rather be to lessen than to increase his recorded total. Besides which, as we have already pointed out, the evidence is twofold.

And now we have to conclnde with a word of deep regret: none could have spoken in higher terms of the reproduced tracings of the self-recording instruments, as given in the first volume, than we did.* We can do so no longer. In the present number the scales are altered, and the Committee seem to be bent on a process of condensation which shows marvellous skill, but is, to our mind, as useless as writing the Ten Commandments in the space of a shilling, while it is worse than that amusement, because it will prevent many persons from examining the traces. Our editorial eyes may be somewhat dimmer than of yore, but we decline to strain them over the curves as now supplied.

THERMOMETER STAND EXPERIMENTS.

To the Editor of the Meteorological Magazine.

SIR,—In common, I believe, with many of your readers, I have been for some time looking anxiously for the promised abstract of the results of Mr. Griffith's experiments with thermometer stands at Strathfield Turgiss.

It seems a pity that the result of such a careful and elaborate series of comparative observations should not be made public as soon as possible. All admit the unsatisfactoriness of the present state of things, but, probably, few who have not given special attention to the subject, are aware of the extent to which the accuracy of our observations is affected by it, and how often readings which purport to be exceptional or extraordinary would be found to be simply the result of some peculiarity in the position of the thermometers, &c.

From some little experiments which I made on my own account during the hot weather of last August, I found that two thermometers placed only a few inches above the thermometers with which I usually take observations, but hung so as to rest against the vertical board of the thermometer stand instead of with their bulbs about three inches below it, as directed by Mr. Glaisher, generally registered a maximum temperature from 4° to 5° higher than the latter; this discrepancy being of course due to the fact that the lower series of thermometers were at all times exposed to a free current of air from all directions, while those hung against the board were, to a great extent, sheltered, especially from the southerly breezes which generally prevail during a period of great heat—the stand of course facing towards a northerly point during the hottest hours of the day.

It is not my present purpose to express any opinion as to the relative

* *Met. Mag.*, Vol. 5, p. 142.

advantages of the two methods of placing the thermometers, though, I think, common sense would suggest that thermometers intended to register the temperature of the air, should be placed so as to be freely exposed to the influence of the air, but merely to point out the great differences of reading that may result from what to many persons would appear but a trifling difference of position. For, if so large a difference as 5° may result from the cause I have mentioned, we can readily understand how still greater discrepancies might often be registered in the stands used by amateurs, in many of which the protection against the direct influence of solar radiation is very inadequate. There can be little doubt that many of the extraordinary high shade temperatures reported in the daily papers during our summer heats are to be put down to causes of this nature, and not to any peculiarity of climate.

This letter has run to a greater length than I intended, but I am sure that you, Mr. Editor, will agree with me that the subject is one which demands the attention of all who value accuracy of observation.

In the meantime—*i.e.*, until some uniform pattern of thermometer-stand can be agreed upon—the only remedy is that which you justly insist upon in a recent number of your magazine, viz., that every observer sending reports of exceptional temperatures should send therewith a full description of the thermometer-stand used by him as well as of his thermometers. Having said this I must not conclude without adding that my own stand is modelled as closely as possible after that known as the "Glaisher," or "Greenwich," being that in use by Mr. Glaisher at the Greenwich Observatory. It is of the dimensions recommended by Mr. Glaisher for ordinary observations, constructed of one inch deal throughout, and made to revolve on its post, so that the face of the stand carrying the instruments may always be kept turned from the sun. The thermometers which I use for regular observations are by Burrows, of Malvern, and have all been verified at Kew Observatory. The index error is, in most cases, so trifling (seldom exceeding 0·1°) that I have not thought it necessary in practice to apply the corrections supplied with the instruments, but as a guarantee of accuracy the practice adopted by Messrs. Burrows of supplying corrections with all their instruments cannot be too highly commended. Some of the thermometers used in the comparative observations to which I have alluded were unverified instruments purchased of Negretti and Zambra, but before making the observations I carefully compared these with my verified thermometers.—I remain, Sir, yours truly,

GEORGE T. RYVES.

Buildwas Parsonage, Ironbridge, Shropshire, Oct. 6, 1871.

[Mr. Ryves quite expresses the general opinion, as well as our own, respecting the delay in reporting on these experiments. Irrespective of the magnitude of the work, the completion of the preliminary portion of it has been grievously delayed. It is promised in a fortnight, and our readers may rely on promptitude when it rests with ourselves, so that we hope it will be completed and published long before Christmas.—ED.]

SEPTEMBER, 1871.

Div.		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.	Date.	Min. Deg.	Date.	No. of Nights below 32°. In shade	On grass.
			inches	inches.	in.								
I.	ENGLAND.	Camden Town	5·28	+ 3·02	1·22	29	13	81·0	1	38·1	23	0	0
II.		Maidstone (Linton Park)	4·44	+ 2·22	1·38	24	16	81·0	2	40·0	23	...	...
,,		Selborne (The Wakes)	6·44	+ 4·00	1·06	30	11	76·3	2	36·8	25	0	0
III.		Hitchen	4·40	+ 2·54	1·38	29	13	73·0	1	39·0	20§	0	...
,,		Banbury	5·41	+ 3·04	1·60	29	13	75·0	1	32·5	23	0	...
IV.		Bury St. Edmunds (Culford)	4·40	+ 2·79	1·65	29	13	80·0	1	36·0	23	0	1
V.		Bridport	4·50	+ 2·18	·91	29	13	74·0	2	34·0	23	...	0
,,		Barnstaple	4·37	+ ·61	·95	29	14	74·0	1	39·0	23	..	...
,,		Bodmin	8·52	+ 4·85	1·53	9	16	71·0	2	44·0	22	0	0
VI.		Cirencester	6·70	+ 3·84	1·27	29	12	...	...	...	...	...	...
,,		Shiffnal (Haughton Hall)	5·27	+ 3·32	1·36	29	14	71·0	1	40·0	22	0	...
,,		Tenbury (Orleton)	7·25	+ 4·57	2·02	29	13	73·0	11	32·0	23	1	1
VII.		Leicester (Wigston)	4·50	+ 2·29	1·45	29	14	81·0	1	35·0	20‖	...	...
,,		Boston	3·79	+ 2·22	1·03	29	14	77·8	1	39·2	29	0	1
,,		Grimsby (Killingholme)	6·12	..	1·28	8	18	73·0	1	36·0	20	...	...
,,		Derby	4·92	+ 2·58	1·25	29	14	73·0	1	38·0	23	0	...
VIII.		Manchester	3·82	+ ·13	1·20	27	16	76·2	1	35·0	25¶	...	...
IX.		York	6·60	+ 4·27	1·90	27	13	74·0	1	39·0	25	...	...
,,		Skipton (Arncliffe)	6·04	+ 1·08	1·30	27	15	76·0	1	30·0	29	3	...
X.		North Shields	4·01	+ 2·31	1·08	27	18	71·0	1	38·0	29	0	0
,,		Borrowdale (Seathwaite)	5·53	— 7·68	1·37	3	11	...	...	...	...	...	...
XI.	WALES.	Cardiff (Town Hall)	...	...	...	...	...	...	...	...	...	...	...
,,		Haverfordwest	7·48	+ 3·77	2·54	29	15	71·5	1, 2†	33·0	22	0	3
,,		Rhayader (Cefnfaes)	4·15	+ ·31	1·10	29	11	68·0	...	34·0	...	..	...
,,		Llandudno	3·59	+ 1·25	·89	24	15	72·3	1	39·7	20	0	...
XII.	SCOTLAND.	Dumfries	2·63	— ·10	·60	9	11	70·5	11	32·0	29	0	...
,,		Hawick (Silverbut Hall)	1·95	...	·29	27	14	...	...	..		...	...
XIV.		Ayr (Auchendrane House)	2·08	— 1·65	·55	20	16	73·0	12	29·0	30	3	3
XV.		Castle Toward	1·61	— 3·01	·39	23	11	...	...	...	...	...	...
XVI.		Leven (Nookton)	1·44	— 1·04	·42	19	11	68·0	1	35·0	30	0	6
,,		Stirling (Deanston)	1·90	— 1·25	·38	19	14	68·0	11‡	27·5	30	2	4
,,		Logierait	1·19	...	·50	19	12	...	...	...	...	...	...
XVII.		Ballater	3·46	...	·70	21	10	70·0	15	27·0	30	3	..
,,		Aberdeen	2·17	...	·40	23	15	66·8	3	36·2	27	0	7
XVIII		Inverness (Culloden)	2·90	...	·72	23	9	67·8	1	36·1	30	4	0
,,		Portree	4·81	— 5·95	·80	21	18	...	...	..	...	...	...
,,		Loch Broom	1·76	...	·68	20	11	...	...	...	...	...	...
XIX.		Helmsdale	3·64	...	1·44	20	17	...	...	..	...	...	...
,,		Sandwick	6·99	— 3·33	1·33	21	16	65·7	1	31·5	30	0	1
XX.	IRELAND.	Cork	4·59	...	1·89	26	8	...	...	...	...	...	...
,,		Waterford	...	...	...	...	...	...	...	...	...	...	...
,,		Killaloe	2·02	— 2·14	·62	9	11	72·0	2	30·0	24	2	...
XXI.		Portarlington	1·60	— 1·68	·50	27	16	67·0	3	32·5	23	0	0
,,		Monkstown	3·41	+ 1·42	1·07	26	12	...	...	...	...	...	...
XXII.		Galway	2·18	...	·55	3	11	73·0	7	35·0	23	0	...
,,		Bunninadden (Doo Castle)	2·21	...	·40	29	15	63·0	5,6	25·0	29	0	4
XXIII		Bawnboy (Owendoon)	...	...	.	...	...	...	...	...	..	...	...
,,		Waringstown	3·36	...	1·01	8	12	75·0	11	30·0	24	3	5
,,		Strabane (Leckpatrick)	2·39	..	·38	7	18	69·0	3, 11	...	...	...	...

† And 11. ‡ And 14. § And 24. ‖ And 22. ¶ And 26, 29.

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

METEOROLOGICAL NOTES ON SEPTEMBER.

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.

CAMDEN TOWN.—T on 2nd, L on 6th in the evening.

LINTON PARK.—A fine month, for although 3·52 in. of R fell during the last 8 days, it was all wanted, the rest of the month, as well as August, having been dry. T on 2nd, with sultry weather. Cool morning, approaching a frost, on 23rd. No very high winds; bar. steady the first 20 days, afterwards very low and fluctuating with frequent change of wind.

SELBORNE.—T and L at 11 a.m. on 6th; and at 7 p.m. on 10th, with high S. winds and heavy R. Wind early in the month S.W., about the middle N. and N.E., later very variable. The R of the last 8 days 4·50 in., caused the roads to be flooded on the 1st of October. On 30th, at 11.30 p.m., the L struck the ground on the terrace of Newton Valence Parsonage (one mile from Selborne), making a hole and scattering the gravel in all directions.

HITCHIN.—Wettest September since our record began (in 1849); lowest bar. since 1849; and lowest max. temperature since 1860, on 24th and 29th.

BANBURY.—T and L on 6th.

CULFORD.—T on 2nd, 6th, 27th and 29th. Heavy fall of R on 29th, amounting to 1·65 in., and R more or less every day from the 23rd to the end, on the morning of that day (23rd), the grass was crisp with frost.

BRIDPORT.—Cold and (at the latter part) stormy month, 3·16 in. of R fell during the 6 last days; gale from S.E. to S.W. on 10th; distant T and L on 11th and 16th; very heavy gale from S.E. to S.W. on 27th. Bar. fell ½ an in. between 9 a.m. on 26th and 10 p.m. on 27th, and rose ½ an inch by 9 a.m. on 28th. ·91 of R fell on 29th.

BODMIN.—This month has been remarkable for its abundant rainfall, and for the variable heavy gales from the 24th. Average bar. 29.81, average temperature 57°·2, being 1°·9 below the average for the month.

SHIFNAL.—Up to the 17th the month was warm (averaging 65°·0), from which day cold set in to the close, and the max. temperature only once (20th) reached 60°. The min. never fell to the freezing point. Up to the 23rd, with the exception of one day (6th, when 1·01 in. fell), there was but little R fell, but from the 23rd to the end it fell daily; on the 29th, 1·36 fell, making the total for the month 5·27, nearly three times the average. The winds were westerly to the 9th, when they changed to some point of E. till the end. The harvest, though delayed by the R, was all got in without injury by the end of the month; the swedes, and other green crops, abundant.

ORLETON.—Generally warm with much cloud, and R till 11th; great fall of R (1·72) on 6th; from 9th to 23rd no measurable R, but generally cloudy and cold. From the 23rd to the end very rainy; great falls of rain on 27th and 29th, (1·16 and 2·02 respectively), which caused the rivers to be flooded. Distant T on 6th and 9th, and L on 6th, 9th, and 30th. Temperature nearly 2°·5 below the average.

WIGSTON.—Easterly winds have prevailed during the latter part of the month, and the temperature much below the mean for the time of the year, which has checked the growth of turnips, mangolds, &c. The harvest was completed before the wet stormy weather of the last week of the month; the max. temperature of the 29th was only 49°·0.

BOSTON.—L seen on 2nd and 6th, T S on 27th, heavy gales on the coast on 26th, 27th, and especially on 29th, with loss of many vessels.

GRIMSBY, KILLINGHOLME.—The beginning and the end of the month very wet. Much sheet L on night of 6th. The great bulk of the harvest secured by the middle of the month.

YORK.—Slight auroræ between 9 and 10 p.m. on 4th and 15th, and at 8.30 p.m. on 7th; T S at 11 p.m. on 6th, with heavy fall of R.

NORTH SHIELDS.—Auroræ on 1st and 9th; T S on 6th.
SEATHWAITE.—T S on 29th.

WALES.

HAVERFORDWEST.—The month commenced fine and warm, a continuance of the weather of the previous month; some R fell at night, considerable quantities fell during the first 9 days, thence to the 20th the weather was delightful, a cold gloomy period then set in, the nights wintry cold, wind constantlv E. or N.E., and the month terminated with stormy weather and excess of R, 2·54 in. having fallen on the 29th, and the total for the month twice the average for this month.

CEFNFAES.—The month mostly dry and cold. Harvest of grain well secured, with generally average crops. Prevailing winds N.E. and N.W.

LLANDUDNO.—At 6.30 on 1st, a most beautiful setting-sun rainbow, the sky a splendid pink tint and colors of rainbow very brilliant. At 8.30 p.m., on 2nd, a splendid meteor, commencing like a straight line of magnesium light, and then breaking into balls of blue and crimson.

SCOTLAND.

DUMFRIES.—The first 9 days stormy, fine to 23rd, variable to the close. The harvest was concluded under the most favourable circumstances by the 23rd. Wheat nearly an average, oats above it, barley excellent. Potatoes a prolific crop, one-fourth to one-half diseased; turnips a splendid crop; pastures very verdant, and the country fresh and beautiful. R fell above, and temperature below, the average of the month.

SILVERBUT HALL, HAWICK.—A very mild month, slight frost on 28th and 29th. Potato disease very prevalent in this district, harvest operations about concluded, and the most of the grain crops gathered into the stackyard.

AUCHENDRANE.—This month nearly all the weather-tests are below our local September means, in the preceding months these tests were nearly all above our August means. During the wet and warm August, with a great bar. range and a very weak evaporation, followed by a cold and dry September with a small bar. range and rather full evaporation, the potato crops have suffered severely. The winds in August were Polar 6, Equatorial 18, Calms 7. This month the winds are Polar 11, Equatorial 7, Calms 12, with L and a great fluctuation of bar. and ther. on 30th. Rivers very low throughout the month, but grain crops well harvested. Dews on 13 nights and no T S.

CASTLE TOWARD.—This has been a very favorable month for the harvest, it being all cut and stacked in good order. The potato crop is very much diseased, in fact, more than half the crop being bad. Turnip crops look well, and pastures still good. We have had some light frosts in the morning, but nothing to injure the bedding plants, gardens looking quite gay and fruit stored fast.

DEANSTON.—From 1st to 9th unsettled, showery and windy; then till 18th, dry, bright and mild; from 18th to the end of the month, dull, rainy, windy, and cold; very sharp frosts on mornings of 25th and 30th. Dahlias and tender plants spoiled.

LOGIERAIT.—A very fine month and harvesting well completed. Potato disease universal; decided frosty nights on 27th and 29th.

BALLATER.—The early part of month dry and fine, latter part cold and wet, unfavorable for harvesting, and much of the crops in this district still unsecured. S on the hills on morning of 29th; severe frost on 30th, blackening potato stems, but no disease reported.

ABERDEEN.—The early part of the month (1st to 16th) very fine, warm and dry, the latter part dull, wet, and cold. Temp. in sun, *in vacuo*, on 4th, 128°·2, on grass on 26th, 24°·7.

PORTREE.—With the exception of the first eight days and from 19th to 22nd, which was wet and rather stormy, the weather was very fine during the month, and very favourable for the ingathering of the crops, which are now in the stackyard in good condition, except small patches here and there in very late places. The potato blight is generally very bad throughout the island. A strong gale from N.W. on 18th. Lunar halo on 27th.

LOCHBROOM.—This has been a remarkably fine month. Crops have been all secured in excellent condition, and much earlier than usual. In this district the potatoes are quite safe, but the disease has appeared in adjacent districts.

IRELAND.

MONKSTOWN.—A fine, cool month, the wet days, though few in number, being large in quantity, the fall on 26th (1·07) being the greatest since Oct. 8th, 1870.

DOO CASTLE.—On the whole a very fine harvest month; except in a few isolated cases it has been well secured. The oat crop very satisfactory, but the potatoes sadly diseased, one-third (of only a small yield) being rotten.

WARINGSTON.—Generally fine and dry, though cold; remarkable for the prevalence of easterly winds, which blew strongly almost the whole month. Temp. low; heavy fall of R (1·01) on 8th.

THE METEOROLOGICAL OFFICE.

To the Editor of the Meteorological Magazine.

