The Lowest Monthly Temperature was in February 1855, . . . 28°·4
The Mean Annual Temperature of Arbroath for Twenty-two Years, from 1845 to 1866 inclusive (*Journal*, vol. ii. p. 143), ... 46°·3
The Mean Annual Temperature of Arbroath for Twenty-six Years, from 1845 to 1870 inclusive (*Journal*, vol. iii. p. 104), ... 46°·5
The Mean Annual Temperature of Arbroath for Thirty-seven Years, from 1843 to 1879 inclusive, as above, ... 46°·6
Mean of the Three Periods, ... 46°·5

The observations were made by self-registering thermometers in the shade, 11 feet from the ground, 70 feet above the level of the sea, and distant therefrom 783 yards in a direct line. Very great care is taken to protect the instruments from the effects of radiation and other disturbing influences.

Months.	Column 1	Column 2	Column 3	Months.	Column 1	Column 2	Column 3
	°	°	°		°	°	°
January, . .	37·1	37·2	+·1	July, . . .	58·7	57·6	−1·1
February, . .	37·8	37·4	−·4	August, . .	57·6	57·3	−·3
March, . .	40·0	39·8	−·2	September, .	53·7	52·8	−·9
April, . .	44·5	44·1	−·4	October, . .	47·1	47·2	+·1
May, . .	49·2	49·5	+·3	November, .	40·8	40·2	−·6
June, . . .	55·4	55·6	+·2	December, . .	37·9	38·6	+·7
				Year, . .	46·6	46·7	

In the Table, column 1 is the Monthly Mean Temperature at Arbroath from 1843 to 1879 inclusive, and column 2 is the Monthly Mean Temperature of 55 of the stations of the Meteorological Society of Scotland, as given in Table XIII., p. 18 of the Supplement to the Monthly and Quarterly Returns of the Births, Deaths, and Marriages registered in Scotland in 1879 for the Decennial Period 1855–64,—in regard to which the Report says: 'The period 1855–64 is that which . . . . we have been accustomed to consider as the standard period to which the observations of succeeding years are conveniently referred, when it is desired to study their conformity with, or deviation from, the results of general experience.' The Annual Temperature of column 2 seems to be erroneously stated 46°·7, instead of 46°·4. Column 3 shows the difference between columns 1 and 2,—the months of February, March, April, July, August, September, and November being lower for the whole of Scotland than the temperature of Arbroath, while for the months of January, May, June, October, and December the temperature of Scotland is higher than Arbroath.

7.

THE TAY BRIDGE STORM OF 28TH DECEMBER 1879.

By Alexander Buchan, Meteorological Secretary.

The storm of 28th December 1879 will be long remembered among British storms, not only as having occasioned the fall of the Tay Bridge, but also as having presented peculiarities which, taken together, make it one of the most remarkable storms yet observed in these islands. The most remarkable of these peculiarities were the barometric fluctuations, which were of an extraordinary character, along or near the central track of the storm, from South Uist to Wick. The following are the barometric readings, reduced to 32° and sea level, made at

the lighthouses of Dhuheartach, to the south-west of Iona, and of Kyleakin, between Skye and the mainland, and at Wick,—observations having been made at these places with sufficient frequency to show the fluctuations of pressure:—

Dhuheartach.		Kyleakin.		Wick.	
	inches.		inches.		inches.
10.0 a.m.	29·615	9.0 a.m.	29·553	6.0 p.m.	29·025
Noon	·405	4.0 p.m.	28·953	7.0 p.m.	28·825
1.30 p.m.	·205	6.15 p.m.	·603	7.30 p.m.	·711
4.0 p.m.	28·905	8.0 p.m.	29·003	8.0 p.m.	·653
5.5 p.m.	·705	9.0 p.m.	·191	9.0 p.m.	·575
6.0 p.m.	·645	11.0 p.m.	·341	10.0 p.m.	·645
7.0 p.m.	29·105	...		12.0 p.m.	29·025
9.0 p.m.	·342	...		...	

The following are the barometric observations, reduced to 32° and sea level, made at the observatories of the Meteorological Council at Armagh, Stonyhurst, Glasgow, and Aberdeen; at Edinburgh and Dunecht House, those for Edinburgh being eye observations:—

	Armagh.	Stonyhurst.	Glasgow.	Edinburgh.	Aberdeen.	Dunecht.
	inches.	inches.	inches.	inches.	inches.	inches.
Noon.	29·663	29·830	29·639	...	29·616	29·647
1 p.m.	·565	·805	·594	29·605	·581	·627
2 p.m.	·467	·756	·494	·572	·546	·582
3 p.m.	·400	·711	·361	·463	·492	·522
4 p.m.	·381	·681	·243	·323	·366	·422
5 p.m.	·426	·646	·161	·229	·238	·262
6 p.m.	·490	·625	·177	·200	·090	·172
7 p.m.	·545	·626	·196	·195	28·974	·057
8 p.m.	·598	·633	·247	·233	·860	28·947
9 p.m.	·629	·665	·317	·288	·792	·942
10 p.m.	·647	·682	·400	·365	·945	29·087

