Obſerv. VII. *Of ſome* Phænomena *of Glaſs drops.*

THeſe *Glaſs Drops* are ſmall parcels of coarſe green Glaſs taken out of the Pots that contain the *Metal* (as they call it) in fuſion, upon the end of an Iron Pipe; and being exceeding hot, and thereby of a kind of ſluggiſh fluid Conſiſtence, are ſuffered to drop from thence into a Bucket of cold Water, and in it to lye till they be grown ſenſibly cold.

Some of theſe I broke in the open air, by ſnapping off a little of the ſmall ſtem with my fingers, others by cruſhing it with a ſmall pair of Plyers; which I had no ſooner done, then the whole bulk of the drop flew violently, with a very brisk noiſe, into multitudes of ſmall pieces, ſome of which were as ſmall as duſt, though in ſome there were remaining pieces pretty large, without any flaw at all, and others very much flaw'd, which by rubbing between ones fingers was eaſily reduced to duſt; theſe diſperſed every way ſo violently, that ſome of them pierced my skin. I could not find, either with my naked Eye, or a *Microſcope*, that any of the broken pieces were of a regular figure, nor any one like another, but for the moſt part thoſe that flaw'd off in large pieces were prettily branched.

The ends of others of theſe drops I nipt off whilſt all the bodies and ends of them lay buried under the water, which, like the former, flew all to pieces with as brisk a noiſe, and as ſtrong a motion.

Others of theſe I tried to break, by grinding away the blunt end, and though I took a ſeemingly good one, and had ground away neer two thirds of the Ball, yet would it not fly to pieces, but now and then ſome ſmall rings of it would ſnap and fly off, not without a brisk noiſe and quick motion, leaving the Surface of the drop whence it flew very prettily branched or creaſed, which was eaſily diſcoverable by the *Microſcope*. This drop, after I had thus ground it, without at all impairing the remnant that was not ground away, I cauſed to fly immediately all into ſand upon the nipping off the very tip of its ſlender end.

Another of theſe drops I began to grind away at the ſmaller end, but had not worn away on the ſtone above a quarter of an inch before the whole drop flew with a brisk crack into ſand or ſmall duſt; nor would it have held ſo long, had there not been a little flaw in the piece that I ground away, as I afterwards found.

Several others of theſe drops I covered over with a thin but very tuff skin of *Ichyocolla*, which being very tough and very tranſparent, was the moſt convenient ſubſtance for theſe tryals that I could imagine, having dipt, I ſay, ſeveral of theſe drops in this tranſparent Glue whilſt hot, and ſuffering them to hang by a ſtring tied about the end of them till they were cold, and the skin pretty tough; then wrapping all the body of the

drop (leaving out only the very tip) in fine ſupple Kids-leather very cloſely, I nipped off the ſmall top, and found, as I expected, that notwithſtanding this skin of Glue, and the cloſe wrapping up in Leather, upon the breaking of the top, the drop gave a crack like the reſt, and gave my hand a pretty brisk impulſe: but yet the skin and leather was ſo ſtrong as to keep the parts from flying out of their former poſture; and, the skin being tranſparent, I found that the drop retained exactly its former figure and poliſh, but was grown perfectly opacous and all over flaw'd, all thoſe flaws lying in the manner of rings, from the bottom or blunt end, to the very top or ſmall point. And by ſeveral examinations with a *Microſcope*, of ſeveral thus broken, I found the flaws, both within the body of the drop, and on the outward ſurface, to lye much in this order.