SIR,—I cannot believe that the authorities of the Meteorological Office would have passed the paragraph to which you drew attention on page 127, unless there was some foundation for it. Strongly holding the opinion that the progress of science, as of other matters, is best promoted by friendly emulation, and that if all is to be under any one person's control little progress will be made, I am yet anxious impartially to consider the claim now put forward by the Meteorological Committee. Will you or some of your readers tell me upon what it is based?—Yours truly. C. H. GRIFFITH.

[We are unable to answer the above question. Admiral FitzRoy's report for 1857 contains a letter from the Royal Society, dated February 22nd, 1855, which certainly refers to land observations, but not to land observations in the British Isles. On page 26, it is stated that "data are still pressingly required" from British North America, the Mediterranean, Australia, New Zealand, and the West Indies. As, however, no steps have been taken either by Admiral Fitzroy, or the present Committee, to establish observatories in those localities where they were so "pressingly required," we fail to see the grounds for ignoring the instructions of the Royal Society, and concentrating all their efforts on a country not mentioned in the letter of 1855.—ED.]

RAINFALL OF SEPTEMBER 8th, 1871.

To the Editor of the Meteorological Magazine.

SIR,—Mr. Pratt, the Astrono-Meteorologist, predicted hail or rain storms on Sept. 8th, 9th. I registered, on the morning of the 9th, 0·54 in. of rain. May I ask if each of your correspondents will kindly favor me *(on a post card)*, with the quantity registered on the 9th, with the times of the commencement and end of the fall, also a brief note of the state of the weather on the preceding and following day. My object is to ascertain the geographical limits of the fall and its rate of progress. Results will be forwarded for publication.

Yours truly, W. R. BIRT.

Cynthia Villa, Walthamstow.

SYMONS'S

MONTHLY

METEOROLOGICAL MAGAZINE.

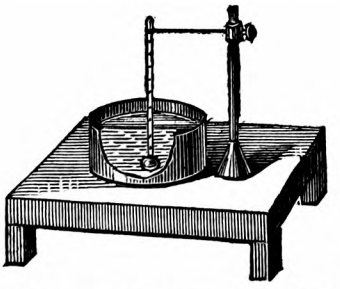
LXX.] NOVEMBER, 1871. [PRICE FOURPENCE, or 5s. per ann. post free

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.

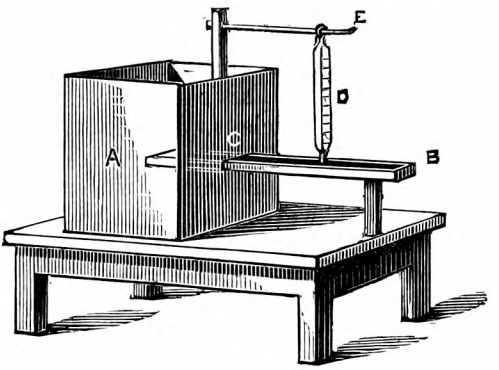
"LE ROY'S HYGROMETER.—The instrument consists of a tin vessel containing water, in which a thermometer is immersed. The temperature of the water and containing vessel is gradually lowered by the introduction of ice, and when it has fallen below the dew-point of the adjacent air, a portion of the vapour 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.	102·06 in.	108·98 in.	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 manyyears 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.

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* 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.

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

OCTOBER, 1871.

Div.		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.	Date.	Min. Deg.	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; TS 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 Septemberand 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, 20th 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.

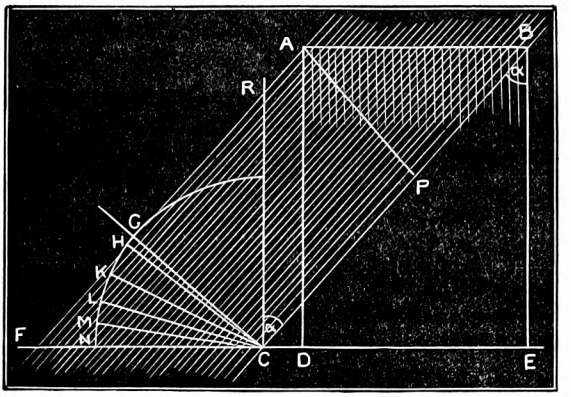
Harpenden, St. Albans.

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.

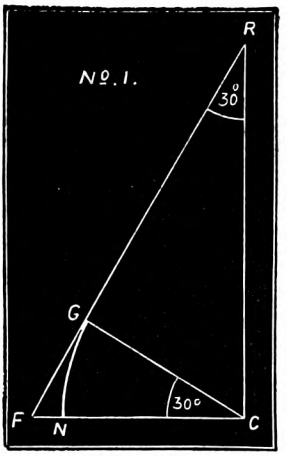
1st. See fig. No. 1.

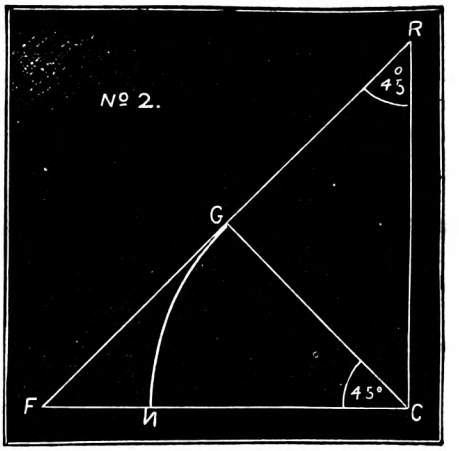
Let $a = 30°$, then $\frac{CF}{CG} = \sec 30°$

$$\text{Sec } 30° - 1 = \frac{2}{\sqrt{3}} - 1 = \frac{2}{\frac{7}{4}} - 1 \text{ nearly} = \frac{8}{7} - 1 = \frac{1}{7} \text{ nearly}$$

$\therefore$ the loss $= \frac{1}{7}$ 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

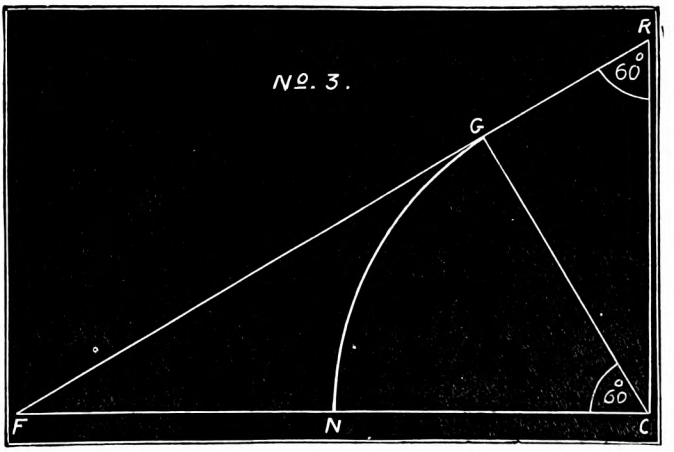
or, in this case, a horizontal gauge at whatever height will catch twelve inches instead of seventeen.

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 = ∞.

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 situa-

tions, 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.

SYMONS'S

MONTHLY

METEOROLOGICAL MAGAZINE.

LXXI.] DECEMBER, 1871. [PRICE FOURPENCE, or5s. *per ann. post free*

BRITISH RAINFALL.

WE desire to bring the following letter, which appeared in the *Times* of Dec. 9th, under the notice of our readers, and shall be glad if they also will convey its purport to any persons who may be observing, but not yet communicating the results:—

"Mr. G. J. Symons writes to us on the subject of rain gauges under date 62, Camden Square, N.W., Dec. 8:—

"'The time has again come round at which it is requisite to ascertain the completeness of the corps of observers of rainfall in the British Isles, and to endeavour to obtain fresh ones in those districts in which no observations are now made, either from the death or removal of previous observers. At the Edinburgh meeting the British Association voted a small sum of money to provide rain gauges gratuitously for certain localities, but the first necessity is to ascertain exactly and completely all the places at which observations are now being made.

"'In furtherance of this primary object I trust that you will (as on former occasions) allow me to ask any of your readers who may be recording the fall of rain, or intending to record it, who are not already in communication with me, but are willing to assist by forwarding copies of their observations, to at once oblige me with their names and addresses, so that duplicate gauges may not be started unnecessarily near to them.'"

Moreover, we have another request to lay before our readers, viz., that they will endeavour to procure observers in any of the undermentioned localities. Surely among our numerous correspondents, some must have friends resident, or property, in some of these localities. As very heavy demands have already been made on the British Association grant, it is desirable that as far as may be the new observers purchase their own gauges; but we hope it will be distinctly understood, that in the neighbourhood of any of the undermentioned localities, gauges will be provided gratuitously on loan, if desired.

Berkshire.—East Ilsley.
Cambridge.—March, Ely, (a gauge on or near the ground required.)
Cheshire.—Tarporley, Middlewich.
Cornwall.—Lostwithiel, Saltash, Camelford, Jacobstowe.
Cumberland.—Ulpha, Ravenglass, Hesketh Newmarket, Kirkoswald, Alston.
Derbyshire.—The South-western part of the County.
Devon.—Hartland, South Brent, Exmoor.
Dorset.—Beaminster, Bere Regis.
Gloucester.—Upton-on-Severn
Hampshire.—Freshwater I.W., Lyndhurst, Stockbridge, Whitchurch.
Hereford.—Bromyard.

Kent.—Romney, Wye, Strood, Sheerness, Tunbridge.
Lincoln.—Sleaford, Horncastle, Kirton, Saltfleet, Epworth,
Norfolk.—Thetford, New Buckenham, Cromer, Holt, Lynn.
Northumberland.—Along the Cheviots.
Somerset.—Minehead, Dulverton, Castle Cary, Weston-super-Mare.
Stafford.—Eccleshall, Crewe.
Suffolk.—Debenham, Halesworth, Mildenhall.
Sussex.—Ticehurst, Chiltington.
Warwick.—Kineton, Southam.
Wiltshire.—Devizes, Malmesbury.
Yorks.—Hornsea, Bridlington, Hawes, Masham, North York Moors.

WALES.—Gauges are more or less wanted throughout the Principality, excepting in Major Mathew's district around Carnarvon, the positions in which the want is greatest will readily be seen by reference to the tables in last year's *British Rainfall.*

SCOTLAND.—We have much pleasure in announcing, that through the courteous co-operation of the directors of the Highland and Dingwall and Skye Railways, a series of observations will be commenced at a large number of their stations on the 1st of January next, which will go far towards supplying information, of which we have been long in want. We are also indebted to Mr. Buchan for several new stations, but, after all, much remains to be done, and there are few parts of the country from which additional returns would not be welcome. The following list contains only a few of the more important :—

Aberdeen.—Huntly, Banchory.
Argyll.—In Cantyre, on Loch Awe, North-east of Ben Cruachan.
Banff.—Banff.
Berwick.—On Lammermuir Hills.
Caithness.—Any station inland.
Forfar.—Forfar, Glen Esk.
Inverness.—Within 10 miles on either side of Caledonian Canal, near Loch Rannoch.
Kincardine.—Stonehaven.
Linlithgow.—Linlithgow.
Peebles.—Biggar.
Ross.—Between Loch Broom & Gairloch, Ben Wyvis.
Stirling.—Kilsyth.
Sutherland.—Any station inland, except Lairg.
Wigton.—Newton Stewart, Port Patrick.

IRELAND.—Reference to the last year's volume of *British Rainfall* will show that the representation of this country is steadily becoming more complete; we shall, however, gladly welcome any offers of additional returns, and promise our warmest co-operation.

We need hardly point out that this notice should be acted upon with extreme promptitude, or the observations cannot be commenced for the new year.

EVAPORATION.

To the Editor of the Meteorological Magazine.

SIR,—Discussion on any question is no doubt one of the best methods of arriving at the truth, and I cannot expect that the conclusions drawn in my paper on evaporation should pass unchallenged, but looking to what has taken place upon "Decrease of rainfall with elevation," I have the strongest possible objection to enter into a controversy upon so difficult a subject as evaporation;—and must therefore ask your correspondents not to accuse me of want of courtesy if in future, I abstain from replying to their communications. With these remarks, I ask permission to say a few words upon Dr. Hudson's

letter which appeared in your last number; for the sake of brevity, in speaking of the temperature of the dew point, the words "dew point" only are used.

Proposition No. 1 is qualified by No. 2, but if read alone it is incorrect. I should prefer it as follows:—

When air is saturated with moisture, and the water is of the same temperature as the air, neither evaporation nor condensation can take place.

I do not like the words "when air is saturated," with which the three first propositions commence, not from their incorrectness, but from the tendency they have to convey a false impression; except as it affects the dew point, it is a matter of little consequence whether the air is saturated or not; other circumstances being the same, it is the difference between the temperature of the water and that of the dew point which determines the amount both of evaporation and condensation.

In Paragraph 5, page 167, a case is supposed, which in my opinion can never exist; air under the circumstances named is *not* "capable of abstracting vapour," and therefore *cannot* "surrender its previous spoils again;" on the contrary, strange as it may appear, water of a lower temperature than the dew point, will rob the driest air of a part of the small quantity of moisture which it contains; this I have found to be the case, by placing water of a lower temperature than the dew point, in the heated air of a drying-room, when I have invariably found it to increase in weight.

It is quite true that in Table 2 of my paper, evaporation appears to take place from water when at a lower temperature than the dew point, but it will be observed that the words "calculated dew point" are generally used, and the tendency of my experiments was to throw a doubt upon the correctness of the tables used for the determination of the dew point; further experiments have convinced me that they require correction, that they generally, but not always, give the dew point too high, but some anomalies which I have noticed, and to the solution of which at present I can see no clue, lead me at times to doubt if the wet and dry bulbs can ever give more than an approximation to the moisture in the atmosphere.

The time at which evaporation commences from water, or from any other substance covered with moisture, in its relation to the dew point, is a question of great nicety, to be determined only by the most careful experiments. To me it has sometimes appeared to differ, in different currents of air, but the whole question is beset with difficulties of no ordinary kind, one of which would be to determine the temperature, not of the water, but of its surface, and at the same time to get the correct dew point; the latter at times appears very changeable, the moisture in the air, if I may be allowed the expression, is badly mixed, masses of air very differently charged with moisture, are rolling over the surface of the earth, in the same manner as the clouds above, the difference being that they are invisible.

I cannot agree with the conclusion Dr. Hudson has drawn, that water will evaporate when at a temperature several degrees below the dew point; it certainly does not do so when the air is nearly saturated; his reasonings with regard to water appear to me to apply also to any other substance covered with moisture, and the important bearings which such a state of things would have in retarding the formation of dew must not be overlooked.

I will only add that at present much of what is said both by myself and others, upon this difficult subject, must be received with some reserve, but up to the present time nothing has occurred to alter my conviction of the truth of one leading idea, namely, that if the surface temperature of water or of any other substance be colder than the dew point, condensation will take place, and on the contrary, if the surface of water, or of any other substance covered with moisture be warmer than the dew point, evaporation will ensue.

GEORGE DINES.

Cobham, Surrey, Dec. 1st. 1871.

THE WINTER AND COMING SUMMER.

To the Editor of the Meteorological Magazine.

SIR,—The following rule seems to show that the Yorkshire rainfall in November, often indicates the character of our coming winter and summer. It does not, however, appear to apply to spring seasons. The rule may be thus stated :—

When the rainfall of November has been below 2 inches at Well Head, near Halifax, in Yorkshire, (the mean fall for November there is 3 inches); the succeeding winter and summer have each had a mean temperature above the average of 100 years.

The following are *all* the instances since 1829, (when the monthly rainfall records at Halifax appear to have commenced). The rainfall amounts are taken from the table of Mr. Waterhouse, the mean temperatures from Mr. Glaisher's Greenwich tables.

Year.	Rainfall of November, at Well Head, Halifax.	Year of Winter.	Difference of Mean Temp. of Dec. to Feb. inclusive, from Greenwich average of 100 years.	Year of Summer.	Difference of Mean Temp. of June to Aug. inclusive, from Greenwich average of 100 years.
	inches.		deg.		deg.
1833	1·50	1833–4	+5·2	1834	+2·4
1845	1·85	1845–6	+5·2	1846	+4·2
1848	1·95	1848–9	+4·5	1849	+0·9
1851	0·80	1851–2	+3·2	1852	+1·5
1855	0·96	1855–6	+1·1	1856	+1·0
1856	1·27	1856–7	+0·8	1857	+3·9
1857	1·40	1857–8	+1·2	1858	+2·4
1858	1·47	1858–9	+3·6	1859	+4·2
1862	1·06	1862–3	+4·6	1863	+0·2
1867	0·62	1867–8	+1·3	1868	+4·2
1871	0·87	1871–2			

It will be seen from the foregoing table that, as the rainfall of last month, at Halifax, was only 0·87 in., the winter of 1871-72 should be

somewhat warmer than the average. I may here remark that the season most resembling the present was that of 1782, when, according to the tables of Mr. Barker, of Lyndon, September had an enormous rainfall, and *November was very dry*. Mr. Glaisher says, "it was severe in November, 1782, and during the first half of December." The latter half of December 1782, was, according to Mr. Barker, mild. The rest of the winter of 1782-3, was, on the whole mild, and the succeeding summer very hot, exactly in accordance with the foregoing rule.

During the last 57 years, or as far back as the Greenwich records go, there have only been 4 years when the November rainfall at that station was below one inch, viz, in 1851, 1858, 1868, and 1871; and in the following summers of 1852, 1859, and 1868 very great heat occurred, according to the above table, however, the coming summer may be, (as in 1863), only a little warmer than the average.

We sometimes have a cold summer after a mild winter, as in 1833, 1862, and 1866, and sometimes a hot summer after a cold winter, as in 1780, 1808, 1847, 1865, and 1870; but it appears that when a mild, or rather mild winter occurs after a dry November, we always have a warm or hot summer follow.

It is a remarkable fact, that *all* the summers of maximum heat, that is all the summers that had a mean temperature of about 4 degrees in excess of the average, were preceded by dry Novembers at Halifax. The only summers during the last 100 years, in which the mean temperature at Greenwich reached 64 deg., were 1846, 1857, 1859, and 1868, and all these dates occur in the above table.

It is also a remarkable fact, that in the only instance of 4 hot (including 3 extremely hot) summers occurring in immediate succession, (I mean the summers of 1856, 57, 58 and 59); there was a corresponding exceptional succession of dry Novembers at Well Head, Halifax.—I am &c.,

GEORGE D. BRUMHAM.