It will be observed that the hourly variations at these places, whilst considerable, did not reach the large variations at the three places of the previous list, which are all situated comparatively near the central path of the storm. Of these six places, the least variation between any two consecutive hours occurred at Stonyhurst, in Lancashire, which was the most distant of all the places from the centre of the storm. The largest variation for any single hour at each of the six places was 0·160 inch, from 4 to 5 p.m., at Dunecht House; 0·148 inch, from 5 to 6 p.m., at Aberdeen; 0·140 inch, from 3 to 4 p.m., at Edinburgh; 0·133 inch, from 2 to 3 p.m., at Glasgow; 0·098 inch, from 1 to 2 p.m., at Armagh; and 0·049 inch, from 1 to 2 p.m., at Stonyhurst.

Contrast these now with the variations recorded at Wick, Kyleakin, and Dhuheartach. At Wick, the barometer fell 0·200 inch from 6 to 7 p.m., and in the following hour there was a still further fall of 0·172 inch, making a fall of 0·372 inch in these two hours. At Kyleakin, the barometer fell 0·350 inch from 4 to 6.15 p.m., rose 0·400 inch from 6.15 to 8 p.m., and in the next hour, from 8 to 9 o'clock, there was a further rise of 0·188 inch. But it was at the Dhuheartach Lighthouse where the most extraordinary barometric fluctuations were recorded—a fall of 0·300 inch having occurred from 1.30 to 4 p.m.; a fall

of 0·200 inch from 4 to 5.5 p.m.; a rise of 0·460 inch in the hour from 6 to 7 p.m.; and in the next two hours a further rise of 0·237 inch.

That these extraordinary fluctuations were not isolated phenomena is shown by the readings at the other lighthouses in that part of Scotland, at each of which it is the practice of the lighthouse-keepers to note, at least, in addition to the regular 9 a.m. and 9 p.m. observations, the lowest point to which the barometer falls, and the time of its occurrence. Among the more remarkable of the recorded fluctuations are the following:—0·790 inch, from 4 to 9 p.m., at Barrahead; from 5 to 9 p.m., 0·681 inch at Monach, 0·760 inch at Ushenish, and 0·660 inch at Skerryvore, but only 0·320 inch at the Mull of Kintyre; from 5.30 to 9 p.m., 0·700 inch at Ardnamurchan Point; and from 7 to 9 p.m., 0·560 inch at Isle Oronsay, whilst at Eallabus House, Islay, farther distant from the centre of the storm, it was only 0·224 inch.

From the observations made at the Society's stations, including the 61 Scottish lighthouses, and the hourly observations already given, weather maps were constructed for each hour from 1 to 10 p.m., from which the position, each hour, of the centre of the storm could be determined with a close approximation to exactness. At 4 p.m. the position of the centre was a short way to westward of South Uist, from which point its course was nearly E.N.E. as far as Dingwall, which it reached at 7 p.m., and thence N.E., passing out to sea near Wick, and pursuing the same course a little to the east of Orkney and Shetland. The rates of progress of the storm bodily forward for these five hours were, in statute miles—

4 to 5 p.m.	.	30 miles.
5 „ 6 „	.	45 „
6 „ 7 „	.	53 „
7 „ 8 „	.	70 „
8 „ 9 „	.	70 „

the rate of progress from 7 to 9 p.m. being thus three and a half times the average progressive rate of storms in this part of Europe.

The temperature accompanying the storm was also very remarkable. Everywhere it rose till the centre of the storm passed the station, after which it markedly fell. The maximum temperature of the day thus marks the crest of heat-wave which accompanied the storm. These temperatures set down in their places on the map disclose the interesting fact, that everywhere on the mainland of Scotland the temperature rose to from 51°·0 to 57°·0; and it is further remarkable that the higher of these temperatures occurred at the more inland stations. In other words, the temperature of Scotland rose on this occasion to the average of the first week of June. On the northern side of the central path of the storm much lower temperatures were noted—the highest at Stornoway being 46°·4, at Sandwick 45°·1, at Sumburghhead 43°·0; at Thorshavn it rose to 47°·3, whilst at Stykkisholm, Iceland, it only reached 37°·5, the winds there blowing strongly from the N.E., thus showing Iceland to be on the northern side of this storm.

