PHILOSOPHICAL TRANSACTIONS.

Wednesday, July 18. 1666.

The Contents.

A new Frigorifick Experiment shewing, how a considerable degree of Cold *may be suddenly produced without the help of* Snow, Ice, Haile, Wind, *or* Niter, *and that at any time of the year.*

THis subject will it self, 'tis presumed, without any other *Preamble*, speak the Cause, why this present Paper is publish't at this (unusual) time of the Month: though, by the by, it may not be amiss to add on this occasion, that the Publisher of these *Tracts* never meant so to confine himself to a *Set* time, as not to retain the Liberty of taking any other, when there is occasion. And there being one given him, before another Month is come in, he does without any scruple or delay comply therewith, presenting the Curious with an Experiment which he thinks is both seasonable, and will not be unwellcome to them; furnish't out of the Ample Magazin of that Philosophical *Benefactor*, the Noble Mr. *Boyle*; Concerning which, thus much is further thought requisite to intimate on this occasion, that it, and some others of the same Gentlemans, that have been, and may be, mentioned in the *Transactions*, belong to certain Treatises, the Author hath lying by him; but that yet he denys not

to communicate them to his Friends, and to allow them to diſpoſe thereof, upon a hope, that equitable Readers will be ready to excuſe, if hereafter they ſhould appear alſo in the Treatiſes they belong to, ſince he conſents to this Anticipation, but to comply with thoſe, that think the imparting of real and practical Experiments, may do the Publick ſome Service, by exciteing and aſſiſting mens Curioſity in the interim.

As for the Experiment, you ſaw the other day at my Lodgings, though it belongs to ſome Papers about *Cold*, that (you know) could not be Publiſh'd, when the reſt of the *Hiſtory* came forth, and therefore was reſerved for the next *Edition* of that Book; yet the Weather having been of late very hot, and threatning to continue ſo, I preſume, that to give you here in compliance with your Curioſity an Account of the Main and Practical part of the Experiment, may enable you to gratify not onely the Curious among your Friends, but thoſe of the Delicate, that are content to purchaſe a Coolneſs of Drinks at a ſomewhat chargeable rate.

You may remember, that the Spring before the laſt, I ſhew'd you a particular Account of a way, wherein by a certain ſubſtance obtain'd from *Sal Armoniack*, I could preſently produce a conſiderable degree of *Cold*, and that with odd Circumſtances, without the help of *Snow*, *Ice*, *Niter* &c. But that Experiment being difficult and coſtly enough, and deſign'd to afford men *Information*, not *Accommodations*, I afterwards tryed, what ſome more cheap and facile mixtures of likely Bodies with *Sal Armoniack* would do towards the Production of Cold, and afterwards I began to conſider, whether to that purpoſe alone (for my firſt experiment was deſign'd to exhibite other *Phænomena* too) thoſe mixtures might not without inconvenience be omitted: and I was much confirm'd in my conjecture, by an accident, which was caſually related to me by a very Ingenious Phyſician of my acquaintance, but not to be repeated to you in few words, though he complain'd, he knew not what to make of it.

Among the ſeveral ways, by which I have made infrigidating Mixtures with *Sal Armoniack*, the moſt ſimple and facile is this: Take one pound of powder'd *Sal Armoniack*, and about three Pints (or pounds) of Water, put the Salt into the Liquor, *either* altogether, if your deſign be to produce an intenſe, though

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but a ſhort coldneſs; *or* at two, three, or four ſeveral times, if you deſire, that the produced coldneſs ſhould rather laſt ſomewhat longer than be ſo great. Stirre the powder in the Liquor with a ſtick or whalebone (or ſome other thing, that will not be injur'd by the fretting Brine, that will be made) to haſten the diſſolution of the Salt; upon the quickneſs of which depends very much the intenſity of the Cold, that will enſue upon this Experiment. For the clearing up whereof, I ſhall annex the following particulars.