Barnsbury, Dec. 7th, 1871.

AUTUMN DROUGHT AT BRIGHTON.

To the Editor of the Meteorological Magazine.

SIR,—The drought during the past two months has been so remarkable here, that a few particulars will, I think, be interesting to your readers.

The September rainfall was above the average, owing to the heavy rains in the last few days. In October, which is a very rainy month here, the total was remarkable; ranging in various parts of the town from 1·42 in to 1·69 in., whilst the mean of 21 years is 3·83 inches, so that the *deficiency was about two-and-one-third inches.* In October of the following years the totals were very small—1850, 1·85 inches recorded at Terminus Road; 1858, 1·53 inches at Clifton Terrace; 1860, 1·76 inches at the Water Works; and in 1864 at the same place 1·75 inches, and at Cambridge Road 1·40 inches. I think, therefore, that this year's October rainfall may be regarded as the lowest since 1842. November was again dry, and I can find no

instance in which October and November successively were as dry as in the present year. The totals range from 0·58 in., to 0·85 in., the 21 years mean is 2·41 in., so that there is again a *deficiency of about one-and-three-quarters inches.* In the years 1851 and 1853, 0·91 in. was recorded at Terminus Road, and in 1862, 0·76 in. at the Water Works, therefore this November is, I think, the driest since 1842.

The following table shows the totals in various parts of the town, for the three autumn months, and also the totals in previous dry years.

Autumn Rainfall, 1871.

	Sept. in.	Oct. in.	Nov. in.	Total. in.
Water Works, Lewes Road	3·44	1·69	0·77	5·90
Do. Goldstone Bottom	3·38	1·44	0·85	5·67
55, Buckingham Place (F. E. Sawyer)	3·19	1·44	0·67	5·30
Do. 35 ft. above ground	2·89	1·20	0·44	4·53
St. James's Street (E. Rowley, Esq., F.M.S.)	3·55	1·49	0·58	5·62
14, Eaton Place (Dr. S. Barker, F.M.S.).....	3·41	1·42	0·66	5·49
Mean, 21 years (1849 to 1870)	2·68	3·83	2·41	8·92
1851—Terminus Road	0·16	2·87	0·91	3·94
1858—Clifton Terrace	1·32	1·53	1·30	4·15

Thus it will be seen that the autumn total this year is more than 3 inches below the average, that it is the lowest since 1858, and with the exception of that year and 1851, is the lowest of the past 29 years.—I am, Sir, Your obedient Servant,

FREDERICK E. SAWYER, F.M.S.

55, Buckingham Place, Dec. 5, 1871.

THE EXPERIMENTAL THERMOMETERS IN THE FROST.

To the Editor of the Meteorological Magazine.

SIR,—Under the above heading I sent to you in January, 1870, a short note of the minimum temperatures recorded on the various thermometer stands on December 28th, 1869. It may possibly be of interest to supply similar details as to the extremely low temperature on the 19th ult.—Yours truly,

C. H. GRIFFITH.

Strathfield Turgiss Rectory, Winchfield, Dec. 1st, 1871.

Minimum Temperatures recorded at 9 a.m. Nov. 19th, 1871.

James	15°·3	Morris's	19°·4
Martin	16°·0	Griffith's	15°·0
Stevenson	18°·7	Kew	16°·8
Glaisher	15°·7		

[We think the variation in the two instances (see *Meteorological Magazine*, Vol. IV., p. 186,) on the whole may be considered satisfactorily accordant. The higher temperature shown by Stevenson's stand on the recent occasion, is doubtless due to its having been removed from the thermometer enclosure to the partial shelter of the Rectory, near Morris's stand. This was purposely done, to determine the influence of such shelter.—ED.]

REVIEW.

Meteorological Report for the Year 1869. Edited by the Rev. R. F. Wheeler, M.A. [From the Natural History Transactions of Northumberland and Durham.] 8vo, 109 pages.

Meteorological Report for the Year 1870. Edited by the Rev. R. F. Wheeler, M.A. 8vo, 43 pages. Newcastle : John Bell.

We extremely regret to find the following notice affixed to the cover of the last mentioned work :—

"The Rev. R. F. Wheeler finds that the demands made upon his time by other duties compel him to resign the Editorship of the Meteorological Report. He quits the work with the greatest regret, as it is one in which he took an ever-growing interest, and which brought him into pleasant communication with many friends."

Considering the extremely complete and careful manner in which Mr. Wheeler has worked up these reports, and the development which they have received under his direction, we are not at all surprised to learn that the work has become too heavy to be carried on simultaneously with his other duties, nor that the Field Club have had considerable difficulty in finding a successor. We thank him for the information he has collected, for infusing something of his own energy into many of his correspondents, and especially for setting a good example for his successor to follow.

Having on several previous occasions drawn attention to, and described these reports, it is unnecessary for us to say more than that the two now before us are equal or superior to any of the previous ones, full of facts and figures, and very free from errors and misprints. Some indication of the benefit conferred by local publications of this kind is afforded by the preservation of the following instructive details:—

"On the afternoon of the April 14, in the midst of a severe storm of thunder and lightning, with the wind varying constantly in different directions, a whirlwind swept over the farm of Sweethope, on the estate of Sir W. C. Trevelyan, Bart. It commenced its work of destruction on the S.W. of a small plantation and passed on to the north-east side. Every tree was uprooted and scattered in various directions. A strong stone wall, seven yards in length, next succumbed to its violence, then passing over a field it levelled seventy yards more of wall. It then came in contact with a flock of sheep whirling them up into the air killing five, and breaking the legs and tearing off the horns of several others. Sweethope Lough was next visited. Here one side of the room over the boat-house was carried away, the walls and beams below being also lifted out of their places. Close by, a stable had been built which was entirely thrown down, and a large beam of wood carried between seventy and eighty yards away. The spars and slates were found scattered about in all directions, hundreds of yards away from the spot. Pieces of slate were driven fast into the fir trees. Meeting another wood in its course it made a passage ten yards in width, uprooting hundreds of trees, snapping many in half, and breaking others at various heights from the ground. It overthrew a stack of hay about 400 yards away from this last plantation, and then ceased.

"The appearance of the wind was that of dense white mist, and the shape triangular, with the apex downwards.

"On the same day there was a heavy fall of hail about 3 P.M., which broke several squares of glass in the vineries and plant houses, and cracked others."

We hope that Mr. Wheeler will still find leisure to continue his efforts towards obtaining rain returns from the higher parts of the Cheviots, and that they will be warmly seconded by the new editor.

NOVEMBER, 1871.

Div.		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.	Date.	Min. Deg.	Date.	No. of Nights below 32° In shade	On grass
			inches	inches.	in.								
I.	ENGLAND.	Camden Town	·60	— 1·81	·22	14	8	52·5	1	21·0	19	15	21
II.		Maidstone (Linton Park)	·76	— 2·43	·16	1	10	55·0	16	22·0	19	15	...
,,		Selborne (The Wakes)	·57	— 2·97	·23	14	5	52·0	8	16·0	19	21	23
III.		Hitchen	·93	— 1·21	·28	14	14	49·8	8	20·0	18	22	...
,,		Banbury	·80	— 1·40	·32	14	11	50·7	8	17·0	19	24	...
IV.		Bury St. Edmunds (Culford)	1·52	— ·87	·54	14	9	51·0	3, 15	20·0	18	22	27
V.		Bridport	1·29	— 1·87	·42	14	6	56·0	15	22·0	18‡	10	...
,,		Barnstaple	1·79	— 2·35	·43	24	11	54·0	16	27·0	12	...	...
,,		Bodmin	1·87	— 3·11	·32	14	12	51·0	1	28·0	18	2	7
VI.		Cirencester	·40	— 2·39	·35	14	...	...	...	...	...	...	...
,,		Shiffnal (Haughton Hall)	·89	— ·68	·20	14	15	49·0	15	20·0	19	21	...
,,		Tenbury (Orleton)	·80	— 1·67	·23	14	12	52·8	15	20·0	13‡	16	23
VII.		Leicester (Wigston)	1·04	— 1·12	·43	15	8	52·0	15	20·0	18	..	...
,,		Boston	1·33	— ·81	·58	14	10	51·0	1	25·0	19	16	...
,,		Grimsby (Killingholme)	2·29	..	·45	27	16	50·0	1, 3*	24·0	19	11	...
,,		Derby	1·05	— ·58	·68	14	13	52·0	1, 15	21·0	19	14	...
VIII.		Manchester	1·41	— 1·35	·75	14	10	51·8	15	24·0	12§	14	21
IX.		York	1·25	— ·73	·42	14	12	50·0	1	14·0	19	19	...
,,		Skipton (Arncliffe)	2·13	— 4·32	1·17	14	10	50·0	3	15·0	16	14	...
X.		North Shields	1·84	— ·86	·29	10	18	51·0	15	26·0	19	13	15
,,		Borrowdale (Seathwaite)	6·24	—10·43	2·78	15	10	...	...	...	...	...	...
XI.	WALES.	Cardiff (Town Hall)	...	...	...	...	...	...	...	...	...	...	...
,,		Haverfordwest	1·81	— 3·86	·80	14	13	54·0	14	24·3	17	8	10
,,		Rhayader (Cefnfaes)	1·24	— 3·34	...	...	16	51·0	...	20·0	...	..	...
,,		Llandudno	3·24	+ ·08	·91	21	13	55·2	14	32·9	19	...	...
XII.	SCOTLAND.	Dumfries	2·31	— ·91	·98	14	9	52·5	15	19·5	18	13	...
,,		Hawick (Silverbut Hall)	2·09	...	·50	29	13	...	...	...	...	...	...
XIV.		Ayr (Auchendrane House)	2·80	— 1·27	·68	14	14	59·0	20	19·0	18	12	19
XV.		Castle Toward	...	...	...	...	...	...	...	...	...	...	...
XVI.		Leven (Nookton)	3·43	+ ·39	1·01	20	16	52·0	14+	23·0	13‡	15	24
,,		Stirling (Deanston)	3·13	— ·38	·99	21	10	53·5	14	19·0	18	21	23
,,		Logierait	1·16	...	·29	21	10	...	...	...	...	...	...
XVII.		Ballater	1·22	...	·37	10	9	50·5	14	21·0	18	17	..
,,		Aberdeen	2·49	...	·43	7	25	50·2	1	29·2	13	7	25
XVIII		Inverness (Culloden)	2·35	...	·52	10	14	53·2	20	31·0	13	2	26
,,		Portree	8·06	— 2·42	2·73	20	18	...	...	...	...	...	...
,,		Loch Broom	2·69	...	·54	8	17	...	...	...	...	...	...
XIX.		Helmsdale	3·31	...	·46	10	22	...	...	...	...	...	...
,,		Sandwick	4·04	+ ·04	·49	20	24	50·0	14+	29·3	17	3	21
XX.	IRELAND.	Cork	3·43	...	·95	18	12	...	...	...	...	..	...
,,		Waterford	4·39	+ ·44	1·55	20	14	60·0	16	26·0	18	4	...
,,		Killaloe	2·00	— 2·89	·47	20	11	55·0	14	20·0	12	6	...
XXI.		Portarlington	1·65	— 2·27	·44	21	19	54·0	3	23·0	17	10	...
,,		Monkstown	1·10	— 1·79	·19	29	14	...	...	...	...	6	...
XXII.		Galway	1·38	...	·42	13	13	57·0	1,2	25·0	12	5	...
,,		Bunninadden (Doo Castle)	2·57	...	·36	19	13	45·0	23**	21·0	18	14	...
XXIII		Bawnboy (Owendoon)	...	...	..	...	...	...	...	...	..	...	...
,,		Waringstown	1·74	...	·62	14	15	56·0	3	27·0	12	16	22
,,		Strabane (Leckpatrick)	3·07	..	·50	20	20	...	...	...	...	...	...

* And 4, 15. ** And 28 † And 15. ‡ 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 NOVEMBER.

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.—Brilliant aurora on night of 10th. Dense fog all day on 23rd. Early part of month fine and dry, the roads almost dusty; the middle frosty, but still mostly dry; the last week dull and dirty, but the whole month may be regarded as a favourable one, the frost not being severe enough to interfere with out-door work. Bar. generally high; wind mostly N. and N.W. For the two consecutive months—October and November, the past have been the driest I have on record, being 1·44 in. and 0·76 in. respectively—2·20 in. in all. The corresponding months in 1858 being 1·45 in. and 0·77 in., or 2·22 in. the two months, while the same months in 1865 were 8·14 in. and 2·74 in., or 10·88 in. the two.

SELBORNE.—The coldest November I have ever recorded. Very damp white frosts on 10 days; the aurora on the 9th extremely fine, the lower part a bright white light, passing into roseate; the following night there was also a fine aurora, but without colour; there was not on any day sufficient snow to measure.

CULFORD.—November entered with cold, north-easterly winds, accompanied by a very low temp. for the season, and which has continued throughout the month; ice strong enough to bear skaters, &c., about 11th, and in good order for storing in ice-houses, &c. Easterly winds prevailed on thirteen, and westerly on seventeen, days; average temp. of the month, 36°.

BRIDPORT.—Fine, but cold; more or less easterly winds almost throughout the month; south-westerly gale on 14th; swallows seen on 7th, and one on 14th. Several raspberries picked in the garden in the early part of the month. Fine aurora on 10th.

BODMIN.—This month has been remarkable for its dryness and excessive cold.

SHIFNAL.—This month has quite surpassed its proverbial character for unpleasantness. Rain, sleet, and frost having interchanged throughout with fog on the 23rd and 24th, and although the depth of rain was (as is usual in this month) moderate, the frequent fall kept up constant damp. The easterly winds which set in at the close of October, continued for the first week, when they changed to westerly points, but went back again on the 24th for the rest of the month. Dahlias remained unscathed until the 11th, when frost set in with ice ½ in. thick. The max. temp. never exceeded 49° (15th), and min. sank to 20° (19th), and to below 32° on 21 nights. A fine aurora on night of 9th, repeated in saffron tints less brilliantly on the 10th.

ORLETON.—A very dry month, with many bright days and much less cloud and fog than usual. The first ten days about the mean temp., the remainder of the month very cold, with severe frosts. Temp. of the month 4°·5 below the average and lower than in any year since 1862. Brilliant aurora on the nights of the 9th and 10th. S on the 21st.

WIGSTON.—An unusually dry month, the rainfall not half the mean of the month taken for many years. The temp. much below the mean of the month, nevertheless the weather has been agreeable.

GRIMSBY.—Aurora on the 10th; winter began on 17th with wind N.N.W. 8, S at intervals from 7 a.m. to 1.30 p.m., it melted partly as it fell, and very gradually for a week afterwards. Min. temp. 24° (19th); on 23rd the trees in places coated with ice, which fell in the form of oblong angular flakes at midday, covering the ground beneath.

DERBY.—This month has been unusually cold, the mean temp. being 4° below the average; the rainfall is generally light for November, but on this occasion is less than usual. The character of the month is fine, not having been visited with any decided fogs.

YORK.—Auroræ on 8th, 9th, 10th, and 15th—very fine on the 10th. Slight fall of S on 15th; heavy fall of S with strong gale from N. on 17th; thick fog on 23rd; snowy showers, like April showers, with clear sky intervening, on the 28th.

ARNCLIFFE.—Small rainfall, but ther. unusually low for Nov.; early winter.

NORTH SHIELDS.—Fine auroræ on 8th, 9th, and 10th; very fine mock sun from sunrise to 9 a.m. on 13th.

SEATHWAITE.—S on 9th, 10th, 21st, 22nd, and 30th. T on 11th.

WALES.

HAVERFORDWEST.—A cold, damp month, although the rainfall was below the average, the ther. near freezing point on 10 and below it on 8 nights; prevailing winds, N.N.W. and N.E.

CEFNFAES, RHAYADER.—The month dry and cold, generally frosty, wind N.E. and S.E.; S on the hills, 11th, 17th, and 23rd.

LLANDUDNO.—On 3rd, fine but dull, at 2.30 p.m. a thick fog for half-an-hour over the sea and hills. T S and H at noon on 8th, showery after, at 11·55 p.m., most vivid L. Aurora on 10th. The coldest and wettest November known for some years; at the commencement of the month the wind for several days in the E.; in the latter part the wind prevailed from the N.E.

SCOTLAND.

DUMFRIES.—The first half of the month fine, with frost at night; excessive R on 14th, fine with frosts to 19th; a week of coarse weather followed; the close of the month fine, with some frost, snow, and sleet, on 9th, 10th, 21st, 22nd, and 30th. On the night of the 9th a beautiful display of aurora borealis, and again on the 10th. The rainfall is 0·39 in. below the average of five years preceding.

SILVERBUT HALL.—An open month. Fine aurora on 9th and 10th; beautiful rainbow on the morning of the 21st; the bow appeared a few minutes after sunrise, and so strong was the refraction that the tints were reflected with a fulness and a beauty rarely to be seen even in a spring or summer rainbow. S, R, and H on the same day; snow-storm on the 29th and 30th, 6 inches deep.

AUCHENDRANE.—With a temp. below our general November mean, the other weather tests agree; the capacity of the air for vapour was small, and even that small capacity was saturated only on 8 of the 60 observations. The difference also between the mean temp. and the mean dew-point was greater than the Nov. mean, implying greater dryness of the air. In this month, reckoning the calms and variable winds as neutral, the polar and equatorial nearly balanced each other, but the half of the total rainfall fell in the week ending on Saturday, the 25th, when also occurred our principal equatorial gale; the polar winds, though strong elsewhere, never rose here to the strength of a gale. River low up to 14th, with a total rainfall of ·46 in.; from 14th to 25th, river high, with a total rainfall of 2·34 in. and equatorial winds; from 25th to end, river again decreased, with polar winds and ice. Winter has commenced very severely.

NOOKTON —Aurora on 10th.

DEANSTON.—The month began dry and frosty, and continued so with very little rain till the 14th, which was wet and stormy; slight snow shower on the 16th. Very wet and stormy on 19th, 20th, and 21st, with S 2 inches deep on night of 21st. The remainder of the month dry, frosty, and very little wind.