The following are the directions of the wind, with the velocity in miles, each hour from noon to 10 p.m., at Armagh, Stonyhurst, Glasgow, Aberdeen, and Dunecht House:—

	Armagh.		Stonyhurst.		Glasgow.		Aberdeen.		Dunecht House.	
	Direction.	Velocity. Miles.	Direction.	Velocity. Miles.	Direction.	Velocity. Miles.	Direction.	Velocity. Miles.	Direction.	Velocity. Miles.
Noon.	S. by W.	23	SW.	12	SSW.	17	S.	9	S.	10
1 p.m.	S. by W.	24	SW. by S.	10	S. by W.	16	SSE.	10	SE.	10
2 p.m.	SSW.	31	SSW.	17	SSE.	10	S.	16	SSE. by E.	14
3 p.m.	SSW.	40	SW. by S.	19	S. by E.	21	S.	16	SSE.	16
4 p.m.	SW. by S.	41	SSW.	22	S. by W.	41	SSE.	22	SE.	27
5 p.m.	SW.	39	SSW.	23	SSW.	50	SSE.	31	SE.	26
6 p.m.	SW. by W.	32	SW. by S.	30	SW.	45	SSE.	28	SE.	24
7 p.m.	WSW.	25	SW. by S.	26	WSW.	58	SSW.	39	S.	49
8 p.m.	WSW.	22	SW. by W.	34	WSW.	55	SSW.	47	S.	61
9 p.m.	SW. by W.	16	SW. by W.	32	W. by S.	45	SW. by S.	57	SW. by W.	50
10 p.m.	SW. by W.	13	WSW.	25	W. by S.	38	W. by S.	58	WSW.	29

As regards the above returns supplied by the Meteorological Office, Mr. R. H. Scott writes:—'With reference to the velocities of wind recorded by self-registering instruments at the Glasgow and Aberdeen Observatories on the evening of 28th December 1879, I beg to report that the greatest number of miles registered in any 60 consecutive minutes was 71 at Glasgow, between 6.20 p.m. and 7.20 p.m., and at Aberdeen the maximum registered was 63 miles, between 8.50 p.m. and 9.50 p.m. Both these velocities are higher than any shown in the Table, the values of which are for the intervals between 30 minutes before and 30 minutes after the hours.

'Taking much shorter periods than 60 minutes, the traces show still greater velocities. I shall estimate the hourly rates for the under-mentioned intervals as follows:—

From	6.25 p.m.	to	6.30 p.m.	.	96 miles per hour.	
,,	6.55	,,	7.0	,,	. 72	,,
,,	7.15	,,	7.18	,,	. 120	,,
,,	7.30	,,	7.35	,,	. 84	,,
,,	7.45	,,	7.50	,,	. 96	,,
,,	8.43	,,	8.46	,,	. 110	,,

Similarly at Aberdeen, from 7.15 to 7.20 p.m., 8 miles were registered, equalling a rate of 96 miles per hour.

'The hourly velocity at Seaham was not more than 40 miles at the time of the wind's greatest strength, say from 6 to 9 p.m., but at 6.50 p.m., during a squall, the rate must have been at least 150 miles per hour. A note sent by Mr. Aird states that the gusty force of the gale on Sunday night stopped the mill-vane of the anemometer. The wind moderated after 9 p.m.'

Dr. Copland writes that many hundreds of trees were blown down in Dunecht grounds between 9 and 10 p.m., the timber being mostly about fifty years' growth. In connection with the velocities of the wind at Dunecht Observatory in the above Table, they are stated for the following hour thus—the first, viz. 10 miles, was the velocity from noon to 1 p.m.; and the last, viz. 29 miles, was the velocity from 10 to 11 p.m.; being thus different from the times calculated for the observatories of the Meteorological Office.

The extraordinary fluctuations of the barometer at Dhuheartach Lighthouse have been referred to; and the force of the wind there appears to have been greater than has been experienced since the lighthouse was built in 1872. Regarding the storm, Mr. James Ewing, the keeper, writes that 'the hurricane burst on

us with terrific force, and during four hours the lighthouse was buried in spray, it being spring-tides and high water when the storm occurred. The spray struck the lantern, which is 145 feet above high water, with a sound like that which would have been produced by road metal. To show the quantity of sea-water passing over the lantern, it may be stated that a large coil of rope used as a tackle was washed from the windward round to the leeward side of the balcony. This may seem incredible, but Mr. M'Guffie and I were in the lighthouse at the time this occurred. The vibration of the building was most perceptible in the light-room, but not so apparent in any other apartment. No damage was done.'

Much damage was done to forests, many trees being blown down in different parts of Scotland, but particularly in the central districts and in the Highlands. In Glen Lyon, for example, the destruction to woods was very great, where, as Mr. F. M. Menzies informs me, whole forests of Scotch firs were blown down and not a tree left standing, the trees being of very considerable age. It was noted, in proof of the extreme violence of the wind, that in several cases where the trees were rooted in the crevices of the living rock, the lower parts of their thick trunks were broken up to the consistence of matches, thus forming a joint near their roots.