1. That a conſiderable degree of Cold is really produced by this operation, is very evident: *Firſt*, to the touch; *Secondly*, by this, that if you make the Experiment (as for this reaſon I ſometimes chuſe to do) in a Glaſs-*B*ody or a Tankard, you may obſerve, that, whilſt the Solution of the Salt is making, the outſide of the Metalline Veſſel will, as high as the mixture reaches within, be bedew'd (if I may ſo ſpeak) with a multitude of little Drops of Water, as I have * elſewhere ſhown that it happens, when mixtures of Snow and Salt, being put into Glaſſes or other Veſſels, the aqueous vapors, that ſwim to and fro in the Air, and chance to glide along the ſides of the Veſſels, are by the coldneſs thereof condens'd into Water. And in our Armoniack Solution you may obſerve, that if you wipe off the Dew from any particular part of the outſide of the Veſſel, whilſt the ſolution does yet vigorouſly goe on, it will quickly collect freſh Dew, which may be ſometimes copious enough to run down the ſides of the Veſſel. *But Thirdly*, the beſt and ſureſt way of finding out the Coldneſs of our Mixture is that, which I ſhew'd you by plunging into it a good ſeal'd Weatherglaſs furniſh't with tincted Spirit of Wine. For, the *B*all of this being put into our frigorifick mixture, the Crimſon Liqnor will nimbly enough deſcend much lower, than when it was kept either in the open Air, in common Water, of the ſame temper with that, wherein the *Sal Armoniack* was put to diſſolve. And if you remove the Glaſs out of our Mixture into common water, the tincted Spirit will, (as you may remember, it did) haſtily enough reaſcend for a pretty while, according to the greater or leſſer time, that it continued in the *Armoniack* Solution. And this has ſucceeded with me, when inſtead of removing the Mixture into *Common* Water, I removed it into water newly impregnated with *Salt-peter*.

* *In the Hiſtory of Cold.*

2. The *Duration* of the Cold, produc'd by this Experiment, depends upon ſeveral Circumſtances; as *Firſt*, upon the Seaſon of the year, and preſent temperature of the Air; For, in Summer and Hot weather the Cold will ſooner decay and expire. *Secondly*, upon the Quantity of the Salt and Water: For, if both theſe be great, the effect will be as well more laſting, as more conſiderable. *Thirdly*, for ought I yet know, we may here add the Goodneſs & Fitneſs of the particular parcel of Salt, that is imploy'd: for, though it be hard to diſcern beforehand, which will be the more, and which the leſs proper; yet ſome trials have tempted me to ſuſpect, that there may be a conſiderable diſparity, as to their fitneſs to produce Cold, betwixt parcels of Salt, that are without ſcruple look't upon as Sal Armoniack: Of which difference it were not perhaps very difficult to aſſign probable reaſons from the Nature of the Ingredients of this compound Concrete, and the waies of preparing it. But the Duration of the Cold may be conceived to depend alſo, *Fourthly*, upon the Way of putting in the Salt into the Water For, if you caſt it in all at once, the Water wil ſooner acquire an intenſe degree of Coldneſs; but it will alſo the ſooner return to its former temper; Whereas, if you deſire but an inferiour degree of that Quality, but that may laſt longer (which wil uſually be the moſt convenient for the Cooling of Drinks,) then you may put in the Salt by little and little. For, keeping a long Weather-glaſs for a good while in our impregnated Mixture, I often purpoſely try'd, that, when the tincted liquor ſubſided but ſlowly, or was at a ſtand, by putting in, from time to time, 2. or 3. ſpoonfuls of freſh Salt, and ſtirring the Water to quicken the Diſſolution, the Spirit of Wine would begin again to deſcend, if it were at a ſtand or riſing, or ſubſide much more ſwiftly than it did before. And if you would lengthen the Experiment, it may not be amiſs, that part of the Sal Armoniack be but groſly beaten, that it may be the longer in diſſolving, and conſequently in Cooling the Water. Whilſt there are dewy drops produced on the outſide of the Veſſel, 'tis a ſign, that the Cold within continues pretty ſtrong; for, when it ceaſes, theſe drops eſpecially in warm weather, will by degrees vaniſh. But a *ſurer* way of meaſuring the duration of the Cold, is, by removing from time to time the Seal'd Weather-glaſs out of the Saline Mixture into the ſame common Water, with part of which it was made. And though it be not eaſie to determin any thing particularly about this matter; yet it may ſomewhat aſſiſt you in your Eſtimates, to be inform'd, That I have in the Spring by a good Weather-glaſs found a ſenſible adventitious Cold, made by a pound of Sal Armoniack at the utmoſt, to laſt about 2. or 3. hours.

