

XXVI. *Farther Experiments on Cold, made at the Macfarlane Observatory belonging to Glasgow College. In a Letter from Patrick Wilson, M. A. to the Rev. Nevil Maskelyne, D. D. F. R. S. and Astronomer Royal.*

Read May 24, 1781.

DEAR SIR,

Glasgow College,
Feb. 9, 1781.

SOME days of very cold weather, which we had lately in this country, having afforded an opportunity of prosecuting a little farther the experiments and observations begun in the course of last year, I now do myself the pleasure of communicating to you the following particulars, which perhaps may be considered as not unworthy of notice.

The frost set in on Sunday the 21st of January, after a considerable fall of snow on the preceding evening, and about midnight the thermometers were exposed near to the Observatory in the situations mentioned in my former letter. The following register shews the difference of temperature between the snow and the air, till eight o'clock on Monday morning, to which are subjoined some facts which prove very consonant to those described in the former paper.

The sign - prefixed denotes degrees below 0. The sign + degrees above 0 of FAHRENHEIT'S thermometer.

Monday

Monday morning, January 22, 1781.

h.	m.	Thermometer in air.	Thermometer on snow.
1		0	- 12
1	30	+ 2	- 12
1	45	0	- 8
2		- 2	- 7
3		0	- 4
3	45	0	- 8
4		- 1	- 12
4	30	- 3	- 8
5		- 2	- 12
6	15	- 3	- 13
6	45	- 2	- 10
7		- 3	- 13
7	30	- 2	- 10
8		- 4	- 11
8	30	- 2	- 10

From one o'clock till three in the morning the thermometer in air at the balustrade of the east wing of the Observatory pointed from +4 to +6, and on the snow there from -2 to 0. At half an hour after one the thermometer in air, twenty-four feet from the ground, and to the windward of the house, pointed to +7, and at eight o'clock to +1. At three o'clock the snow in the park, three inches below the surface, raised the thermometer to +14, and at six inches below, near the ground, to +24. The barometer stood at 29.8 inches, and there was a perceptible motion of the air from the east and one point south. This night was a very general and lively aurora borealis, most

part of it of a bright red, which formed a crown near to the zenith; but it mostly vanished about three o'clock, after which time the air became more still. During the whole of this night, as well as of the succeeding times of observing, the air was not nearly so much disposed to give out hoar-frost as it was last year.

On Monday evening the difference of temperature was found to be as in the following register.

Monday evening,

h. m.					Therm. in air.	Therm. in snow.
8	—	—	—	—	+ 16	+ 7
8 30	—	—	—	—	+ 14	+ 3
9	—	—	—	—	+ 8	+ 1
9 30	—	—	—	—	+ 7	+ 1
10	—	—	—	—	+ 7	+ 3
10 30	—	—	—	—	+ 6	+ 0
11	Ball of therm. $\frac{1}{2}$ an inch above the surface of the snow,				+ 5	+ 3
12	Ditto, — — — —				+ 5	+ 3

Tuesday morning.

1	Ball of therm. as formerly half immersed in the snow,				+ 6	+ 3
2	—	—	—	—	+ 8	+ 5
2 30	—	—	—	—	+ 10	+ 6

No aurora this evening; the air very still and serene till about two o'clock Tuesday morning, when the wind rose remarkably, and clouds formed in the north-east.

On Thursday, January 25, the difference of temperature was found to be as here set down.

Thursday morning.

h.	m.		Thermometer in air.		Thermometer in snow.
9	45	-	+ 10	-	+ 3
10		-	+ 10	-	+ 3
10	30	-	+ 14	-	+ 4
11		-	+ 14	-	+ 8
11	30	-	+ 17	-	+ 9
12		-	+ 20	-	+ 12
12	30	-	+ 22	-	+ 20
1	afternoon.	-	+ 25	-	+ 26
1	30	-	+ 27	-	+ 27

From ten till eleven o'clock this forenoon the thermometer on the balustrade in air, six inches above the snow, pointed to + 14, and when tried upon the snow to + 10. About noon this day some clouds were formed, which became quite general by one o'clock.

During the two last times of observing, three experiments were made with a view of discovering whether the snow without doors was gaining any thing from the air; or if any of it was carried off in the way of evaporation? For this purpose, a shallow dish, made of sheet brass, four inches in diameter, was exactly filled with snow, and carefully weighed. In order to defend the outside of the dish from the air, that no hoarfrost might attach itself to the metal, a circular hole was cut in the lid of a paste-board box, so wide as just to let in the dish

to the very brim, so that nothing communicated with the external air but the snow itself. The apparatus, in this state, was set without doors for three hours each time, and then brought in to the lobby of the Observatory, where the dish was again weighed: but in none of these trials did it ever appear, that any weight was lost. On the contrary, at the first weighing, which was on Monday night, twelve o'clock, it had gained five grains. In the other two trials the increase of weight was scarce perceivable.