But attention was drawn most forcibly to the storm in that part of its course where the Tay Bridge was wrecked. Here the wind was due west, or at right angles to the Bridge, and in all probability its force was further intensified by the shape of the channel between the ranges of hills through which the Tay here flows seawards, the valley contracting very considerably at this point, and the low hills on both sides approaching near the shores of the Firth. The Tay Bridge is thus situated at a narrow part of a long, wide valley surrounded on three sides with hills. Mr. M'Kelvie, the Society's observer at Dundee, has carefully collected valuable information, by personal visitation of the localities, regarding the effects of the storm. At Rossie Priory some thousands of trees were blown down, the storm making a clear space through the woods, uprooting many trees and snapping many others across at heights varying from 3 to 50 feet above the ground. Many of the prostrated trees were 9 feet in circumference, and several of much larger girth. A beech tree, 15 feet in circumference, growing about two miles from the Bridge, was torn up by the roots, and its six branches, each about 9 feet in girth, springing from the trunk at a height of 20 feet from the ground, were twisted like ropes. In the Eastern Necropolis of Dundee 20 monuments were overturned by the force of the storm, and several large trees were thrown down in the neighbourhood. Mr. M'Kelvie draws attention to the strongest blasts recurring at intervals of about five minutes apart, and being characterised by a strong swirling and lifting power, accompanied at the same time with a cracking, shooting, rumbling noise in the upper air, producing an impression as if it were descending toward the earth—this last feature having been also a characteristic of the Edinburgh hurricane of January 24, 1868. In connection with the strong swirling gusts of the storm, it was noted that the destruction to forests took place at different heights from the ground, as shown by the points at which trees and branches were twisted and broken across.

As the storm had passed over the greater part of Scotland by 9 p.m., the regular observing hour at the Society's stations, there was no very favourable opportunity of ascertaining the steepest barometric gradients which occurred during the

height of the storm. Several steep gradients, however, were, thanks to the extra observations made by the keepers of the lighthouses, ascertained to have occurred. The steepest was at the rate of 1 inch of barometric pressure in 94 miles at 4 p.m. between Rhuvaal, in the north of Islay, and Dhuheartach. Gradients of 1 inch in 118 miles occurred at 9 p.m. between Braemar and Logie-Coldstone, it being at this time that most damage was sustained by the trees in the district; 1 inch to 129 miles at 4 p.m. between Skerryvore and Barrahead; and various gradients of an inch to 140, 160, and 190 miles from 6 to 9 p.m. These gradients are doubtless unusually steep, and such as accompany great and memorable storms, but they are not nearly so steep as the steepest gradients measured during the great Edinburgh hurricane of January 24, 1868, when at 2 p.m. a gradient at the rate of an inch of pressure to 72 miles occurred between Edinburgh and Thirlestane Castle, near Lauder; at 3 p.m. the gradient between these two places was an inch in 76 miles, and at 4 p.m. it was still an inch in 95 miles (see this *Journal*, vol. ii. p. 175). During the Edinburgh hurricane there were twenty-one instances of solid masonry being thrown down by the force of the wind during the interval when the gradient was not less than an inch in 108 miles, the one-half, and the most serious of these, occurring when the gradient was steepest, or an inch in 72 miles. The whole evidence goes to show that the Tay Bridge storm of December 28, 1879, did not equal in intensity the Edinburgh hurricane of January 24, 1868, whether regard be had to the steepness of the gradients which accompanied it, or to the damage done to solidly built structures of mason-work thrown down by the violence of the wind.

For the above valuable observations from the observatories of the Meteorological Council at Armagh, Stonyhurst, Glasgow, and Aberdeen, I have to express my obligations to Mr. Scott, who courteously forwarded the facts relating to this storm which he had brought before the Meteorological Society of London at their meeting on February 19, together with other details referring to the hourly observations of pressure, temperature, and wind direction and velocity. For the observations made at the Dunecht observatory, I have to express my obligations to Dr. Copland.

8.

THE INFLUENCE OF THE FOG OF NOVEMBER 1879 TO FEBRUARY 1880 ON THE HEALTH OF LONDON.

By Dr. Arthur Mitchell.

The following research is intended to show the influence on the death-rate of London of the fog which prevailed there from November 1879 to the first week of February 1880, and which was remarkable alike for its density and protractedness, constituting one of the most remarkable fogs on record in this country.

For this purpose a Table was prepared showing the deviations from the averages of the previous ten years,—corrected for increase of population,—for each of the weeks of the period in question, of the deaths from each cause, given in the Weekly Returns of the Registrar-General.