3. To cool Drinks with this Mixture, you may put them in *thin* Glaſſes, the thinner the better; which (their orifices being ſtopp'd, and ſtill kept above the Mixture) may be mov'd to and fro in it, and then be immediately pour'd out to be drunk: Though, when the Glaſs, I imployed, was conveniently ſhap'd, as, like a Sugar-loaf, or with a long Neck, I found it not amiſs to drink it out of that, without pouring it into any other; which can ſcarce be done without leſſning the Coolneſs. The refrigeration, if the Glaſs viall be convenient, is quickly perform'd: And if one have a mind to cool his hands, he may readily do it by applying them to the outſide of the Veſſel, that contains the refrigerating Mixture; by whoſe help, pieces of Chryſtal, or Bullets for the cooling of the

the Mouths or Hands of thoſe patients, to whom it may be allow'd, may be potently cool'd, and other ſuch refreſhments may be eaſily procur'd.

4. How far Sal Armoniack, mingl'd with Sand or Earth, and not diſſolv'd, but only moiſtn'd with a little Water ſprinkl'd on it, will keep Bottles of Wine or other liquors more coole, than the Earth or that *S*and alone will do, I have not yet had opportunity by ſufficient trials fully to ſatisfie my ſelf, and therefore reſign that Enquiry to the Curious.

5. For the cooling of Air, and Liquors, to adjuſt Weather-glaſſes (to be able to do which, at all times of the year, was one of the chief aimes, that made me bethink my ſelf of this Experiment;) or to give a ſmall quantity of Beer &c. a moderate degree of coolneſs, it will not be requiſite, to employ neer ſo much as a whole pound of Sal Armoniack at a time. *F*or, you may eaſily obſerve by a ſeal'd Weather-glaſs, that a very few ounces, well pouder'd and nimbly diſſolv'd in about 4. times the weight of Water, will ſerve well enough for many purpoſes.

6. And that you may the leſs ſcruple at this, I ſhall tell you, that even before and after Midſummer, I have found the Cold producible by our Experiment to be conſiderable and uſeful for refrigerating of Drinks, &c. but if the Sal Armoniack be of the fitteſt ſort (for I intimated above, that I ſuſpected, 'tis not equally good) and if the ſeaſon of the year do make no diſadvantagious difference, the degree of Cold, that may be produced by no more than one pound (if not by leſs) of Sal Armoniack, may, within its own Sphere of Activity, be much more vehement, than, I preſume, you yet imagine, and may afford us excellent Standards to adjuſt ſeal'd Weather-glaſſes by; and for ſeveral other purpoſes. For I remember that in the Spring, about the end of *March*, or beginning of *April*, I was able with one pound of Sal Armoniack, and a requiſite proportion of Water, to produce a degree of Cold much greater, than was neceſſary the preceding Winter, to make it froſty Weather abroad; nay I was able to produce real Ice in a ſpace of time, almoſt incredibly ſhort. To confirm which particulars, becauſe they will probably ſeem ſtrange to you, I will here annex the Tranſcript of an entry, that I find in a Note book of the *Phænomena* and ſucceſs of one of thoſe Experiments, as I then tryed it; though I ſhould be aſham'd to expoſe to your peruſal a thing ſo rudely pen'd; if I did not hope, you would conſider, that 'twas haſtily written onely for my own Remembrance. And that you may not ſtop at any thing in the immediately annext Note, or the two, that follow, it will be requiſite to premiſe this Account of the ſeal'd Thermoſcope, (which was a good one) wherewith theſe Obſervations were made; That the length of the Cylindrical pipe was 16. Inches; the Ball, about the bigneſs of a ſomewhat large Walnut, and the Cavity of the Pipe by gueſs about an eight or ninth part of an inch Diameter.