Let A B in the Figure X of the fourth Scheme repreſent the drop caſed over with *Ichthyocolla* or *Iſinglaſs*, and (by being ordered as is before preſcribed) crazed or flawed into pieces, but by the skin or caſe kept in its former figure, and each of its flawed parts preſerved exactly in its due poſture; the outward appearance of it ſomewhat plainly to the naked eye, but much more conſpicuous if viewed with a ſmall ſenſs appeared much after this ſhape. That is, the blunt end B for a pretty breadth, namely, as far as the Ring C C C ſeemed irregularly flawed with divers clefts, which all ſeemed to tend towards the Center of it, being, as I afterwards found, and ſhall anon ſhew in the deſcription of the figure Y, the Baſis, as it were, of a Cone, which was terminated a little above the middle of the drop, all the reſt of the Surface from C C C to A was flawed with an infinite number of ſmall and parallel Rings, which as they were for the moſt part very round, ſo were they very thick and cloſe together, but were not ſo exactly flaw'd as to make a perfect Ring, but each circular part was by irregular cracks flawed likewiſe into multitudes of irregular flakes or tiles; and this order was obſerved likewiſe the whole length of the neck,

Now though I could not ſo exactly cut this *conical Body* through the *Axis*, as is repreſented by the figure Y; yet by *anatomizing*, as it were, of ſeveral, and taking notice of divers particular circumſtances, I was informed, that could I have artificially divided a flaw'd drop through the *Axis* or *Center*, I ſhould with a *Microſcope* have found it to appear much of this form, where A ſignifies the *Apex*, and B the blunt end, C C the Cone of the Baſis, which is terminated at T the top or end of it, which ſeems to be the very middle of the blunt end, in which, not only the conical body of the Baſis C C is terminated, but as many of the parts of the drop as reach as high as D D.

And it ſeemed to be the head or beginning of a Pith, as it were, or a a part of the body which ſeemed more ſpungy then the reſt, and much more irregularly flawed, which from T aſcended by E E, though leſs viſible, into the ſmall neck towards A. The Grain, as it were, of all the flaws, that from all the outward Surface A D C C D A, was much the ſame, as is repreſented by the black ſtrokes that meet in the middle D T, D T, D E, D E, *&c.*

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Nor is this kind of Grain, as I may call it, peculiar to Glass drops thus quenched; for (not to mention *Coperas-stones*, and divers other *Marchasites* and *Minerals*, which I have often taken notice of to be in the very same manner flaked or grained, with a kind of Pith in the middle) I have observed the same in all manner of cast Iron, especially the coarser sort, such as Stoves, and Furnaces, and Backs, and Pots are made of: For upon the breaking of any of those Substances it is obvious to observe, how from the out-sides towards the middle, there is a kind of Radiation or Grain much resembling this of the Glass-drop; but this Grain is most conspicuous in Iron-bullets, if they be broken: the same *Phænomena* may be produced by casting *regulus* of *Antimony* into a Bullet-mold, as also with *Glass of Antimony*, or with almost any such kind of *Vitrified substance*, either cast into a cold Mold or poured into Water.

Others of these Drops I heat red hot in the fire, and then suffered them to cool by degrees. And these I found to have quite lost all their *fulminating* or flying quality, as also their hard, brittle and springy texture; and to emerge of a much softer temper, and much easier to be broken or snapt with ones finger; but its strong and brittle quality was quite destroyed, and it seemed much of the same consistence with other green Glass well nealed in the Oven.

The Figure and bigness of these for the most part was the same with that of the Figure Z; that is, all the surface of them was very smooth and polisht, and for the most part round, but very rugged or knobbed about D, and all the length of the stem was here and there pitted or flatted. About D, which is at the upper part of the drop under that side of the stem which is concave, there usually was made some one or more little Hillocks or Prominences. The drop it self, before it be broken, appears very transparent, and towards the middle of it, to be very full of small Bubbles, of some kind of aerial substance, which by the refraction of the outward surface appear much bigger then really they are; and this may be in good part removed, by putting the drop under the surface of clear Water, for by that means most part of the refraction of the convex Surface of the drop is destroyed, and the bubbles will appear much smaller. And this, by the by, minds me of the appearing magnitude of the *aperture* of the *iris*, or *pupil* of the eye, which though it appear, and be therefore judged very large, is yet not above a quarter of the bigness it appears of, by the *lenticular* refraction of the *Cornea*.