BALLATER.—This month opened with cold wind and occasional R; S on the hills on the 8th; bright aurora, meeting at zenith, on 10th; lunar halo on 23rd.

ABERDEEN.—A month of cold, bleak, dull weather.

PORTREE.—Fine weather the first six days; afterwards cold, wet, and stormy; a good deal of S on the high grounds, with sharp frosts from the 24th to the end of the month. A heavy gale from S. on 19th and 20th, which stripped the slates from many houses; nearly 3 in. of rain fell on the 20th.

LOCHBROOM.—Except the four days at the beginning and the six at the end, the whole month has been one of unusual severity. So far as storms, rain, cold, and early winter are concerned, a very severe month.

SANDWICK.—November has been a cold month, being 3·2 in. below the mean, but with the exception of three gales of from 40 to 50 miles an hour, which extended (with lulls) over eight different days—viz., 8th, 9th, 10th, 16th, 17th, 20th, 21st, and 22nd—the wind was moderate. The rain was very near the average, with very little snow. Aurora on 7 nights; rainbow on 15th and 23rd; large solar halo on 13th; large lunar halo on 23rd.

IRELAND.

WATERFORD.—Aurora appeared on 9th and 10th, being finer, more intense and brilliant on the latter night; greatest brightness in the W. and N., round to the N.E., bright rose in W., green towards zenith, rapid flashes and streamers at 9.30, assumed overhead the form of an inverted cup.

MONKSTOWN.—An unusually dry and cold November. Aurora on 10th, over almost the whole sky, some parts crimson, very rapid in motion. Ther. at window, 25° at 7 a.m. on 18th; vivid L and T at 5 p.m. on 27th. Very heavy H in Dublin at 9.55 a.m. on 30th.

GALWAY.—Brilliant aurora on 10th.

DOO CASTLE.—Fine month; a good many frosty nights; aurora on 10th.

WARINGSTOWN.—A very fine and seasonable month; wheat sowing nearly finished; rainfall very small; strong gale S.E. on 21st.

THE SEPTEMBER RAINS.

To the Editor of the Meteorological Magazine.

SIR,—In the last two numbers of your magazine you have alluded to the heavy rainfall of last September, and stated "that in the longest registers very few equal to it are to be found."

It may perhaps interest some of your readers to know, that at my Uckfield observatory only 3·07 in. fell during the entire month, which was 0·30 in. only above the average of the last twenty-eight years; and that during this period *twice* the quantity has fallen on one occasion, and *nearly* twice on two other occasions—viz., September, 1852, 6·54 in.; 1856, 6·06 in.; and 1866, 6·12 in. The fall of rain during the last eight days of September, 1871, was as follows:—23rd, ·82; 25th, ·31; 26th, ·50; 27th, ·26; 29th, ·40; total, 2·29 ins. At my Crowborough Beacon Observatory, the total rainfall for the same days was exactly 3 inches.—I am, &c.,

Uckfield, Nov. 17th, 1871. C. L. PRINCE.

To the Editor of the Meteorological Magazine.

SIR,—Finding you have published in the last number of your Meteorological Magazine returns (including one from Chippenham), of the unusually heavy rainfalls from 23rd to 30th Sept, I enclose mine for the same period, thinking it may—though late in reaching you—still afford some interest, if only for comparison.—Yours truly,

West Tytherton, Chippenham, Wilts, 19th Oct., 1871. F. B. GRITTON.

Rainfall at Tytherton, Chippenham, Wilts, from Sept. 23rd to 30th., 1871.

23rd,	24th,	25th,	26th,	27th,	28th,	29th,	30th,	Month,	8 days.
0·62	0·01	0·79	0·85	0·31	0·08	0·98	0·30	5·68	3·94

To the Editor of the Meteorological Magazine.

SIR,—The rainfall here in September was 6·81, rather more than half of which (3·67) fell between the 23rd and 30th inclusive. This total has been twice exceeded in the last six years, viz: 12·50 in Sept. 1866, and 8·28 in Sept. 1869. The three falls, taken together, are remarkable for a dry month, and will disturb my September average for many years to come. The heaviest fall was 1·26 on the 29th, and 1·16, and 1·05 fell on the 3rd and 6th respectively. The rain here was not so confined to the end of the month as in many localities. I subjoin figures, as you may like to see them.—Yours, &c.,

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

Rainfall at Tynant Radyr, Cardiff, from Sept. 23rd to 30th, 1871.

23rd,	24th,	25th,	26th,	27th,	28th,	29th,	30th,	Month,	8 days.
0·32	0·00	0·46	0·78	0·46	0·03	1·26	0·36	6·81	3·67

[More on this subject in *British Rainfall*, 1871.—ED.]

DECREASE OF RAINFALL WITH ELEVATION.

To the Editor of the Meteorological Magazine.

SIR,—If you do not think that sufficient space in your magazine has been already absorbed by this controversy, I beg to ask for the publication of the views contained in this letter, especially as, so far as I am aware, I am breaking new ground.

For the sake of brevity, I shall call the phenomenon in question *Altitude-Difference.*

Most of your correspondents appear to think that, if they can show that rain-drops in their descent are brought nearer together, Altitude-difference must result. This, however, is not necessarily the case, as we shall see further on.

In order to explain my views, I will take first a very simple case, because the argument, if sound for that, will apply to other and more complicated circumstances.

It is a well-known fact, that currents of air at different altitudes have frequently different velocities, increasing as we ascend, when stormy winds prevail, although this is by no means always the case when the wind on the earth is moderate. Let us, however, take the case of a cloud discharging rain, having a greater velocity than the lower regions of the air, and let us assume that the wind-force continuously decreases during the descent, but that the same direction is preserved, say from the N. After the rain has fallen for a few seconds, and long before it reaches the earth, the drops, while the force of the wind remains unchanged, will be practically moving in parallel straight lines inclined at a certain angle to the horizon. As soon as they arrive at a stratum of air having a less horizontal velocity than they possess, they will experience a new resistance in a horizontal direction opposite to that of the wind. The first or southernmost layer of drops will be retarded horizontally, and will thereby lose a portion of their horizontal *vis viva* which will be imparted to the air; but, considering the relative densities of air and water, a great increase of velocity will be acquired by the air for a small decrease in that of the rain. The next layer of drops will suffer less resistance from the air thus affected, there being less difference of velocity than in the former case, and will therefore

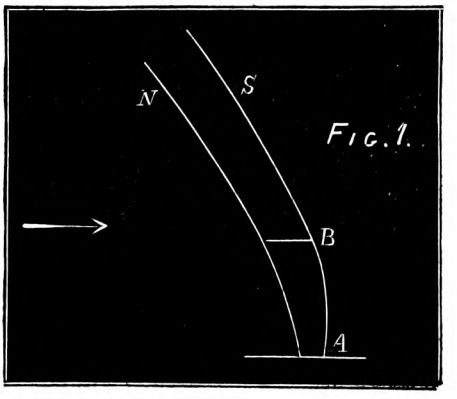
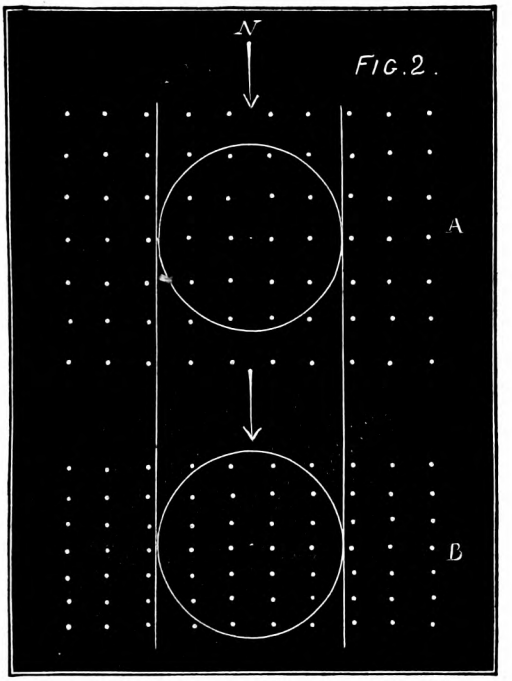


FIG. 1.

be less deflected than the first layer, and so on to the northernmost layer, which will suffer the least deflection of all; and as, according to our hypothesis, the wind has continually less velocity as the rain descends, the shower will be more and more compressed in a direction from S. to N. as it approaches the earth, so that it will assume the form shown in Fig. 1, where the arrow gives the direction of the wind. Let us suppose there are two rain-gauges, one at A, and the other at B; these will collect precisely the same amount of rain, (although the shower at B will last longer than it will at A) because the arrangement



of the drops at A and B will be similar to that shown in Fig. 2, which represents cross sections of the shower at those two places, as in each case the only drops caught will be those between the two parallel lines drawn in that figure. Under these circumstances, the compression of the drops is in the direction of the cloud-wind, which I will call *longitudinal* compression, and which, as we have seen, can produce no altitude-difference.

Now, let us consider the case of a change in the *direction* of the wind between the upper and lower strata of air. Suppose the cloud-wind to be N., and that of a lower stratum to the E. of N.; we may consider the latter as the resultant of two winds, one N. and the other E. The N. component we may neglect, because, whether it has greater or less velocity than the rain-cloud, it can only produce longitudinal compression, which, as we have seen, cannot cause altitude-difference. But the E. component is a very different affair: it will, by parity of reasoning to the former case, produce a lateral deflection of the drops, to a greater

extent on the easterly than on the westerly layers, thus giving to the shower a lateral compression in the direction E. to W., and continuing this compression to the surface of the earth; so that, if we take cross sections of the shower at A and B, as before, we shall find the arrangement of the drops like that shown in Fig. 3; and as, no matter in

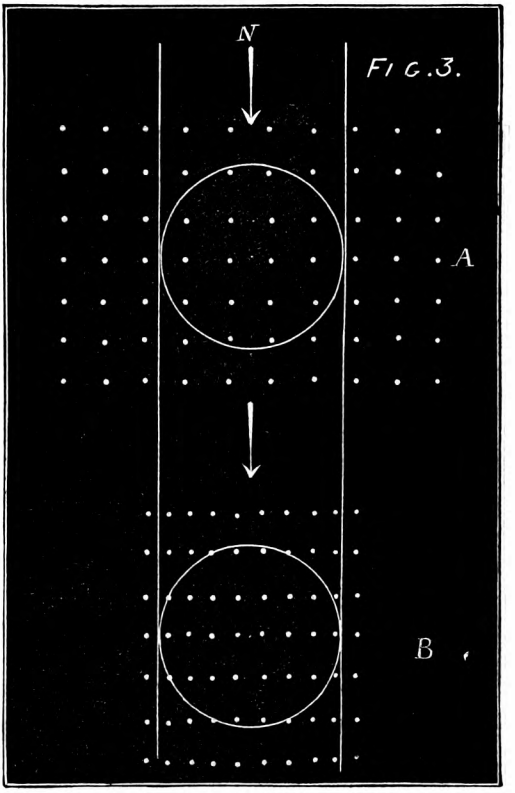


FIG. 3.

what direction the wind may be blowing at the surface of the earth, the shower will move from N. to S., it is evident that a rain-gauge at

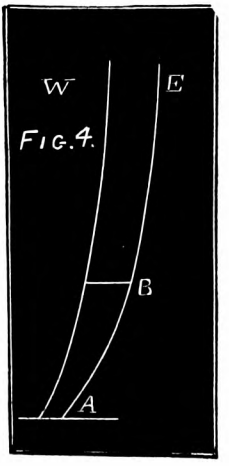


FIG. 4.

A must catch more drops than an equal one at B. The shower, as viewed by an observer looking N., will assume the form shown in Fig. 4; and this is no mere hypothetical representation, but what I have frequently observed, and which led me to the above solution of the altitude-difference difficulty.

The compression of a shower, as above described, appears to be analogous to that of a very imperfectly elastic body.

My theory, then, is, that if and when rain, in its descent, passes through a stratum of air having a horizontal motion in a different *direction* from that of the rain-cloud (a circumstance, as observation has shown, of no unfrequent occurrence), altitude-difference must necessarily ensue; but this is not exclusive of any other possible mode of accounting for this phenomenon.

It is obvious that this theory will explain the cause of a deluge of rain traversing a narrow track of country, as sometimes happens during violent storms.—I am, Sir, your obedient Servant,

JOHN PARNELL.

Hadham House, Upper Clapton, Nov., 1871.

To the Editor of the Meteorological Magazine.

SIR,—It appears to me that Mr. Cator has made a serious error in one step of the proof of his theorem in this month's magazine, so that, unless I greatly mistake, the results worked out are utterly opposed to the correct state of the case. I refer to page 185, where Mr. C. says, "Next suppose the position CH 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," and so on, down to the 14th line. Now, I submit that the *angle of the rain* has nothing to do with this effect, but that the *sole cause* of the diameters CH, CK, CN catching a *less number* of drops than CG is, that there is a *greater space between the drops* as they fall upon them than upon CG; in this case, we need not wonder that we get a *less number* of drops upon them (this will appear more evident by increasing the size of the diagram): the fact is, that Mr. Cator is comparing the results of horizontal gauges CN, CK, CH, CG receiving respectively rain of *different* density or volume, for Mr. C. has ignored the fact that, in a shower of a given density, the relative *horizontal* distance of the drops is *constantly the same, at whatever angle with the vertical the rain may fall.* Mr. C. assumes CN, CK, CH, CG to be horizontal, though the diagram does not show the horizontal relative distances of the drops to be equal throughout the four diameters. This serious error causes a mis-application of the results worked out in the three examples; thus, from figure 1, Mr. C. finds "that when rain falls at an angle of 30° with the vertical, a horizontal gauge loses one-seventh of the rainfall." The fact actually deduced is, that a gauge will catch one-seventh more rainfall, if we tilt it up from a horizontal position to one at right angles to a shower falling at an angle of 30° with the vertical. So from figure 2 the deduction should be stated: when rain falls at an angle of 45°, a

gauge will catch five-twelfths more rainfall if we tilt it up from a horizontal position to one at right angles with the rain. From figure 3 : when rain falls at 60° with the vertical, a gauge will catch twice as much rain if we tilt it up from a horizontal position to one at right angles with the rain. The deductions are comparisons of *horizontal* and *inclined* gauges, a very different thing from the comparison of horizontal gauges receiving rain at *different angles with the vertical.*

Mr. Cator's diagram clearly brings out, as all mathematical figures must do, the truth of the fact, that *the angle* of rainfall does *not* affect the *quantity* received by a given *horizontal* surface.

With respect to the decrease of rainfall with elevation, I have a strong persuasion that the *velocity of the wind* (the cause of angle of rain with the vertical) is also *the cause* of loss of rain, as shown by a horizontal gauge at an elevation : (1) the wind rebounds from the interior of the funnel, (2) eddies are produced around the gauge, (3) the out-splash of rain is great, from the violence and perpendicular direction with which it is driven upon a small area of the interior part of the funnel. Experiments have shown that gauges inclined at 45° do *not* show the loss of rain at an elevation, and I conceive that the wind and rain in this case are driven nearly perpendicularly down the mouth of the gauge, meeting no opposed part of the funnel, so that the rain reaches its destination, undiminished in quantity, neither blown away nor out-splashed.—Yours truly,

G. WARREN.

Merton Villa, Cambridge, Nov. 20, 1871.

SIR,—If you will allow a little practical knowledge a place in this discussion, it may possibly aid in solving the problem, which as I understand it is— *Why does a gauge perched upon a pole collect less rain than a gauge on the ground?—and why does a gauge placed on a hill of equal height with the pole collect more than the gauge at the bottom of the pole?* To begin, I assume that the pole and the hill are in different places, and that the results were obtained from different rain-clouds. My experience was gained in the mountains of Western India, where the rainfall is magnificent, and where I indulged my fancy by being constantly out in it. From an elevation of 4000 ft. I have seen storms and showers falling below me, while around and overhead it was quite clear. I have descended into the clouds, and met first mist, then drizzle, and then rain. From the top of one mountain, I have seen the crest of another, at a distance of 20 miles or thereabouts, the intervening country being hidden with clouds ; on riding into them I have found the same process, with heavy rain on the level ; on the opposite ascent I have gradually got out of the rain, and found sunshine on the hill-top. From the level plains I have seen the mountain-tops thick with clouds ; I have sometimes met the rain heavy on the ascent, and at other times heavy on the summit. From the tops of the mountains I have seen the rain-cloud rising from the distant sea, spreading over the shore, enveloping the

hills, and falling in a regular down-pour—no drops, but thick streams. I gathered from these facts, and from many others of a like nature, that rain-clouds vary in thickness from about a hundred yards to more than a mile, that the weight or size of the rain-drops increase as they reach the point of attraction—this point is the earth, and may be the mountain-top or the level plain; as the latter does not fall in with so much moisture as the former, its chances of attraction are fewer, and the water "rests on the hills," so that the hill gauge shows a greater fall than the gauge in the plain. I see it mentioned in your correspondence that a gauge at 100 ft. of elevation loses 40 or 50 per cent. of rain; such instances are by no means unlikely; I have seen rain falling from clouds not a hundred yards in thickness, so that 100 ft. of elevation above the line of attraction would get up into the drizzle before the drops are formed; this drizzle and the haze above it move faster than the rain-drops, so that a gauge running up into the cloud-moisture could not receive so much water as that placed on the attracting line, simply because the water is not formed. Of all the able and interesting correspondents in your November number, Mr. Franklen G. Evans is the only one who approaches the truth; he has mountains near him, and it is only in such districts that opportunities are given of looking into cloud phenomena; some seem to think that a cloud discharges its contents in actual rain-drops; if it did, there would be no moisture left to go on with, but an All-Wise Creator has arranged otherwise, and while some of the vapour is accumulating into rain-drops for us, the rest is passing on to bless the dry earth beneath. It will be obvious to you that water-spouts and thunder-storms are exceptions to the system I describe. In India there are seldom two layers or more of clouds—in England, as far as I have been able to ascertain, it never rains without two layers.

I am, your obedient servant, H. P. MALET.

Nettlebed, 20th November, 1871.

To the Editor of the Meteorological Magazine.