The Firſt Experiment is thus regiſtred. *March* the 27th, in the Seal'd Weather glaſs, when firſt put into the Water, the tinged Spirit reſted at $8\frac{5}{8}$ inches: being ſuffered to ſtay there a good while, and now and then ſtirr'd to and fro in the Water; it deſcended at length a little beneath $7\frac{1}{2}$ inches; then the *Sal Armoniack* being put in, within about a quarter of an hour or a little more it deſcended to $2\frac{11}{16}$ inches, but before that time, in half a quar-

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ter of an hour it began manifeſtly to freeze the vapours and drops of water on the outſide of the Glaſs. And when the frigorifick power was arriv'd at the height, I ſeveral times found, that water, thinly plac'd on the outſide, whilſt the mixture within was nimbly ſtirr'd up and down, would freeze in a quarter of a minute (by a Minute-watch.) At about $\frac{1}{4}$ of an hour after the infrigidating Body was put in, the Thermoſcope, that had been taken out a while before, and yet was riſen but to the loweſt freezing mark, being again put in the liquor, fell an inch beneath the mark. At about $2\frac{1}{2}$ houres from the firſt Solution of the Salt I found the tinged liquor to be in the midſt between the freezing marks, whereof the one was at $5\frac{1}{2}$ inches (at which height when the Tincture reſted, it would uſually be, ſome, though but a ſmall, Froſt abroad;) and the other at $4\frac{1}{4}$ inches; which was the height, to which ſtrong and durable Froſts had reduced the liquor in the Winter. At 3. hours after the beginning of the Operation, I found not the Crimſon-liquor higher than the upper Freezing mark newly mention'd; after which, it continued to riſe very ſlowly for about an hour longer; beyond which time I had not occaſion to obſerve it.

Thus far the *Note-book*; wherein there is mention made of a Circumſtance of ſome former Experiments of the like kind, which I remember was very conſpicuous in this newly recited. For, the frigorifick mixture having been made in a Glaſs-body (as they call it) with a large and flattiſh bottom, a quantity of water, which I (purpoſely) ſpilt upon the Table, was by the operation of the mixture within the Glaſs, made to freeze, and that ſtrongly enough, the bottom of the Cucurbite to the Table; that ſtagnant liquor being turn'd into ſolid Ice, that continued a conſiderable while unthaw'd away, and was in ſome places about the thickneſs of a half Crown piece.

Another Obſervation, made the ſame Spring, but leſs ſolemn, as meant chiefly to ſhew the Duration of Cold in a high degree, is recorded in theſe terms: The firſt time, the Seal'd Weather-glaſs was put in, before it touch'd the common water, it ſtood at $8\frac{1}{8}$, having been left there a conſiderable while, and once or twice agitated the water, the tinged liquor ſunk but to $7\frac{1}{8}$, or at furtheſt, $7\frac{6}{8}$; then the frigorifick liquor being put into the water with circumſtances diſadvantagious enough, in (about) half a quarter of an hour the tinged liquor fell beneath $3\frac{3}{4}$; and the Thermoſcope, being taken out, and then put in again, an hour after the water had been firſt infrigidated, ſubſided beneath 5 inches, and conſequently within $\frac{1}{4}$ of an inch of the mark of the ſtrongly freezing weather.