The cause of all which *Phænomena* I imagine to be no other then this, That the Parts of the Glass being by the excessive heat of the fire kept off and separated one from another, and thereby put into a kind of sluggish fluid consistence, are suffered to drop off with that heat or agitation remaining in them, into cold Water; by which means the outsides of the drop are presently cool'd and *crusted*, and are thereby made of a loose texture, because the parts of it have not time to settle themselves leisurely together, and so to lie very close together: And the innermost parts of the drop, retaining still much of their former heat and agitations, remain

of a loose texture also, and, according as the cold strikes inwards from the bottom and sides, are quenched, as it were, and made rigid in that very posture wherein the cold finds them. For the parts of the *crust* being already hardened, will not suffer the parts to shrink any more from the outward Surface inward; and though it shrink a little by reason of the small parcels of some Aerial substances dispersed through the matter of the Glass, yet that is not neer so much as it appears (as I just now hinted;) nor if it were, would it be sufficient for to consolidate and condense the body of Glass into a *tuff* and close *texture*, after it had been so excessively rarified by the heat of the glass-Furnace.

But that there may be such an expansion of the aerial substance contained in those little *blebbs* or bubbles in the body of the drop, this following Experiment will make more evident.

Take a small Glass-Cane about a foot long, seal up one end of it *hermetically*, then put in a very small bubble of Glass, almost of the shape of an Essence-viol with the open mouth towards the sealed end, then draw out the other end of the Pipe very small, and fill the whole Cylinder with water, then set this Tube by the Fire till the Water begin to boyl, and the Air in the bubble be in good part rarified and driven out, then by sucking at the smalling Pipe, more of the Air or vapours in the bubble may be suck'd out, so that it may sink to the bottom; when it is sunk to the bottom, in the flame of a Candle, or Lamp, nip up the slender Pipe and let it cool: whereupon it is obvious to observe, first, that the Water by degrees will subside and shrink into much less room: Next, that the Air or vapours in the Glass will expand themselves so, as to buoy up the little Glass: Thirdly, that all about the inside of the Glass-pipe there will appear an infinite number of small bubbles, which as the Water grows colder and colder will swell bigger and bigger, and many of them buoy themselves up and break at the top.

From this *Disceding* of the heat in Glass drops, that is, by the quenching or cooling Irradiations propagated from the Surface upwards and inwards, by the lines C T, C T, D T, D E, *&c.* the bubbles in the drop have room to expand themselves a little, and the parts of the Glass contract themselves; but this operation being too quick for the sluggish parts of the Glass, the contraction is performed very unequally and irregularly, and thereby the Particles of the Glass are bent, some one way, and some another, yet so as that most of them draw towards the Pith or middle T E E E, or rather from that outward: so that they cannot *extricate* or unbend themselves, till some part of T E E E be broken and loosened, for all the parts about that are placed in the manner of an Arch, and so till their hold at T E E E be loosened they cannot fly asunder, but uphold, and shelter, and fix each other much like the stones in a Vault, where each stone does concurre to the stability of the whole Fabrick, and no one stone can be taken away but the whole Arch falls. And wheresoever any of those radiating wedges D T D, *&c.* are removed, which are the component parts of this Arch, the whole Fabrick presently falls to pieces;

pieces; for all the Springs of the ſeveral parts are ſet at liberty, which immediately extricate themſelves and fly aſunder every way; each part by its ſpring contributing to the darting of it ſelf and ſome other contiguous part. But if this drop be heat ſo hot as that the parts by degrees can unbend themſelves, and be ſettled and annealed in that poſture, and be then ſuffered gently to ſubſide and cool; The parts by this nealing loſing their ſpringineſs, conſtitute a drop of a more ſoft but leſs brittle texture, and the parts being not at all under a flexure, though any part of the middle or Pith T E E E be broken, yet will not the drop at all fly to pieces as before.