SIR,—As the discussion is to go on, I must beg for a few words, chiefly of explanation. I doubt whether Mr. Evans is correct in saying that the fall on mountain *tops* is greater than in valleys. There is generally an increase of 3 per cent. in each 100 ft. of elevation above the sea level. This is probably owing to the absorption of much of the rain by the drier strata of air below, as well as the greater condensation caused by the immediate proximity of the mountain masses. But when a gauge is placed on the very top of a hill, or in any very exposed position upon it, this increase is much lessened and often turned into a decrease. Hence we find the fall on the summit of Scawfell scarcely half that at the Stye; or, to refer to my own experiments, the fall on the top of Ling Hill, in the months Oct., Nov., and Dec., nine-tenths of that in the level light-house garden, 100 ft. lower, and that in the experimental gauge field 3 in. less in

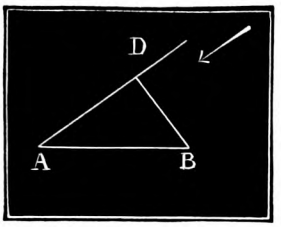
the year than that in my garden at Hawsker. That the cause of this decrease, whether the gauge be on a hill-top or a pole, is the greater obliquity of the rain at the higher station I have not the smallest doubt, but it was no part of my "original theory" to explain the precise mode in which obliquity produced this effect. About this there are different opinions, and I am not sure that at present it is possible either to explain the mode, or to prove (any more than to disprove) what nevertheless I believe to be a solid fact, that the *decrease with elevation is produced by greater obliquity of rain consequent on greater exposure.* As to the mode, I am inclined, as may be seen from my letter in your October number, to agree on the whole with Mr. Crallan. A drop of rain, however, is not simply a projectile, having a certain initial velocity, but a projectile acted on during the whole of its course by an accelerating force (*i. e.*, wind), gradually diminishing in intensity, and very rapidly diminishing as it nears the ground. Though perhaps this may only affect the shape of the curve which it describes, and not the questions at issue, if the wind is a horizontal force, which it is not always.

When I speak of drops *diverging*, I mean that the distance of their paths from one another, measured along lines perpendicular to them, increases. Surely this is the obvious sense of the words, and if this is incompatible with *preserving the same horizontal distance*, and, as Mr. Du Port says, "refutes" it, it is consoling to find that this self-refuting proposition is the same which he and Dr. Burder have been maintaining all this time as the law solely and exclusively followed by all rain-drops.

I am quite ready to admit, and in fact I so understood Mr. Crallan from the first, that during the continuance of a uniform fall of rain the height from which the drops fall should (if his theory be true) be of no importance. It is when the shower begins or ends, *or when the thickness of cloud is increased or diminished*, that it should make a difference. So far from this being an "exception with which we have no concern," it may prove to be very important indeed. Any one who has been much among mountains knows how incessantly the clouds change, lowering and lifting, parting and then closing again; and no doubt every change in the amount of rain received in a given time is accompanied by some change in the thickness of the clouds. Who has not on a rainy day observed partial gleams over and over again, followed by denser clouds, and very likely in every case the thickness of the discharging rain-cloud was altered by thousands of feet. It may be difficult to find a numerical expression for the continuity or non-continuity of rainfall, but I should not wonder if the fact which sorely puzzled me may thus find an explanation—viz., that decrease with elevation is great in showery and light rains, and least, sometimes *nil*, in heavy and continuous downpours. I will try to work out some figures on the subject.

Mr. Du Port has not, I presume, observed my definition of "presenting a smaller area of aperture," or he would not have again quoted

my words in some sense of his own. Perhaps the following may be still simpler :—



If A B be the mouth of a gauge (for simplicity we neglect the width), and D A B the angle at which rain meets it, B D, the perpendicular upon A D, is a measure of the aperture which A B presents to rain falling in a direction parallel to D A, since any drops which pass without D B must pass also without A B. If rain falls vertically, D A B is a right angle, and B D coincides with A B, but if rain falls at an angle with the vertical, B D must be less than A B—that is the aperture presented by A B is less when rain falls obliquely.

I am, Sir, your obedient Servant,

FENWICK W. STOW.

Harpenden, St. Albans, Nov. 22, 1871.

P.S.—I have examined my register from April, 1870, to the end of the year, and have taken out all instances in which I ceuld approximate to the duration of each fall, dividing them into two classes, with the following result :—

	Falls of short duration.						*Falls of long duration.*					
	No. of falls.	At 1 ft.	At 10 ft.	Per-centage of fall at 1ft.	Estd force of wind 0—12	Duration of each fall.	No. of falls.	At 1 ft.	At 10 ft.	Per-centage of fall at 1ft.	Estd force of wind 0—12	Duration of each fall.
		in.	in.			hours.		in.	in.			hours.
	2	0·060	0·055	92	3	0·5	1	0·030	0·050	167	4	6 (?)
	0	0·090	0·080	89	7	0·5	1	0·030	0·030	100	0	4
	2	0·070	0·050	71	4	0·5	2	1·990	1·950	98	1	4
	1	0·070	0·065	93	3	1·0	2	0·128	0·120	94	2	5
	1	0·050	0·050	100	1	0·5 (?)	2	0·355	0·325	91	3	6
	3	0·212	0·190	90	5	1·0	1	0·470	0·430	91	3	5
	1	0·230	0·212	92	6	0·5	1	0·140	0·100	71	4	4·5
	1	0·105	0·090	86	6	1·0	2	0·140	0·130	93	3	12
	1	0·090	0·075	83	2	2·0	2	1·250	1·200	96	5	9
	1	0·080	0·070	87	4	2·0	3	2·500	2·330	93	7	17
	1	0·090	0·080	89	5	1·0	3	0·710	0·685	96	9	3
	1	0·035	0·025	71	7	2·0 (?)	1	0·830	0·800	96	8	5 (?)
	2	0·070	0·055	79	2	0·5	2	0·342	0·310	91	5	3
	6	0·360	0·300	83	4	1·0	1	0·380	0·365	96	5	7
							1	0·615	0·568	92	4	16
							1	0·220	0·210	95	1	6
							1	0·440	0·430	98	4	9
Sums	23	1·612	1·397		59	14·0	27	10·570	10·033		68	121·5
Means		0·070	0·061	86·6	4·2	0·6		0·391	0·371	94·9	4·0	4·5

The result is certainly remarkable, and the more so that the force of the wind was so nearly equal in both cases. Is it possible that the drops shelter one another, and so the tail of a shower converges towards the middle of it?

F. W. S.

To the Editor of the Meteorological Magazine.

SIR,—I must apologize for sending you another letter on this subject, of which you must be heartily sick.

So far from there being any real discrepancy between Mr. Stow's figures on page 71, and those of Mr. Cator in your last number, the latter are a complete verification of the former; and Mr. Cator might have avoided the trouble of his formula and calculations, deducing his results from Mr. Stow's in the following simple manner:—

$$\frac{13}{100-13} \times 100 = 14{\cdot}94\ldots \text{ for an angle of } 30°.$$

$$\frac{30}{100-30} \times 100 = 42{\cdot}85\ldots \quad ,, \quad 45°.$$

$$\frac{50}{100-50} \times 100 = 100 \quad ,, \quad 60°.$$

$$\frac{100}{100-100} \times 100 = \infty \quad ,, \quad 90°.$$

The trifling difference in the results in the two first per-centages merely arises from Mr. Cator's approximations for the trigonometrical ratios being rather closer than Mr. Stow's: but this of course is immaterial.

It seems almost needless to point out that the two sets of figures have reference to two different things: Mr. Stow's gave us a comparison of the deficiency caused by obliquity, with what he supposed would be collected if the rain always fell vertically; Mr. Cator's on the other hand give a comparison of the amount lost with that actually collected. In other words, referring to the diagrams on page 186, while Mr. Stow was comparing FN with FC, Mr. Cator compares FN with NC.

Now with regard to horizontal, vertical, and inclined gauges, we have three laws, viz:—

(1) The ratio of the amount of rain caught by a horizontal gauge varies as the cosine of the angle which the rain makes with the vertical.

(2) The ratio of the amount caught by a vertical gauge varies as the cosine of the angle which the rain makes with the horizon.

(3) The ratio of the amount caught by a gauge inclined at right angles to the showers varies as the cosecant of the angle which the rain makes with the horizon.

The first of these was stated by Mr. Stow on p. 71, and has been abundantly verified by Mr. Cator; the second is the converse of it; the third I endeavoured to establish in the October magazine, and anyone can verify it for himself.

There can be little doubt I think, of the *general* truth of these laws; and none whatever, if we may do as Mr. Cator suggests, and "treat the angle made by the direction of the rain with the surface of the gauge, as the only element on which the differences of the amounts caught depend," ignoring minor considerations, about which opinions differ.

But while it may be useful and interesting to know them, these results have not in the least helped us to a solution of the difficulty. No one who thinks much about it would deny the truth of Mr. Stow's law, as showing to what extent a horizontal gauge presents a smaller aperture to oblique than to vertical rain: but this is a very different thing from admitting that if the same amount of rain fell, first vertically, and then obliquely, the amount caught by such a gauge would be different.

It appears to me that the mathematical part of the question has been exhausted. What we want to know is whether the unquestionably smaller aperture presented by a horizontal gauge to oblique, than to vertical rain, is, or is not, counterbalanced by some modified condition of the rain itself; and this question no mathematical consideration as to the extent of the decrease in aperture can in the slightest degree help us to answer. One side interprets the results to prove that in windy weather horizontal gauges catch too little rain, and the other to prove that inclined and vertical ones catch too much. This being the case, we can only adopt the suggestion of Mr. Stow at the end of his last letter.

I do not quite understand the second paragraph of that letter. I understood that Mr. Stow considered horizontal gauges in error at elevations above the ground, and I took exception to the conclusions drawn by him from the use of vertical and inclined gauges: but I never supposed anything so absurd as that he wanted other gauges inclined.

I think he is rather unnecessarily severe about the suggestion in the October Magazine, and with due deference to his unquestionably better judgment and experience, I still think, that although we cannot attempt so to *settle* the matter, it would be interesting to know the general opinion.—I am, Sir, Your obedient Servant,

REGINALD BUSHELL.

Hinderton, Neston, Cheshire, Nov. 30th, 1871.

To the Editor of the Meteorological Magazine.

SIR,—In the interesting discussion of this question, I believe that what may be called the *forces of precipitation* have been shown to be at their maximum at the earth's surface. That is to say, that (as shown by Mr. Evans and Dr. Hudson in your last issue) the aggregation of rain-drops due to electrical changes, and their condensation in falling through a relatively warmer stratum of air charged with moisture, prove rainfall to be a cumulative process. How far then is this result modified by other forces? The force of the wind is observed to be *distributive*, as when, (1) in the case of a shower, the rainfall from a cloud of given area or capacity is distributed over a more lengthened area of land, or when, (2) in more continuous rain, the *abrading force* of the wind tears off from each falling rain-drop

minute particles of vapour, and thus lessens precipitation. All observers will have noted this buoyant action of the wind, and how the angle of rainfall, varying with the force of the wind acting unequally on the heavy and light rain-drops, shows intersecting lines. Naturally therefore, "they are not surprised" if the rainfall is found to be greatest at the point where (as a rule) precipitation is least interfered with, viz: at the earth's surface.

Of course, I do not mean to say that the distributive action of the wind is uniformly as above stated; I have seen the wind tear up a column of rainfall, and then dash it in a denser sheet of water to the ground, and I have seen the finer particles of rain cast upwards by the wind so as to wet the inside of my umbrella; but at present I speak only of the wind's ordinary action, to arrive at a rule of observation for general application.—Yours faithfully,

HUGH INGRAM, M.A.

Steyning, 7th Dec., 1871.

To the Editor of the Meteorological Magazine.

SIR,—Mr. Cator's diagram in your last number (p. 184), is so excellently devised to illustrate the point in dispute, and, to my mind, is so convincing of the truth of my own view, that I am much disappointed at finding that Mr. Cator himself holds a different view. For I cannot take any comfort from his admission that both Mr. Stow and myself "are for the most part right." My contention is that both Mr. Stow and Mr. Cator are radically, absolutely, and fundamentally wrong. I have the greatest respect for both these gentlemen, and gladly acknowledge their eminent services to meteorology, but on the point now at issue I yield not one inch of my original position

Mr. Cator's letter divides itself into two parts. In the first part (to paragraph 5 inclusive) he proves more clearly than I have ever done (not having had the advantage of a diagram) that the amount of rain received by a horizontal surface is not affected by the inclination at which the rain falls. In the second part he endeavours to show that the amount of rain received by a horizontal surface is affected by the inclination at which the rain falls. It seems to me that one of these conclusions must be erroneous; and I think it is not very difficult to detect the fallacy by which the latter of them is vitiated.

Mr. Cator argues justly enough from his diagram (which I beg my readers to refer to throughout the reading of these remarks), that in the case of driving rain, a smaller gauge tilted to meet the rain will catch the same amount as a larger gauge placed horizontally, and more than itself placed horizontally. "Suppose a gauge," says Mr. Cator, "the diameter of whose receiving surface is in the position C G (diagram, p. 184), 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."

Up to this point we are in perfect accord. But Mr. Cator further contends that to alter successively the position of the gauge with reference to the rain, will be the same thing in its effect as to alter successively the inclination of the rain with reference to the gauge. Accordingly, he directs us to vary the position of the diagram so as to make each transverse line in turn a horizontal line; and thus, if we have not all our wits about us, it is proved, before we are aware, 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."

It is difficult to imagine a line of argument more plausible and yet fallacious. The fallacy lies in turning the diagram about, not seeing that in so turning it we alter its meaning. Paradoxical as it may at first sight seem, the meaning of such a diagram as that to which I am referring is contingent upon the position in which it is held. A little reflection will show that this is so. If the diagram is held in its natural position, so that the line C N is horizontal (I am still referring to the diagram on p. 184), then the oblique lines represent rain of a certain degree of intrinsic density—namely, of such a degree of intrinsic density as to correspond to the vertical lines let fall from the line A B. But if the diagram is held so that the line C G is horizontal, then the lines representing the rain represent a denser rain than in the former case, as would be plainly seen if a rectangular slip were cut out of the diagram in the direction C G (*i.e.*, a slip of which C G should be one of the longer sides), and the same were applied to A B, so as to compare vertical with vertical. It would then appear that the same number of vertically falling drops which are represented between A and B are also represented between C and G, and the latter being the shorter line, it follows that the rain in the latter case is denser; the direction being in each case vertical, and the two kinds of rain being therefore strictly comparable.

Or, to put the argument in a more strictly logical form, the rain represented as falling vertically from the line A B is clearly of the same intrinsic density with the rain represented as falling obliquely from the same line, for it is the same rain, drop for drop. But the rain represented as falling vertically upon C G (the diagram being turned), is shown by the experiment just described to be intrinsically denser than the rain represented as falling vertically from A B. Therefore the rain represented as falling vertically upon C G (the diagram being turned) is intrinsically denser than the rain which the same lines represent as falling upon C G (the diagram being erect);

and therefore the meaning of the rain-lines *quoad* intrinsic density, does vary with the position in which the diagram is held.

Hence it follows that the reason why, in turning the diagram about so as to bring the lines C G, &c., to C N successively horizontal, a smaller and smaller quantity of rain falls within the length of the line, is not that the inclination of the rain is by these movements successively increased, although such increase is a fact. The real reason is that, in turning the diagram, the lines representing the rain come to represent successively a less and less dense kind of rain—a rain in which the approximation of the drops is less and less due to intrinsic density and more and more due to slope.

For it cannot be too strongly insisted upon or too constantly remembered in this discussion, that there are two distinct ways in which the approximation of rain-drops may vary. First, there may be more of them in a given horizontal space. Secondly, they may be driven by the wind in an oblique direction. In the first case the rain is intrinsically denser; more falls on the earth, and more falls in a horizontal gauge. In the second case, the approximation of the drops applies only to a measurement across their path. Their horizontal distances are unaffected, and the quantity received by the earth or by a horizontal gauge is neither increased nor diminished. In the first case, the multiplication of the drops is real; in the second case it is fictitious. I believe that it is through the overlooking of this distinction that most of the confusion has arisen. The density of a slanting rain is a fictitious density, but a tilted gauge records it as if it were real; and he who forgets that it is fictitious and for the moment regards it as real, will easily fall into the error of supposing that the horizontal gauge, because it catches less than the tilted one, catches therefore less than it ought; the truth being, not that the horizontal gauge catches too little, but that the tilted gauge catches too much.

GEORGE F. BURDER, M.D.

Clifton, 9th December, 1871.

AURORÆ OF 9TH AND 10TH NOVEMBER.

To the Editor of the Meteorological Magazine.

SIR,—On the evening of Thursday, the 9th inst., a rather fine display of aurora was seen here; on the following evening, the 10th, just before sunset, a very dark cloud suddenly appeared in the N.W., and spread rapidly over nearly the whole heavens. The setting sun, shining from under the cloud, cast a lurid glare over the landscape, resembling that of a solar eclipse when the sun is three parts or more obscured. A beautiful rainbow in the N.E.; cloudy more or less, with rain, till 9 p.m., when a very fine aurora was visible. Unfortunately, I did not witness it myself. The friend who described it to me said there was a perfect arch, like a rainbow, from N.E. to S.W., with beautiful streamers and coruscations. It would seem to have been almost as fine as that of Oct. 24th last year.—Yours very truly,

JOHN THRUSTANS.

Wolverhampton, Nov. 11th, 1871.

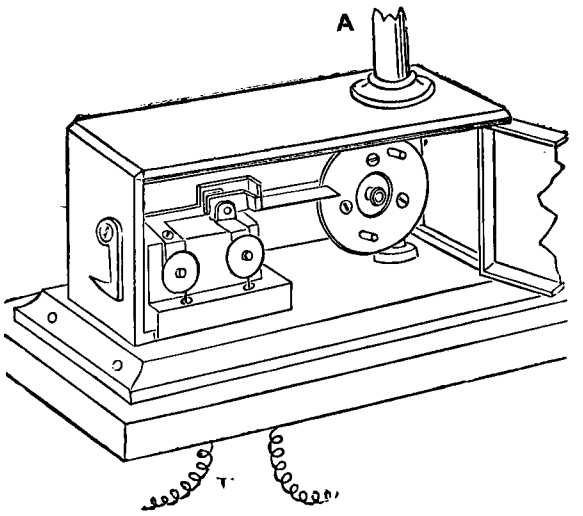


Fig. 1.