7. Whereas the grand thing, that is like to keep this Experiment from being as generally *Uſeful*, as perhaps it will prove *Luciferous*, is the Dearneſs of Sal Armoniack; two things may be offered to leſſen this Inconvenience. For *firſt*, Sal Armoniack might be made much cheaper, if inſtead of fetching it beyond-ſea, our Country-men made it here at home; (which it may eaſily be, and I am ready to give you the Receipt, which is no great Secret.) But *next*, I conſidered, that probably the infrigidating vertue of our mixture might depend upon the peculiar Texture of the Sal Armoniack whereby, whileſt the Water is diſſolving it, either ſome Frigorifick particles are extricated and excited, or (rather) ſome particles, which did before more agitate the minute parts of the water, are expell'd (or invited out by the ambient Bodies) or

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come to be clogg'd in their motion: Whence it ſeem'd reaſonable to expect that upon the Reunion of the Saline particles into ſuch a Body, as they had conſtituted before, the redintegrated Sal Armoniack having, neer upon, the ſame Texture, would, upon its being rediſſolv'd, produce the ſame, or a not much inferior degree of Coldneſs: And hereupon, though I well enough foreſaw that an Armoniack ſolution, being boyl'd up in *Earthen* veſſels (for Glass ones are too chargeable) would, by piercing them, both loſe ſome of the more ſubtle parts, and thereby ſomewhat impaire the texture of the reſt; yet I was not deceiv'd in *Expecting*, that the dry Salt, remaining in the pipkins, being rediſſolv'd in a due proportion of water, would very conſiderably infrigidate it; as may further appear by the Notes, which for your greater ſatisfaction you will find here ſubjoyn'd; as ſoon as I have told you, that, though for want of other veſſels I was firſt reduc'd to make uſe of *Earthen* ones, and the rather, becauſe ſome Metallin Veſſels will be injur'd by the diſſolv'd Sal Armoniack, if it be boyl'd in them; yet I afterwards found ſome conveniencies in Veſſels of other Mettall, as of Iron; whereof you may command a further Account.

March the 29th, the Thermoſcope in the Air was at $8\frac{7}{8}$ inches; being put into a ſomewhat large evaporating glaſs, fill'd with water, it fell (after it ſtaid a pretty while, and had been agitated in the liquor) to 8. inches: then about half the Salt, or leſs, that had been uſed *twice* before, and felt much leſs cold than the water, being put in and ſtirr'd about, the tincted Spirit ſubſided with a viſible progreſs, till it was faln manifeſtly beneath 4. inches; and then, having cauſed ſome water to be freſhly pump'd and brought in, though the newly mention'd Solution were mixt with it, yet it preſently made the Spirit of Wine manifeſtly to aſcend in the Inſtrument, much faſter, than one would have expected, *&c.*

And thus much may ſuffice for this time concerning our *Frigorifick* Experiment; which I ſcarce doubt but the *Carteſians* will lay hold on as very favourable to ſome of their Tenents; which you will eaſily believe, it is *not* to the Opinion, I have elſewhere oppos'd, of thoſe Modern Philoſophers, that would have *Salt-petre* to be the *Primum Frigidum*: (though I found by trial, that, whilſt 'tis actually diſſolving, it gives a much conſiderabler degree of Cold, than otherwiſe.) But about the Reflexions, that may be made on this Experiment, and the Variations, and Improvements, & Uſes of it, though I have divers things lying by me; yet, ſince you have ſeen ſeveral of them already, and may command a ſight of the reſt, I ſhall forbear the mention of them here, not thinking it proper, to ſwell the bulk of this Letter with them.

An Account of two Books lately printed in London.

1. *EUCLIDIS ELEMENTA GEOMETRICA, novo ordine ac methodo demonſtrata.* In this compendious and pretty Edition, the Anonymous Author pretends to have rendred theſe Elements more expeditious; by bringing all together into one place, what belongs to one and the ſame ſubject: Compriſing 1. what *Euclid* hath ſaid of *Lines*, Streight, Interſecting one another, and Parallel. 2. What he hath demonſtrated of a *Single Triangle*, and of *Triangles Compared* one with another. 3. What of the *Circle*, and its Properties. 4. What of *Proportions* in Triangles and other Figures. 5. What of *Quadrats* and *Rectangles*, made of Lines diverſly