This Conjecture of mine I ſhall indeavour to make out by explaining each particular Aſſertion with *analogous* Experiments: The Aſſertions are theſe.

Firſt, That the parts of the Glaſs, whilſt in a fluid Conſiſtence and hot, are more rarified, or take up more room, then when hard and cold.

Secondly, That the parts of the drop do ſuffer a twofold contraction.

Thirdly, That the dropping or quenching the glowing metal in the Water makes it of a hard, ſpringing, and rarified texture.

Fourthly, That there is a flexion or force remaining upon the parts of the Glaſs thus quenched, from which they indeavour to extricate themſelves.

Fifthly, That the Fabrick of the drop, that is able to hinder the parts from extricating themſelves, is *analogus* to that of an Arch.

Sixthly, That the ſudden flying aſunder of the parts proceeds from their ſpringineſs.

Seventhly, That a gradual heating and cooling does anneal or reduce the parts of Glaſs to a texture that is more looſe, and eaſilier to be broken, but not ſo brittle.

That the firſt of theſe is true may be gathered from this, That *Heat is a property of a body ariſing from the motion or agitation of its parts*; and therefore whatever body is thereby toucht muſt neceſſarily receive ſome part of that motion, whereby its parts will be ſhaken and agitated, and ſo by degrees free and extricate themſelves from one another, and each part ſo moved does by that motion *exert* a *conatus* of *protruding* and diſplacing all the adjacent Particles. Thus Air included in a veſſel, by being heated will burſt it to pieces. Thus have I broke a Bladder held over the fire in my hand, with ſuch a violence and noiſe, that it almoſt made me deaf for the preſent, and much ſurpaſſed the noiſe of a Musket: The like have I done by throwing into the fire ſmall glaſs Bubbles hermetically ſealed, with a little drop of Water included in them. Thus Water alſo, or any other Liquor, included in a convenient veſſel, by being warmed, manifeſtly expands it ſelf with a very great violence, ſo as to break the ſtrongeſt veſſel, if when heated it be narrowly impriſoned in it.

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This is very manifest by the *sealed Thermometers*, which I have, by several tryals, at last brought to a great certainty and tenderness: for I have made some with stems above four foot long, in which the expanding Liquor would so far vary, as to be very neer the very top in the heat of Summer, and prety neer the bottom at the coldest time of the Winter. The Stems I use for them are very thick, straight, and even Pipes of Glass, with a very small *perforation*, and both the head and body I have made on purpose at the Glass-house, of the same metal whereof the Pipes are drawn: these I can easily in the flame of a Lamp, urged with the blast of a pair of Bellows, seal and close together, so as to remain very firm, close and even; by this means I joyn on the body first, and then fill both it and a part of the stem, proportionate to the length of the stem and the warmth of the season I fill it in, with the best rectified *Spirit of Wine* highly *ting'd* with the lovely colour of *Cocheneel*, which I deepen the more by pouring some drops of common *Spirit of Urine*, which must not be too well rectified, because it will be apt to make the Liquor to curdle and stick in the small perforation of the stem. This Liquor I have upon tryal found the most tender of any spirituous Liquor, and those are much more sensibly affected with the variations of heat and cold then other more flegmatick and ponderous Liquors, and as capable of receiving a deep tincture, and keeping it, as any Liquor whatsoever; and (which makes it yet more acceptable) is not subject to be frozen by any cold yet known. When I have thus filled it, I can very easily in the forementioned flame of a Lamp seal and joyn on the head of it.