The temperature of the air in the west room of the Observatory remaining very constantly for near two days at $+27^{\circ}$, a dish of snow, similar to the other exposed there, was found to lose weight very sensibly, and for the most part at the rate of two grains in an hour. Notwithstanding this, the snow thus wasting or evaporating had no power of sinking the thermometer below $+27$, the temperature of the surrounding air; though at one time it was fanned for four minutes by a piece of paper fastened to the end of a long stick. Not to disturb the uniform temperature of this room during these experiments, care was taken to stay in it a very short time at every visit, and to keep the door and the window-shutters close.

On Christmas-day we had a frost, which in the morning made the thermometer in air point to $+21$; and during the preceding night there had been a profuse deposition of hoar-frost. A pound of this was collected, and its capacity for heat compared to that of ice, and found equal as nearly as could be judged. Before making the two mixtures necessary for this experiment, the ice was reduced to a powder, and spread out on a paper beside the hoar-frost till both had acquired the same temperature.

On Monday night, January 22, about twelve o'clock, having occasion to take up a little snow, there was observed a cohesion among its parts rather greater than what might have been expected in a substance, at that time, so much frozen. This circumstance was farther examined by the following experiment. A pane of glass was laid on the surface of the snow till it had acquired the temperature of $+3$, after which, with a bit of parchment equally cold, some snow was scraped from the very surface, and shaken all over the pane, so as to cover it in most parts lightly. Upon now lifting the pane, and holding it with the snow undermost, the whole of it adhered, and it required some smart raps before the greater part fell away. What remained cleaved to the glass with still a greater adhesion.

The experiments related above afford further reasons against the opinion of the difference of temperature betwixt the snow or hoar-frost and the air depending upon evaporation. It would moreover appear, that this phenomenon depends not either upon the deposition of hoar-frost. What renders this the more probable is, that on last year there was a much more copious deposition at times when the difference of temperature was not more remarkable. But allowing that a deposition had been found a necessary circumstance, and always in proportion to that difference, the experiments on the capacities of hoar-frost and ice seem to shew, that the sensible heat which disappears enters not into the composition of the hoar-frost; otherwise the capacity of this substance for heat, compared to that of ice or common snow, should be very different. It must be confessed, however, that the above mentioned experiment would have been more applicable to this reasoning, had it been made with hoar-frost given out in colder states of the air.

If the air, at low temperatures, had any power of acting upon the snow or hoar-frost, so as to produce a gradual melting, this circumstance, according to the known laws of heat, might occasion the difference of temperature under consideration. And what renders this idea not altogether improbable, is the peculiar cohesion among the parts of the snow above described. Perhaps a gentle melting might take place without much altering the appearance of the snow or hoar-frost at the surface, as the parts, when dissolved, might be gradually sucked downwards, and be afterwards distributed through the whole drier mass. It may also be worthy of an experimental inquiry to determine, how far that sort of concretion, observable all over the surface of snow which has been long frozen, bears any marks of a slow process of this kind. From a hill, a little way to the N.E. of the town, and which was to windward during the frost, there were gathered two portions of snow, the one from the surface, and the other seven inches below it. The water produced from the two kinds is preserved in very clean phials, in order to be compared together by some chemical trials, which, perhaps, may throw some light upon the whole of this matter.

At present I shall conclude this letter, perhaps already much too long, with just mentioning one other fact which was new to me; namely, the power of ardent spirits of dissolving snow, and consequently of producing with it a freezing mixture. The alcohol and snow separately were at eight degrees below the freezing point, and when mixed suddenly and intimately, the temperature became in the space of twenty seconds 28° below 0 . This is a cold only 12° short of that which FAHRENHEIT first produced by using spirit of nitre for the experiment; and
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it is not improbable, had the present experiment been tried with more precaution and address, that the result would have been still more remarkable. There was employed only about a pint of alcohol, but the proportion of snow was not then attended to, and the thaw coming soon afterwards prevented a repetition of the experiment.

I am, &c.

P O S T S C R I P T.

I beg leave to add, that the water mentioned as produced from the superficial snow has been examined by several chymical trials, with a view of discovering if it differed in any respect from the water obtained from snow gathered at considerable depths, and near the ground. Had the atmosphere, when the thermometers pointed so low, been disposed to furnish any saline principle, the union of such an ingredient with the snow would have tended to produce an excess of cold at the surface, similar to what was then observed. Or if the snow at these low temperatures had acquired any remarkable power of dephlogisticating the air in contact with it, a cooling process at and near the confines of the snow and air might thereby have been maintained. In either of these cases, some very sensible indications of a saline or of a phlogistic principle might be expected on the water given by
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the snow collected from the surface. But in opposition to both these views it remains now to be mentioned, that nothing of this kind did appear in the course of the experiments, which indeed were contrived chiefly to detect such circumstances.

If therefore the arguments produced in both papers upon this subject will not allow us to account for so remarkable a cooling process by an evaporation at the surface of the snow, it would appear, that there remains still something unknown with respect to the cause. A proper investigation of this matter, in climates favourable to such experiments, may possibly unfold some farther properties of heat with which at present we may be wholly unacquainted.