A represents the vertical shaft on which the hemispherical cups are supported.

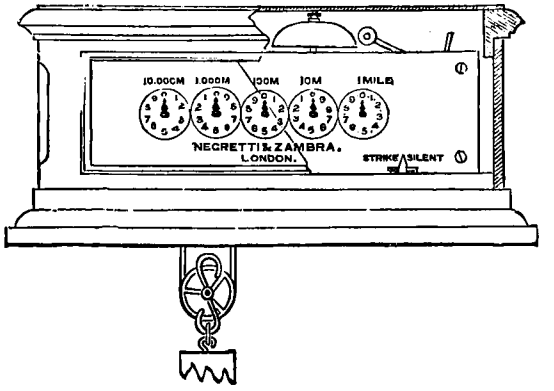


Fig. 2.—Recording Instrument—Exterior.

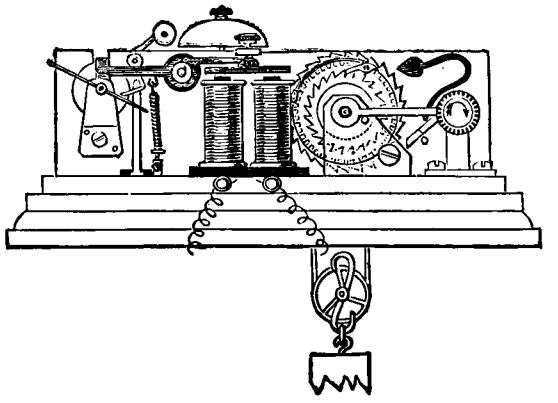


Fig. 3.—Recording Instrument—Interior.

HALL'S ELECTRO-MAGNETIC ANEMOMETER.

[*See p.* 222.

SYMONS'S

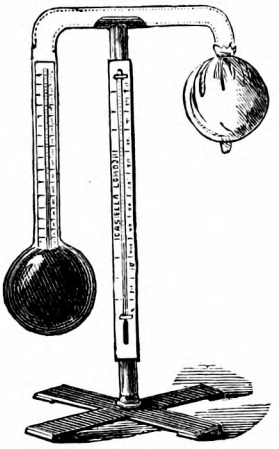
MONTHLY

METEOROLOGICAL MAGAZINE.

LXXII.] JANUARY, 1872. [PRICE FOURPENCE, or 5s. per ann. post free

DEW-POINT AND OTHER HYGROMETERS.

DANIELL'S hygrometer, on the ground both of priority of design and generality of adoption, claims first notice in the group of hygrometers of which the action depends on the evaporation of ether. Its construction and mode of use will be readily understood from the accompanying engraving.



The longer leg contains a small thermometer, the bulb of which is in the centre of the black glass ball, which terminates that leg. The other and shorter leg terminates also in a glass ball, which however is covered with fine muslin. The tube and balls, before hermetical closure, are exhausted of air, and a small quantity of very pure ether is placed in them. By applying the warm hand to the muslin-covered ball, and gently tilting the whole instrument, all the ether may be driven into the black ball, which will become about one-third full. The mode of observation consists in dropping a little ether on to the muslin covering of the short bulb; the cold thus produced condenses the vapour of the internal ether, and promotes evaporation from that contained in the black ball, which thereby becomes cooler, and as soon as, by the continuance of this process, the exterior

been adequately tested. We are sorry that so able a man as Mr. Rowell should thus forget himself. We claim some experience of scientific men, and we deny that there is an atom of foundation for the idea which Mr. Rowell entertains, and not only do we deny it as a general principle, but even in Mr. Rowell's specific case. We cannot spare room to discuss the matter fully, but we do not believe that had Mr. Rowell been a duke, a bishop, or a fisherman, it would have made one iota of difference in the reception of his theories.

The fragmentary nature of the pamphlet before us, the mingling of various subjects, and the fact that the author has burned some of his own papers, combine to render the work by no means easy to review. But the basis of the whole seems to lie in the following sentence :—

"When expanded by heat, the increase of the surface of particles of water giving them a greater capacity for electricity, they are buoyed up into the air by their coating of electricity ; that if condensed near the earth's surface, the extra quantity of electricity is withdrawn, and the vapour falls as dew, &c. ; but if it rises out of the electrical attraction of the earth, and is then condensed, the electricity being insulated, forms an atmosphere around each particle of vapour, which surcharge of electricity not only suspends the vapour by its lightness, but also repels the neighbouring particle of vapour, and prevents the formation of rain ; and on the removal (by any cause) of the electricity inclosing the vaporous particles, the repulsion is removed, and the particles attract each other, and form rain."

Evidently this proposition is more one for the consideration of physicists than meteorologists, and we decline to express an opinion upon it. But the author proceeds to explain various phenomena by this hypothesis, and with respect to evaporation writes as follows :—

"As heat expands the particles of water, it increases their capacity for electricity ; therefore, all other circumstances being alike, the greater the heat the greater the evaporation.

* * * * * * *

"Evaporation from ice is owing to the coldness and dryness of the air separating the minute particles of the surface ; when obtaining their coating of electricity, they are rendered sufficiently buoyant to be carried off by a brisk wind.

"Evaporation from ice, snow, or even water, at very low temperature, is trifling except during windy weather."

We fail to see here any approach to agreement with the recent results of Mr. Dines' experiments.

Again,—

"The concussion caused by a flash of lightning from such a cloud (that is, with its particles pressed nearly into contact) will easily explain the cause of the heavy dash of rain which follows the flash of lightning."

We were not aware that it had been decided that the heavy dash of rain *followed* the lightning. We have often heard the point discussed, and have generally understood the conclusion to be that the rain is the cause, and the lightning the effect, but that owing to the relative velocity of light and rain drops, the effect is seen before the cause.

In his paper on "The Cause of Storms," and in most of the later papers in the pamphlet, which are chiefly reprints of his earlier works, Mr. Rowell exhibits the same ability as in many parts of his "Essay on the Cause of Rain."

The Laws of the Winds prevailing in Western Europe. By W. CLEMENT LEY. Part I. 8vo, 164pp, 27 plates. Stanford.

THE development of what may be described as synchronous, or still better, as chartographic, meteorology is bearing its natural fruit in advancing with rapid strides our knowledge of the "Laws of the Winds." Our Meteorological Office have not yet given us daily, or, like our Transatlantic brethren, *tri-daily* weather-maps, but we understand that we are to have them. Meanwhile, hard workers like Mr. Ley make the maps for themselves, and perhaps in so doing learn their details more thoroughly than if they had them ready to their hands. In the book before us Mr. Ley gives us the first part of the results of ten years' study of synoptic charts of Western Europe. After a brief introduction, in which he points out "the constantly accumulating testimony to the invariability of Ballot's law," and its bearing upon previously accepted theories, he passes on to state his views as to (1) the cause of the formation of the areas of barometric depression which so frequently traverse Western Europe, and (2) the reason of their normal eastward progression. The author's abstract of his views is so clearly expressed that we cannot do better than quote the paragraphs :—

"1. Extensive precipitation occurring in a region of atmosphere previously approaching a condition of tranquillity, is the primary factor of every system of baric depression, with its resulting atmospheric circulation, retrograde in the Northern, and direct in the Southern hemispheres.

"2. Such an atmospheric circulation being established, the changes in their capacity for aqueous vapour which its currents undergo in consequence of the unequal distribution of solar heat, tend to propagate the depression in an Eastward direction."

Mr. Ley is silent as to the originality or otherwise of these propositions, and we therefore infer that they are purely and simply the results to which he has been led, he being probably unaware that a somewhat similar but far less complete form of Proposition I. was published some 30 years since by Mr. Rowell of Oxford. The second proposition we have never seen before.

The body of the work is devoted to illustrating these propositions, which we consider extremely well done—our only objection being to the extreme neatness of the charts. We of course do not object to neatness *per se*, but we think isobars should *always* have their value marked upon them. We think the employment of colour for the principal isobars a good plan, but that it was a mistake to use blue and green in a work which many persons would like to study by artificial light. Mr. Ley's scale runs thus—28·50 orange, 29·00 green, 29·50 red, 30·00 blue, 30·50 brown. We hope that his idea will be copied, but that the chromatic scale will receive further consideration. At first sight it would appear desirable to reject either blue or green on account of insufficient distinction, and that stronger contrasts than red, orange, and brown might be adopted, while we do not see any objection to using a thick black line, and if required, a broken or dotted one of either black or any other colour. We do not presume to decide off-hand on the system of the future, but are of opinion that it should be carefully considered and universally adhered to.

REVIEWS.

Observations upon the Climate of Uckfield, constituting a Meteorological Record for the District from 1843 *to* 1870. *Prognostics of Atmospheric Changes, and some Vital Statistics.* By C. LEESON PRINCE, M.R.C.S., F.R.A.S., F.M.S. 8vo, 240 pp., 1 plate. Churchill.

THE reciprocal obligations of meteorology and the medical profession date back at least as far as Hippocrates, and have never been more extensive than at the present day; and well, indeed, is it that this is the case, for it is hard to say whether its benefits to therapeutics or meteorology have been the greater. The work before us is an illustration of this correlation of the sciences, for though essentially a meteorological work, it also claims a place on the shelves of medical men, not merely as a treatise on local climate, in which respect it is very good, but because scattered through it are pithy hints, and at the close some important remarks on the geography of phthisis.

Our duty is, however, with the work as a local meteorology, and as such we consider that it takes high rank; not surpassing Howard, but having few, if any other equals. It is impossible in the limits of a brief review, to do more than indicate its contents, and make a few passing comments. In the introductory remarks the author gives a sketch of his observatory, and of the instruments in position, with details as to their heights, &c. The following paragraph strikes us as indicating a singular fact:—

"The funnel of the rain gauge has a diameter of 12 inches, and is elevated six feet above the surface of the ground. This height above the ground has been maintained during the whole of the observations, without any appreciable difference in the amount collected in it, and from one of Glaisher's rain gauges, the funnel of which was only four inches above the ground."

Referring to the British Association Report for 1867, p. 456, we find the following remarks on the pedestal gauge:—

"Gauge correct. Good position in centre of town. . . . Would be rather sheltered if lower."

From this one might suspect that in Mr. Prince's comparative observations, the lower gauge did not have a fair chance, but we do not think that that is the solution of the anomaly, because a record was kept very near to Mr. Prince's observatory at that of Mr. Brodie, Moulsey Gore, whose gauge was very well exposed, and only six inches above the ground, with the following result:—

Year.	Uckfield Observatory.	Moulsey Gore.
1865	38·97	39·35
1866	33·79	33·40
1867	30·48	30·48
1868	30·51	31·78
Mean	33·44	33·75

Shewing a deficiency of only 0·31 in. or about one per cent. instead of five or six per cent., which is the case almost everywhere else. It is just

possible that Mr. Prince's six-feet gauge may have a round, or rather flat rim, and that the excess thus obtained neutralizes the decrease due to its elevation above the ground. We shall be glad to see this little uncertainty removed. Meanwhile we may note, *en passant*, that the consistency of the records we have quoted is an indication of the thorough trustworthiness of Mr. Prince's observations.

On page 13 our author explains the short method of averaging barometric and other columns with amounts of small variability, which he discovered for himself, but which we thought had been in general use by computers from time immemorial. In the latter part of this chapter there are several handy rules for the barometric measurement of heights, not exceeding 2,000 or 3,000 feet. This is followed by chapters on the general meteorological character of the several months of the year, together with various excellent and useful tables relating to local temperature, and remarks in reference thereto, on hygrometry, rainfall, and wind. Another gives an account of the leading features in the meteorology of each month from 1843 to 1870. The next is devoted to weather prognostics, and contains a translation of the "Diosemeia" of Aratus, which, though not strictly literal, departs therefrom mainly when the insertion of a few words renders more distinct the meaning of the poet. Without pretending to point out sentences which we should alter, we think that those who are accustomed to the easy diction of the Greek original, or acquainted with Bühle's Latin, or Lamb's flowery English translation, will agree with us that Mr. Prince has felt somewhat hampered by his desire to be at once literal and meteorological. His object, however, has been meteorological, and from that point of view we have no fault to find; on the contrary, we consider it will be interesting and useful to all who are not familiar with the original. The work concludes with a short chapter on the vital statistics of Uckfield and adjacent parishes.

Taken altogether the work is one of considerable utility and excellence, in many respects a good example, and one which must take its place on the shelves of all who desire to be acquainted with the climate of the South-east of England.

Papers on the Cause of Rain, Storms, the Aurora, and Terrestrial Magnetism, reprinted from the Edinburgh New Philosophical Journal, &c., with an Appeal for a Consideration of the Theory advanced. By G. A. ROWELL, Honorary Member of the Ashmolean Society, &c. 8vo, 58 pp., 1 plate. Williams and Norgate.

IT is by no means every writer whose papers are accepted for publication by the *Edinburgh Philosophical Journal*, whose proposals have been approved by such men as Sabine, Wheatstone, Sir John Franklin, Baden Powell, and others; and who is an honorary member of the Ashmolean Society. Mr. Rowell has received all this recognition, and now sends us a pamphlet, complaining that "class feeling was the great bar to a fair consideration of my opinions," and that his "social position" (whatever that may be) has been the reason why his theories have not

of the black glass ball is cooled to the temperature of the dew-point, its bright surface will be dimmed; the internal thermometer is then to be read and again a few seconds afterwards, when the dimness disappears; it is *assumed* that the mean of these two temperature readings is identical with that of the black glass on which the dew is deposited.

The thermometer attached to the pedestal of the instrument is intended to give the air temperature at the time of observation.

This instrument, as its name implies, was designed by Professor Daniell, F.R.S., and was described by him in the year 1820. At the time of its invention, we are not aware that anything at all approaching to its equal as a measure of atmospheric moisture had been designed, and the chorus of opposition with which it was met by the admirers of Saussure's air hygrometer was as unreasonable as it was unsuccessful; we think, however, that the accuracy of Daniell's instrument has subsequently been overrated; owing to the necessarily small size of the enclosed thermometer it is impossible to read accurately small fractions of a degree, and we think it quite open to question whether the internal thermometer really is at the same temperature as the outer glass surface; added to which the necessary proximity of the observer's person must influence the results.

We may possibly recur to this subject when treating of some other instruments, similar in principle, but widely different in detail.

THE WEATHER FROM JANUARY 1 TO JANUARY 7, 1872.

THE rough, unseasonable, and disturbed conditions of the atmosphere during the week seem to claim some notice in these pages. We gather the following notes from various sources, and arrange them in the order of date:—

1st.—Edinburgh was visited by a very severe gale, which seems to have prevailed over a wide extent of country. The streets were rendered dangerous through the falling of slates and chimney cans. Several accidents occurred to pedestrians, but none of a very serious character. The hydraulic machinery foundry of Messrs. Brown Bros., situated between Edinburgh and Leith, was blown down. The loss is estimated at £4,000 or £5,000.

3rd.—A gale began at Falmouth about 8 p.m., lasting till 3 a.m. on the 4th.

4th.—A storm burst over Manchester and its neighbourhood at an early hour in the morning. The wind began to blow hard soon after midnight, and subsequently there was a heavy fall of hail, the stones being as large as marbles. About three a.m., lightning and thunder followed, the flashes of lightning succeeding each other with great rapidity, and being very vivid, and the wind blowing with great fury. The direction of the storm was from south-east to north-west. About half-past 4 o'clock, after an unusually heavy peal of thunder, a

fire was discovered issuing through the roof of St. Mary's Church, St. Mary's-road, Crumpsall.

A terrific thunderstorm broke over the city of York between 5 and 6 a.m., which seems to have been general throughout Yorkshire and Lancashire. Rain and hail fell in torrents, while the lightning was very vivid, and the peals of thunder were very loud. We have not heard of any particular damage in this neighbourhood resulting from the storm.

At Sheffield, about 5 a.m., slight shocks of earthquake were distinctly felt in several parts. Some persons resident in the south-western part of the town state that they were sensibly lifted in their beds by the shock. The thunderstorm was raging at the time, and in the course of it a blade-striker named Howson was killed by the lightning.

At Horbury, in the West Riding, the storm commenced about 4 o'clock a.m. Considerable damage was done to property, in various parts of the town. Buildings were shaken to their foundations by the thunder. Many persons got out of bed and ran partly dressed into the open streets, thinking the place was being visited by an earthquake. The large mill chimney of Mr. W. Ward was struck by the lightning, which threw down a quantity of bricks from the top of the chimney. These fell through the slates of the roof of the drying-house, and then through the floors successively.

At Malton, in early morning, a very heavy storm of rain and hail raged with fearful violence. It was accompanied by loud and frequent peals of thunder, and lightning also flashed vividly at intervals. The rain and hail fell in torrents for some time, and the public grates in the borough were most of them stopped up by the stones and mud which washed down. The streets were, consequently, almost knee-deep in several places, and were like miniature rivers till the storm abated. About half-past 9 a.m. a second storm came on, when it was almost as dark as night.

At 10 p.m. a decided shock of earthquake at Highbridge, Burnham, Somerset.

5th.—Violent thunderstorm, with nearly an inch of hail, at Portsmouth at 7.30 p.m. Lightning in London at 9.30 p.m.

6th.—Three claps of thunder at Cambridge at 0.45 a.m.

Maiden Newton, Dorset.—Gale, of unusual force, from 8 a.m. of the 4th till 5 a.m. of the 5th. Sudden squall of rain, with fireball and thunder, 4.30 p.m. Severe thunderstorm from 6 to 7.15 p.m., lightning frequent, and from all quarters of the compass. Jan. 6th. Remarkable darkness from 8 to 10.30 a.m. Very sharp thunderstorm, 8.40 to 8.55; five flashes within one mile. No great amount of rain has fallen here, about 0.3 in. each day. There has been little oscillation of the wind, which has varied only a few degrees south or north of west, throughout the whole of the electrical disturbance.