Then, for graduating the stem, I fix that for the beginning of my division where the surface of the liquor in the stem remains when the ball is placed in common distilled water, that is so cold that it just begins to freeze and shoot into flakes; and that mark I fix at a convenient place of the stem, to make it capable of exhibiting very many degrees of cold, below that which is requisite to freeze water: the rest of my divisions, both above and below this (which I mark with a [0] or nought) I place according to the Degrees of *Expansion*, or *Contraction* of the Liquor in proportion to the bulk it had when it indur'd the newly mention'd freezing cold. And this may be very easily and accurately enough done by this following way; Prepare a Cylindrical vessel of very thin plate Brass or Silver, A B C D of the figure Z; the Diameter A B of whose cavity let be about two inches, and the depth B C the same; let each end be cover'd with a flat and smooth plate of the same substance, closely soder'd on, and in the midst of the upper cover make a pretty large hole E F, about the bigness of a fifth part of the Diameter of the other; into this fasten very well with cement a straight and even Cylindrical pipe of Glass, E F G H, the Diameter of whose cavity let be exactly one tenth of the Diameter of the greater Cylinder. Let this pipe be mark'd at G H with a Diamant, so that G from E may be distant just two inches, or the same height with that of the cavity of the greater Cylinder, then divide the length E G exactly into 10 parts, so the capacity of the hollow of each of these divisions will be $\frac{1}{1000}$ part of the capacity of the greater Cylinder.

der. This vessel being thus prepared, the way of marking and graduating the *Thermometers* may be very easily thus performed:

Fill this Cylindrical vessel with the same liquor wherewith the *Thermometers* are fill'd, then place both it and the *Thermometer* you are to *graduate*, in water that is ready to be frozen, and bring the surface of the liquor in the *Thermometer* to the first marke or [o]; then so proportion the liquor in the Cylindrical vessel, that the surface of it may just be at the lower end of the small glass-Cylinder; then very gently and gradually warm the water in which both the *Thermometer* and this Cylindrical vessel stand, and as you perceive the ting'd liquor to rise in both stems, with the point of a Diamond give several marks on the stem of the *Thermometer* at those places, which by comparing the expansion in both Stems, are found to correspond to the divisions of the cylindrical vessel, and having by this means marked some few of these divisions on the Stem, it will be very easie by these to mark all the rest of the Stem, and accordingly to assign to every division a proper character.

A *Thermometer*, thus marked and prepared, will be the fittest Instrument to make a Standard of heat and cold that can be imagined. For being sealed up, it is not at all subject to variation or wasting, nor is it liable to be changed by the varying pressure of the Air, which all other kind of *Thermometers* that are open to the Air are liable to. But to proceed.

This property of Expansion with Heat, and Contraction with Cold, is not peculiar to Liquors only, but to all kind of solid Bodies also, especially Metals, which will more manifestly appear by this Experiment.

Take the Barrel of a Stopcock of Brass, and let the Key, which is well fitted to it, be riveted into it, so that it may slip, and be easily turned round, then heat this Cock in the fire, and you will find the Key so swollen, that you will not be able to turn it round in the Barrel; but if it be suffered to cool again, as soon as it is cold it will be as movable, and as easie to be turned as before.

This Quality is also very observable in *Lead*, *Tin*, *Silver*, *Antimony*, *Pitch*, *Rosin*, *Bees-wax*, *Butter*, and the like; all which, if after they be melted you suffer gently to cool, you shall find the parts of the upper Surface to subside and fall inwards, losing that plumpness and smoothness it had whilst in fusion. The like I have also observed in the cooling of *Glass of Antimony*, which does very neer approach the nature of Glass,

But because these are all Examples taken from other materials then Glass, and argue only, that possibly there may be the like property also in Glass, not that really there is; we shall by three or four Experiments indeavour to manifest that also.

And the First is an Observation that is very obvious even in these very drops, to wit, that they are all of them terminated with an unequal or irregular Surface, especially about the smaller part of the drop, and the whole length of the stem; as about D, and from thence to A, the whole Surface, which would have been round if the drop had cool'd leisurely, is, by being quenched hastily, very irregularly flatted and pitted; which

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I ſuppoſe proceeds partly from the Waters unequally cooling and preſſing the parts of the drop, and partly from the ſelf-contracting or ſubſiding quality of the ſubſtance of the Glaſs: For the vehemency of the heat of the drop cauſes ſuch ſudden motions and bubbles in the cold Water, that ſome parts of the Water bear more forcibly againſt one part then againſt another, and conſequently do more ſuddenly cool thoſe parts to which they are contiguous.

