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 o. The ſign + degrees above o 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. ½ 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

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 hoar-froſt 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

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

it

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.

POSTSCRIPT.

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 the

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.