We think that the American plan of marking the areas of high and of low pressure, with the words "High" and "Low" respectively, is better than that of denoting them by the letters A and B. And lastly, as the author lays so much stress upon the fall of rain as the cause of baric depressions, we think it would have added to the utility of the work had some further indication of the distribution and amount of rain been given than the occasional presence of the letter P. As to the work itself, there is no doubt that it is an extremely able one, and that the facts quoted support the author's views to an extent which will make refutation difficult. The instances quoted as typical cases are also very well chosen. We desire to call special attention to three charts of the mean tracks of baric minima in March, August, and December, whose resemblance to and differences from, the run of the isotherms for those months are equally suggestive and instructive. We recommend the work to the attention of meteorologists in this and other countries, and look forward with pleasure to the publication of Part II.

UNDERGROUND TEMPERATURE.

To the Editor of the Meteorological Magazine.

SIR,—I have but little hesitation in replying in the affirmative to Mr. Malet's query in your November number. It is needless for me to enlarge upon the arguments which he has brought against the theory of central fire; but there are some others which I think I can adduce against this doctrine, of the existence of which its very supporters have said, "There is no geological proof."

I. The low temperature of the sea at great depths. At the depth of 1,200 fathoms at the equator, the temperature of 39½° has been found, and also at all lower depths; where then does the inherent central heat commence? If the increasing heat of certain *gaseous* strata, at the trifling depth of 2,400 feet, is brought forward to prove the existence of a central heat, how much more powerful is the argument which can be adduced against it, viz., that at the depth of 7,200 feet, and at lower depths, a temperature of 39½° only has been found. Is it not, to say the least, highly improbable that the increasing heat is caused by a central fire, instead of by gaseous strata?

II. The cessation of volcanic eruptions. Allowing this theory, how can we account for the cessation of volcanic eruption, and if it be said because the central fire is diminishing, why then do fresh ones break out?

Again, if the local basin theory is accepted as accounting for this phenomenon, there is the potent argument against it, of what possible material, as our hardest rocks are expelled as lava, can these "solid partitions" be formed?

I could bring further arguments to testify in favour of Mr. Malet's suggestion, but am reluctant to intrude longer on your space.

Your obedient servant,

F. R. HAWKES-MASON.

Wereham, Norfolk.

DISCORDANT MAXIMUM TEMPERATURES.

To the Editor of the Meteorological Magazine.

SIR,—Can you or any of your correspondents inform me what variations, if any, are due to the size of the bulb of a mercurial thermometer? I have for some years been taking all my observations in duplicate, and I want to discover the cause of the difference in the readings of the two maximum thermometers. The one by maker A, has a bulb more than twice the size of the other, by maker B, (Phillips' principle), both are Kew verified. I append a table of the variation in each month, of the corrected readings since May 1870; adding that the readings of the two minimum thermometers are almost identical. Which thermometer is right? Which wrong? the positions are on either side of a Glaisher Stand, and an error of a degree or thereabouts, makes a difference in the range, both mean daily and extreme. How is the error to be discovered without breaking the series of observations? I shall be grateful for any explanation.

And am faithfully Yours,

J. INGLEBY MACKENZIE, M.B. Cantab. F.M.S. &c.

P.S. My rainfall up to Oct. 31st, 26·07 inches.

	Max. A.	Max. B.	Diff.		Max. A.	Max. B.	Diff.
	deg.	deg.	deg.		deg.	deg.	deg.
May, 1870	59·9	60·1	+0·2	February, 1871.	48·5	49·5	+1·0
June	67·9	68·0	+0·1	March	50·3	51·5	+1·2
July.....	72·6	72·5	+0·1	April	54·5	55·6	+1·1
August	69·3	69·7	+0·4	May	59·2	60·3	+1·1
September	64·6	65·5	+0·9	June	63·0	63·2	+0·2
October	58·6	59·6	+1·0	July.....	65·8	66·0	+0·2
November	49·1	50·1	+1·0	August	69·8	70·7	+0·9
December	40·0	40·4	+0·4	September	62·9	63·6	+0·7
January, 1871...	39·9	40·8	+0·9	October	57·3	58·2	+0·9

SNOWFALL REGISTRATION.

To the Editor of the Meteorological Magazine.

SIR,—May I be allowed to suggest that, in entering the amount of melted snow in the register of rainfall (daily), the same be entered in coloured ink—violet, for instance—we might then dispense with the prefix "S" mentioned in the "condensed instructions" which appear at the head of this form, and thereby give, if I may so speak, a clearness to the register. The eye could easily embrace the whole of such registrations at once, and the different periods of snowfall would be far more intelligible. The adoption of any course which would bring about such a result must, I think, commend itself. In adopting the suggestion I have here made, the only precaution necessary is to use some colour which may be readily distinguished from the red used for dewfall. The same colour should of course be used by all observers.—Faithfully yours,

JOHN JAMES HALL, F.M.S.

Fulwell, near Twickenham.

HALL'S ELECTRO-MAGNETIC ANEMOMETER.

To the Editor of the Meteorological Magazine.

SIR,—Having some time since experienced considerable difficulty in using the ordinary form of Robinson's Anemometer, owing to the want of sufficient exposure, I directed my attention to, and succeeded in devising, an electrical arrangement to overcome this difficulty, and at the same time introduced an efficient means for the determination of interval or horary velocities. This instrument was first exhibited, and described by me in a paper read before the British Association, Section A (mathematics and physics), Liverpool, 1870.*

The following is a brief *résumé* of its principles and construction :—The anemometer consists essentially of two parts, which are respectively termed the velocity apparatus and registering apparatus. The first is an ordinary set of Robinson's hemispherical cups, which move in a horizontal plane, and communicate their motion downwards by a vertical arbor into a brass box, where it is reduced in angular velocity, and causes an ebonite contact-disc, or *commutator*, in which two platinum contact-pins are fixed, equidistant from one another, projecting on either side of it, to revolve in 0·1 mile (vide Fig. 1). An insulated metallic lever, having a platinum working-face, which best resists corrosion caused by the action of the atmosphere or dust, stands on either side of the disc ; so that, upon the completion of every ·05 mile, one or other of the contact pins comes in contact with the two levers which form the terminals, and completes the circuit. The levers are then raised a few degrees (of circles whose radii they represent), and, after the transit of the pin, fall back to their normal position, ready to be taken up by the next pin, and so on.

The recording apparatus consists of a train of wheels and pinions working in a frame, or between two brass plates, the arbors of which project through a dial-plate, whereon the circles and figures are engraved, and carry the hands. These wheels are driven by a weight attached to a brass wheel or pulley, working on a double silk-line wound round a barrel to which the driving or great wheel is attached ; and a locking-pin disc, the pinion of which works in the *first* or one-mile wheel, is released at every contact of the cup-apparatus by an electro-magnet, which unlocks the pin-disc, and allows the first hand to advance ·05 mile on the graduated dial, by a jump similar to the minute-hand in remontoire clocks.

By turning "on" a "strike-silent" stop at the bottom of, and projecting from, the dial-plate, a hammer lever is brought into connection with the escapement, and strikes a bell at every contact; therefore, the observer, in noting interval-velocities, may confine his visual attention to the seconds-hand of his watch or chronometer—a *centre*, or *split-seconds*, *or chronograph* would be preferable—while he counts the number of times that the bell is struck, each of which corresponds to

* An abstract of this paper was published in the *Meteorological Magazine*, November, 1870, Vol. V., p. 168. NOTE.—Where 1,500th mile appears, *read* ·05 mile.

·05 mile. I have calculated and arranged a very comprehensive series of tables* (consisting of factors, by which to multiply the number of beats observed, to deduce at once the hourly velocity, also wind-velocities and their corresponding pressures) for use with this instrument.

The following formula (which has been re-arranged since the publication of British Association abstract, before referred to) will serve to deduce the hourly velocity from observations during intervals of minutes and seconds. Let T be the interval of observation in min. and sec. expressed decimally, shown by the watch or chronometer, and x the number of times T is contained in one hour, b number of beats on bell, ·05 unit of distance measured, and V velocity required; then

$$\frac{60}{T} = x$$

therefore

$$x \times b \times \cdot 05 = V$$

Therefore, supposing the bell is struck fifteen times in $1^{m}\ 30^{s}$, expressed decimally 1.5^{m}, the hourly velocity will be

$$x \frac{60}{1 \cdot 5} = 40$$

therefore

$$V = 40 \times 15 \times \cdot 05 = 30 \text{ miles.}$$

By noticing the exact seconds upon which the first and last beats are struck, the results will be as accurate as if the instrument were capable of recording the one-thousandth part of a mile, while the battery power is less called into action, from which we may infer its elemental duration will be considerably longer. In noting velocities extending over long periods of time, the instrument is read in the same manner as the ordinary cup and dial, or Robinson's Anemometer, or as a gas meter.

The recording-instrument requires winding once for every 2,800 miles, but it may easily be arranged to run a greater distance.

For further particulars, I must refer to the *Proc. Meteorological Society*, XXXVII., Vol. V., p. 301, also to a lecture delivered by me on this subject at the British Horological Institute, June, 1871, *Horological Journal*, Vol. XIV., pp. 7, 13. This instrument was constructed from my plans by Messrs. Smith and Sons, clockmakers, Clerkenwell, and Messrs. Negretti and Zambra.

JOHN JAMES HALL, F.M.S.

SYSTEMATIC OBSERVATION OF AURORÆ.

To the Editor of the Meteorological Magazine.

SIR,—Though no one has taken up the subject of systematic observations on auroras, which I introduced in your pages some time ago, I hope there are some who would join in such an undertaking if it was commenced. I therefore suggest a few provisional rules to be attended to by those who co-operate.

* Not yet published.

1. Observations to be made at the exact hours and half-hours, Greenwich mean time, from twilight up to 10 p.m.

2. If there is an arch, the position of the apex of its central line should be noted with reference to the stars; or else its altitude should be ascertained carefully, and its azimuth approximately. If the lower or the upper edge of the arch is well defined, give similar particulars respecting it. State the width of the arch; state whether it is regular or not. If it is somewhat irregular, instead of its actual position, give that of an imaginary arch having its average position.

3. If there is any other very conspicuous feature, its position among the stars may be observed; care being taken to describe it sufficiently for it to be recognized in any account from another place. But the position of the corona, or point to which the rays converge, is of no value for determining the height of the aurora.

Observers must not consider themselves tied down to observe on every occasion; any observations, if made in accordance with these rules, may be useful.

The observations should be sent, from time to time, to you; or, if you prefer, I will take charge of them.—Yours truly,

T. W. BACKHOUSE.

West Hendon House, Sunderland, Dec. 7th, 1871.

STORM OF THE 20TH DECEMBER.

To the Editor of the Meteorological Magazine.

SIR,—The following particulars recorded at this station may be of interest:—

	Barometer.		Wind.		Cloud Direction	Air Temperature	
	Uncorrected	At.Ther.	Direction.	Force.		Dry Bulb.	Wet Bulb.
	deg.	deg.		lbs persq.ft		deg.	deg.
9 a.m.....	29·714	46	S.W.	0·1	...	46·4	45·3
11 ,, ...	·608	47	S.S.W.	11	.	...	...
12½ p.m.....	·488	47	S.W. by S.	13	...	...	...
1 ,, ...	·400	47	S.S.W.	14	...	45·8	45·8
2 ,, ...	·336	47	S.W. by S.	14	...	48·0	44·0
3 ,, ...	·304	47	S.W.	21	W. by S.	46·5	44·2
4 ,, ...	·288	48	S.W. by W.	16	W. by S.	45·3	43·1
5 ,, ...	·310	47	W.S.W.	15	W. by N.	44·0	42·5
6 ,, ...	·392	47	W.	...	W.N.W.	...	...
7 ,, ...	·500	46	W. by N.	...	N.N.W.	...	...

Air temperature max. 48°5. Height above the sea 172 feet.

From the changes that took place in the direction of the wind, it would appear that the storm was of a cyclonic character; that the vortex passed from west to east, and north of this station. A comparison of the cloud currents with those on the ground show that the central line of the vortex was inclined from the ground upwards in an advancing or south-easterly direction.

I am, Sir, your obedient servant, J. R. MANN.

Osborne, Isle of Wight, Dec. 29th, 1871.

DECEMBER, 1871.

Div.		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.	Date.	Min. Deg.	Date.	No. of Nights below 32°. In shade	On grass.
			inches	inches.	in.								
I.	ENGLAND.	Camden Town	1·13	— ·37	·41	25	15	49·0	19	20·1	8	11	16
II.		Maidstone (Linton Park)	1·62	— ·21	·33	20	19	52·0	15	17·0	8	18	...
,,		Selborne (The Wakes)	2·40	— ·35	·45	25	11	48·0	20	16·5	8	13	16
III.		Hitchen	1·15	— ·16	·34	19	23	47·0	18+	19·0	4	17	...
,,		Banbury	1·29	— ·38	·45	20	17	48·7	19	17·0	9	17	...
IV.		Bury St. Edmunds (Culford)	·99	— ·50	·20	6	10	48·0	18†	8·0	8	13	18
V.		Bridport	2·53	— ·84	·46	28	13	50·0	14‡	19·0	7	16	...
,,		Barnstaple	3·15	+ ·03	·54	19	20	52·0	31	22·5	5	...	...
,,		Bodmin	4·70	— ·54	·81	21	24	50·0	30	25·0	5	10	19
VI.		Cirencester	2·33	+ ·04	·76	19	10	...	...	...	...	...	...
,,		Shiffnal (Haughton Hall)	1·32	— ·36	·25	28	13	50·0	18	16·0	8	18	...
,,		Tenbury (Orleton)	1·47	— ·99	·33	28	13	51·8	14	17·5	9	17	23
VII.		Leicester (Wigston)	1·23	— ·29	·35	21	13	49·0	18‖	17·0	7	..	...
,,		Boston	...	...	...	...	...	...	...	...	...	...	...
,,		Grimsby (Killingholme)	1·69	..	·45	20	19	49·0	30	20·0	8	7	...
,,		Derby	1·29	— ·26	·23	25	15	50·0	18	17·0	8	11	...
VIII.		Manchester	2·50	+ ·17	·36	12	20	51·3	18	17·0	8,9	14	20
IX.		York	2·12	+ ·32	·60	30	10	...	...	...	...	...	...
,,		Skipton (Arncliffe)	4·64	+ ·09	·55	28	15	48·0	20	12·0	8	17	...
X.		North Shields	1·90	— ·30	·36	22	15	53·0	18	25·0	5,8	10	16
,,		Borrowdale (Seathwaite)	21·79	+ 4·84	3·88	18	22	...	...	...	...	...	...
XI.	WALES.	Cardiff (Town Hall)	...	...	...	...	...	...	...	...	...	...	...
,,		Haverfordwest	4·58	— ·25	1·00	20*	12	50·6	29	18·2	4	13	15
,,		Rhayader (Cefnfaes)	2·23	— 1·06	·56	27	8	54·0	...	15·0	...	6	...
,,		Llandudno	2·29	+ ·09	·38	28	17	56·4	18	25·6	8	2	...
XII.	SCOTLAND.	Dumfries	3·84	+ ·38	·90	24	17	53·0	18	17·0	5	11	...
,,		Hawick (Silverbut Hall)	3·16	...	·44	13	19	...	...	...	...	...	...
XIV.		Ayr (Auchendrane House)	5·06	+ 1·04	·94	17	22	51·0	30	17·0	4	13	17
XV.		Castle Toward	...	...	...	...	...	...	...	...	...	...	...
XVI.		Leven (Nookton)	1·98	— ·80	·44	13	15	...	...	...	...	...	...
,,		Stirling (Deanston)	4·30	+ ·10	·74	17	20	53·2	18	17·0	23	24	28
,,		Logierait	3·12	...	·55	13	15	...	...	...	...	...	...
XVII.		Ballater	·78	...	·25	3	6	52·0	18	14·5	8,23	18	..
,,		Aberdeen	1·66	...	·43	28	19	54·6	18	27·4	22	8	29
XVIII		Inverness (Culloden)	·88	...	·15	18	15	53·0	18	29·0	23	4	26
,,		Portree	11·61	— 4·02	1·86	17	29	...	...	...	...	...	...
,,		Loch Broom	5·04	...	·72	17	23	...	...	...	...	...	...
XIX.		Helmsdale	1·44	...	·24	20	20	...	...	...	...	...	...
,,		Sandwick	3·98	+ ·01	·50	19	28	54·2	18	28·7	6	6	14
XX.	IRELAND.	Cork	4·20	...	1·01	27	10	...	...	...	...	..	...
,,		Waterford	3·90	— ·52	1·40	24	15	52·0	19	27·0	6	10	...
,,		Killaloe	3·54	+ ·05	·61	19	19	54·0	18	18·0	5,6	17	23
XXI.		Portarlington	1·82	— 1·38	·31	20	25	54·0	18	20·0	4	16	...
,,		Monkstown	·91	— 1·71	·25	19	10	...	...	...	...	...	4
XXII.		Galway	2·44	...	·42	30	25	53·0	13§	20·0	5	9	...
,,		Bunninadden (Doo Castle)	3·60	...	...	...	...	...	...	...	...	...	...
XXIII		Bawnboy (Owendoon)	...	...	..	...	...	...	...	...	...	..	...
,,		Waringstown	1·97	...	·24	21	19	54·0	18	19·0	4	15	27
,,		Strabane (Leckpatrick)	2·58	..	·48	12	22	...	...	..	...	...	...

* And 28. † And 19. ‡ And 18, 20, 30. § And 19, 29. ‖ And 30.
+ Shows that the fall was above the average ; —that it was below it.

Mr. Stow's latest observation, having often noticed the tail of a shower (seen against the sky) hang like a fringe cut at an angle to the line of rainfall. We have here, then, a tendency to approximation of raindrops, which must have a *constant* effect on elevation differences.

Once more,—to argue the matter inversely,—if the best definition of rainfall is "the drops that water the earth," we may expect to find the means adapted to that end. Accordingly we do find that from the greater resistance of the air,—due (1) to accelerated velocity of fall, and (2) to increased density of the air itself,—there is a constantly increasing pressure, which, as it is proportionally less the larger the drops are, favours (if it does not produce) condensation and coalescence. And hence we may infer that the normal state of the atmosphere is adapted to conduct rainfall of constantly increasing density at an approximately uniform medium velocity to the ground.

In exceptional cases of heavy rain, where complete precipitation has occurred in the upper strata, with no distributive action of wind below, may not the resistance of the air due to greater velocity of fall, subject the drops to greater *friction* than the cohesion of their surface-particles can bear, and so tend to diminish their size? I think it highly probable that in this direction also the atmosphere is a *regulator* of rainfall.

Yours faithfully, HUGH INGRAM.

Steyning, Dec. 30, 1871.

To the Editor of the Meteorological Magazine.

SIR,—Will you allow me to give a short explanation of some parts of my letter in your November number, which have been objected to by some of your correspondents in your December number?

My argument is, shortly, this:—

1. The velocity of the wind is greater at an elevation than it is on or near the ground.

2. The greater the velocity of the wind, the more the rain is deflected from the vertical.

3. Therefore the path of rain at any particular height makes a greater angle with the vertical than it does near the ground.

4. The greater the angle with the vertical, the smaller the area of aperture (to use Mr. Stow's expression) a horizontal gauge presents to the falling rain, as very clearly shown by him at page 207.

5. The greater the horizontal space between the drops, the fewer the drops caught by a horizontal gauge, but not the "sole cause" for it, as stated at page 203.

6. Therefore, the greater the angle which the path of the rain at any height makes with the vertical, the less rain will a horizontal gauge catch, and the angle generally increasing with the height, is generally a cause for the amount caught decreasing with the height—*i.e.*, omitting other considerations, as stated in last paragraph but one, on page 187.

"The horizontal distance of the drops being constantly the same at whatever angle with the vertical the rain may fall" being called *a*

fact, as stated on page 203, amounts to begging the question, for it seems to me that the point in dispute hinges on the question whether the horizontal distance is the same at all heights, or whether it increases as the elevation increases: when either of these alternatives can once be proved satisfactorily, then, as it strikes me, *cadet questio* as to the influence of the angle.

As my line of argument on page 185 is thought by Dr. Burder, on page 211, to be fallacious, I beg first to say that, in doing so, I was following a mode sometimes used for simplicity of proof of some astronomical problems, as when the sun is supposed to revolve round the earth, instead of the reverse, which is the truth, so for the sake of employing only one figure, I showed the gauge in different positions, and supposed the figure to be turned round, instead of showing the different angles of falling rain, which would have complicated the figure, and consequently could not clearly have been shown in one figure, but it would have required a separate figure for each successive angle, by which means, however, the same proof could as easily have been given.

Instead of encroaching on your valuable space by giving a separate figure to each, I propose now to do the same thing by another mode of figure, showing the same gauge placed promiscuously at different heights, C H, C K, &c. (using the same nomenclature as before), of one and the same shower of rain, by which it is seen that the proportion lost, F H, F K, &c., of the total amount F C which would be caught if the rain were to fall vertically and perpendicular to the surface of the gauge increases, and the proportion caught, C H, C K, &c.,

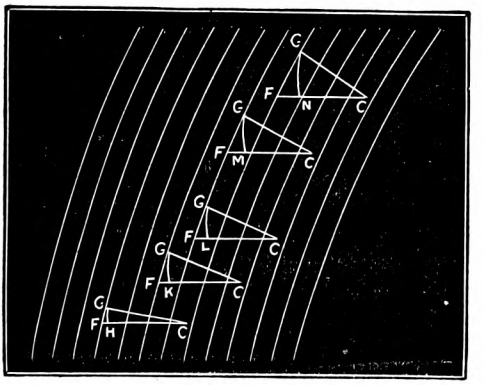


Fig. 1.

of such total amount decreases, with the elevation and with the increase of angle made by falling rain with the vertical (each of the lines C H, C K, &c., *being* equal to C G).

I trust you will soon pass your editorial judgment on the discussion, as was promised some few months ago, and set the question at rest.

C. O. F. CATOR.

P.S. There is another subject closely connected with this—viz., the advisability or otherwise of setting up gauges whose receiving surface shall be parallel to the general surface of the country in different lo-

DECREASE OF RAINFALL WITH ELEVATION.

To the Editor of the Meteorological Magazine.

SIR,—I think Mr. Stow and Mr. Cator, and some other of your correspondents, confuse themselves by looking at the rainfall in a small gauge, instead of in a large area. Let them take a whole county, and imagine two cords placed round it at the height of, say, 1 ft. and 10 ft. above the ground, to represent gauges at those elevations; it must then be evident that, however the winds may vary in force, or the rain-drops in inclination, the amount of rain that falls within the cord at 10 ft., but is blown into the next county before reaching the lower cord, must be extremely small in proportion to the whole rainfall; so also must the amount that is blown *into* the county between the two cords. With the exception of these very small quantities, we would naturally suppose that the same rain would fall within the 10 ft. cord as within the 1 ft. Now, our small gauges are supposed to show the true rainfall; yet they collect more rain at 1 ft. above the ground than at 10 ft. There can be only two ways of accounting for this: either (as has hitherto been believed) more rain *really* falls at a height of 1 ft. than at 10 ft., and therefore rain must be formed in the intervening space to a sufficient extent to make up the difference; or else (as Mr. Harrison and others suggest) the way in which rain has hitherto been measured is utterly wrong.

I would point out *one* way in which the former theory may be reconciled with the experiments on the inclination of rain. *If* the increase of the rain as it descends is due to its collecting particles of moisture, we may easily imagine that it will increase most in a strong wind, because then it will take so much longer to descend from 10 ft. to 1 ft.—Yours, &c.,

T. W. BACKHOUSE.

Nov. 28th, 1871.

To the Editor of the Meteorological Magazine.

SIR,—Mr. Stow misquotes my letter. I did not say anything about valleys, but drew a comparison between rain caught on a solitary hill and on a pole in a plain; the latter, of course, out of the range of the former's attraction. For the sake of brevity, I avoided explanations of points obvious by the context. He is also in error in speaking of "absorption of much of the rain by the drier strata of air below," for moisture decreases as we ascend, as a general rule. The rainfall of valleys is largely increased by the attraction of the surrounding hills, and this circumstance gives me an annual excess of 10 or 12 inches over Cardiff. If a hill-top is prolonged into a lofty slender peak—say over a mile in height, or perhaps much less—it would be above nimbus clouds, and get too little rain. The principle I advocate would operate at altitudes not high enough to diminish sensibly the attraction of gravitation plus the attractive force of the mountain mass. I thank Mr. Malet for his interesting notes, derived from Indian experience, in corroboration of my views; and for the tone of his expression of

opinion. With regard to Mr. Cator's diagrams, November number, page 184, I may remark that, if we apply the test of figures, the fallacy of his deduction will be at once apparent. Let A B D E and F C (see diagram) be taken as five inches, the diameter of an ordinary gauge, and it will be evident that D E and F C are receiving exactly the same amount of rain. If the gauge be tilted up to C G, it is quite clear that it will only receive rain on about three-fourths of its diameter, and that the whole surface would catch 25 per cent. too much. If this proves anything, it is, that a gauge inclined at right angles to oblique rain would receive much more than a horizontal gauge in vertical rain. This is proving too much, and it would not be a correct measure of the rain received on an equivalent area of the earth's surface. Trusting that this discussion by your correspondents will result in much good, I remain, yours faithfully,

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

Tynant, Radyr, Cardiff, Dec. 19, 1871.

To the Editor of the Meteorological Magazine.

SIR,—Let me again try to pick out the threads which may give a clue to the discovery now sought for. Taking Mr. Malet's Indian experience of the ascending scale of cloud-layers as disposed in rain, drizzle, and mist, may we not accept it as evidence of the cumulative process of rainfall? At the lowest level, rain, those drops which fall (*rainfall* proper), which our horizontal gauges duly measure; at the next level above, drizzle, driven rain (*rain-drift*), of which probably whatever is deflected by the wind beyond 75° from the vertical is carried on, unless intercepted by terrestrial objects, or caught in vertical gauges; and at the highest level, mist, vesicles of aqueous vapour (*cloud* proper), which are carried by ascending currents from the lower to float in the higher strata of air; such, probably, is the normal stratification of condensed aqueous vapour, although, perhaps, in windy weather the three forms of it may be found more or less intermixed near the earth's surface.

But the queston still remains *why* rainfall increases as the earth is neared. Of the solutions offered the "electric polarization" of raindrops near the ground, representing a force of precipitation increasing as the square of the decrease of distance from the ground, seems to me the only *adequate* one. Well then, omitting reference to the auxiliary forces mentioned in the course of this discussion, is there any other mechanical force of a like tendency? I believe there is. For each rain-drop, in displacing air as it falls, creates a vortex immediately behind it so as to suck in and attach to itself the particles of vapour lying nearest its path. Hence its increased size. Moreover, a moving body leaves on every side of its path an oblique train of waves or ripples of air which, as observed in the flight of wild-fowl, presents a *path of least resistance* to a following body; and hence there is a constant tendency to convergence of rainfall towards the part where the air is in this way most freely cleft. I can, on this point, confirm

METEOROLOGICAL NOTES ON DECEMBER.

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

ENGLAND.

CAMDEN TOWN.—First 12 days fine, but very cold; thence to the end more mild, with frequent showers.

LINTON PARK.—Sharp frosts from 2nd to 13th, the 8th and 9th being especially severe; but being mostly calm, and a little snow on the ground, its effects were less felt. Brisk wind on 18th and 28th, but the whole of the month after the 13th was mild, with frequent hazy rains, but no heavy rainfall. Dense fog all day on the 23rd, while the next day was bright and sunny. Winds mostly S. and N.W. Bar. generally high from 2nd to 18th, afterwards unsteady. Taken in conjunction with last two months, the three have been the driest I have on record for the like period for 17 years, only 3·82 in. of R having fallen, being less than one-third that fell in the like period in 1859.

SELBORNE.—First half of the month extremely cold, the average min. of the first 12 days being 24°·7. On the 8th the max. was only 28°. A sudden rise of bar. on 20th; at 5 p.m. it stood at 28·9; at 8 p.m. it had risen to 29·44—more than half an inch in three hours, the wind W., and very high. Prevailing winds first half of month, N., N.E. and N.W., afterwards about S.W. Not sufficient S to be measured, though some fell on several days. Very damp from 11th to 17th, dense fog on 17th. On 19th, min. higher than since October (46°). Thrush singing on 26th, and blackbird on 27th.

CULFORD.—First 10 days exceedingly severe, the min. of the year (8°) being on the night of the 8th. From the 11th to the end of the month remarkably mild for the season, the mercury never having gone below 32° since the night of the 10th. Mean temp. of the month 36°·5. Westerly winds during 21 days, and easterly on 10 days. The highest reading of bar. was 30·18 on the 13th, and the lowest 28·90 on the 29th.

BRIDPORT.—First part of the month fine, and very high bar. from 8th to 17th; latter part wet. S.W. gales on 19th, 24th, 28th, and on 31st of Dec. to 1st of Jan. Skating from the 5th to the 9th inclusive.

BODMIN.—Average temp. of month 40°·7, being 2°·1 below the average for December. A very heavy W. gale on the 20th, but of short duration.

SHIFNAL.—An unusually cold December, the first 12 days averaging 25°, and on 18 it was at or below 32°, and on the 8th sank to 16°; on one day only (the 19th) it reached 50°. Up to the 19th very dry, only ·24 of an inch having then fallen. From that date R fell almost every day, and on Christmas Day it rained incessantly. Westerly winds, with two exceptions (23rd and 29th), prevailed throughout. Heavy gale from S.W. on 18th, fog on 23rd and 24th. Vast quantity of hips and haws, and also yew and holly berries. Unusually few woodcocks.

ORLETON.—The dry weather which prevailed during the last month continued till the 18th, with a low temp. and very severe frosts, but no S. The rivers frozen across from the 9th till the 12th; the latter part of the month was warm and rainy, with rough winds. Average temp. of the month about 2°·5 below the mean.

GRIMSBY.—S.W. winds prevailed most of the month, often high. The max. temp. of the month lower than for several years past.

NORTH SHIELDS.—TS on 3rd, S on 3rd, 4th, 6th, and 7th, T on 7th, lunar halos on 18th and 23rd, fine on Christmas Day.

SEATHWAITE.—S on the mountains on 5th and 9th, T H and R on 21st. 3·88 in. of R fell on the 18th, and 3·59 on the 25th. H on the 27th and 28th.

WALES.

CEFNFAES, RHAYADER.—The month has been generally damp, cloudy, and unsettled. Frost at the beginning; the last half mild storms of wind from N.E. nd S.E.

LLANDUDNO.—The month has been mild, with a good deal of R and damp. Little wind and no fog. Very fine on Christmas Day. TS, with H, at 6.40 p.m. on 30th. S on the hills from 2nd to 13th.

SCOTLAND.

DUMFRIES.—The first 10 days of the month were fine, but frosty by day. On the morning of the 5th, the protected ther. registered 17°. The remainder of the month was variable, with much R. S on 22nd and 31st.

HAWICK.—Snowstorms on the 1st, 3rd, 15th, and 22nd. Hurricanes on 17th, 18th, and 31st. Hard frost from 4th to the 10th; the rest of the month pretty open.

AUCHENDRANE.—Of the 62 observations this month, the Polar winds were present on four occasions, Calms on 16, Equatorial on 42. Between 1st and 11th occurred the lowest ther. of the month (17° on 4th), and highest bar. on 8th, with no R. Fine winter weather, and ice on 10 nights. Between the 11th and 31st occurred the highest ther. of the month, and lowest bar. on 28th, with incessant R; boisterous weather. Two very heavy Equatorial gales on 18th and 30th. River in high flood; ice on 23rd, 26th, and 29th; L on 20th. On the 14 occasions when the air was at saturation, six were between the 1st and 11th, the cold period of the month; and eight between the 12th and 31st, the warm period; and the air, though of a higher temp. than the December mean, was not so dry as the mean. The strength of the winds and of evaporation are both below the December means.

DEANSTON.—Frosty and fine till the 10th; a very little S on the 8th; gale on 18th from S.W.; frost again, and two inches of S on 22nd, but which disappeared on 25th. Heavy gale on night of 31st.

LOGIERAIT.—Hitherto a remarkably mild winter; chief characteristic, changeableness. This month severe frost, but of short duration, with a few spring-like days. On the closing of the month a considerable rainfall. The rainfall for the year 1871 is 3·43 in. below the average of the last seven years.

BALLATER.—Sharp snowstorms in the beginning of the month; some lay on the ground for 10 days; latter half of month open weather and quiet, with occasional intense frost.

ABERDEEN.—A month of rather dry weather, and somewhat cold, particularly during the first and second weeks. Wind pressure rather less than usual; no winds from N.E., E., or S.E.; S.W. average; W., N.W., and N. above the average.

PORTREE.—A very wet and stormy month; S and frost in first week; gales on 12th, 17th, 18th, 19th, and 31st; very heavy on 17th and 18th, and a perfect hurricane on 31st. All these gales came on from S., and ended from S.W. The old year went out like a lion, and the new one came in like a tiger.

LOCHBROOM.—Except the first few days, which were frosty, in continuance of last month, this month was very boisterous and rainy, with great storms and continued moisture; the only redeeming quality was that it was open for grazing and pasture. The amount of R precisely the same as in October.

SANDWICK.—From the 1st to the 10th December was cold and frosty, with N. winds. On the 10th, the wind changed to the S.W. and W., and of course we had thaw. Since then the weather has been mild and open, with several gales, that did not amount to storms. Auroræ on seven nights; large lunar halo on 22nd and 24th.

IRELAND.

MONKSTOWN.—A December unusually free from rain, but atmosphere very moist; frost only on mornings of 5th, 6th, 7th, and 31st.

WARINGSTOWN.—A fine month on the whole; hard frost from 4th to 10th; three days' good skating.

calities, instead of, as a matter of course, their being always placed horizontally; for the main object is to ascertain the quantity of rain received by the earth in different localities, and if, on an undulating or hilly surface a gauge is placed horizontally, it will not give a specimen of what the inclined surface of the ground would receive, but would catch a greater or less amount than would be received by an equal area of ground, according as the direction of the falling rain at the time of reaching the earth lies above or below the line which is at right angles to the surface of the ground.

For instance, supposing rain to fall vertically, the amount caught by a horizontal gauge at the position P in annexed sketch would anticipate all the rain that would otherwise have fallen on its projection A D, which is greater; or the amount caught by gauge A B would be

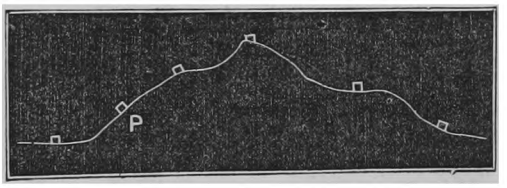


Fig. 2.

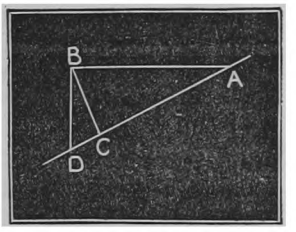


Fig. 3.

erroneously attributed to the area represented by the line A C (= A B), or the error = C D = A D − A C = A D − A B = A B sec. α − A B = gauge's area × (sec. $\alpha - 1$) where α = complement of the angle which the falling rain makes with the surface of the ground.

If the rain should meet the ground perpendicular to its surface, the amount caught by a horizontal gauge would be practically the same as would have fallen on an equal area of the ground, or by the formula, error = area of gauge (sec $\overline{90° - 90°} - 1$) = area (1 − 1) = O.

C. O. F. C.

NOTE.—Two errata in November number: page 185, line 6, *for* "R C" *read* "B C"; page 187, line 7, *after* "sec. 90°" *insert* "—1."

To the Editor of the Meteorological Magazine.

SIR,—I shall feel obliged if you kindly draw the attention of your readers to two *errata* in my letter published in No. 71: in each of the figures 2 and 3, the letters A and B should be transposed. These errors do not occur in the original draft, but I much regret that I did not observe them when correcting the proof sheets.

I am, Sir, your obedient servant,

JOHN PARNELL.

Hadham House, Upper Clapton, Dec. 1871.

END OF VOL. VI.