A Second Argument may be drawn from the Experiment of cutting Glaſſes with a hot Iron. For in that Experiment the top of the Iron heats, and thereby rarifies the parts of the Glaſs that lie juſt before the crack, whence each of thoſe agitated parts indeavouring to expand its ſelf and get elbow-room, thruſts off all the reſt of the contiguous parts, and conſequently promotes the crack that was before begun.

A Third Argument may be drawn from the way of producing a crack in a ſound piece or plate of Glaſs, which is done two wayes, either Firſt, by ſuddenly heating a piece of Glaſs in one place more then in another. And by this means *Chymiſts* uſually cut off the necks of Glaſs-bodies, by two kinds of Inſtruments, either by a glowing hot round Iron-Ring, which juſt incompaſſes the place that is to be cut, or elſe by a *Sulphur'd* Threed, which is often wound about the place where the ſeparation is to be made, and then fired. Or Secondly, A Glaſs may be cracked by cooling it ſuddenly in any place with Water, or the like, after it has been all leiſurely and gradually heated very hot. Both which *Phænomena* ſeem manifeſtly to proceed from the *expanſion* and contraction of the parts of the Glaſs, which is alſo made more probable by this circumſtance which I have obſerved, that a piece of common window-glaſs being heated in the middle very ſuddenly with a live Coal or hot Iron, does uſually at the firſt crack fall into pieces, whereas if the Plate has been gradually heated very hot, and a drop of cold Water and the like be put on the middle of it, it only flaws it, but does not break it aſunder immediately.

A Fourth Argument may be drawn from this Experiment; Take a Glaſs-pipe, and fit into it a ſolid ſtick of Glaſs, ſo as it will but juſt be moved in it. Then by degrees heat them whilſt they are one within another, and they will grow ſtiffer, but when they are again cold, they will be as eaſie to be turned as before. This Expanſion of Glaſs is more manifeſt in this Experiment.

Take a ſtick of Glaſs of a conſiderable length, and fit it ſo between the two ends or ſcrews of a Lath, that it may but juſt eaſily turn, and that the very ends of it may be juſt toucht and ſuſteined thereby; then applying the flame of the Candle to the middle of it, and heating it hot, you will preſently find the Glaſs to ſtick very faſt on thoſe points, and not without much difficulty to be convertible on them, before that by removing the flame for a while from it, it be ſuffered to cool, and then you will find it as eaſie to be turned round as at the firſt.

From all which Experiments it is very evident, that all thoſe Bodies, and particularly Glaſs, ſuffers an Expanſion by Heat, and that a very conſiderable

ſiderable one, whilſt they are in a ſtate of Fuſion. For *Fluidity*, as I elſewhere mention, *being nothing but an effect of a very ſtrong and quick ſhaking motion, whereby the parts are, as it were, looſened from each other, and conſequently leave an interjacent ſpace or vacuity*; it follows, that all thoſe ſhaken Particles muſt neceſſarily take up much more room then when they were at reſt, and lay quietly upon each other. And this is further confirmed by a Pot of *boyling Alabaſter*, which will manifeſtly riſe a ſixth or eighth part higher in the Pot, whilſt it is boyling, then it will remain at, both before and after it be boyled. The reaſon of which odd *Phænomenon* (to hint it here only by the way) is this, that there is in the curious powder of Alabaſter, and other calcining Stones, a certain watery ſubſtance, which is ſo fixt and included with the ſolid Particles, that till the heat be very conſiderable they will not fly away; but after the heat is increaſed to ſuch a degree, they break out every way in vapours, and thereby ſo ſhake and looſen the ſmall corpuſles of the Powder from each other, that they become perfectly of the nature of a fluid body, and one may move a ſtick to and fro through it, and ſtir it as eaſily as water, and the vapours burſt and break out in bubbles juſt as in boyling water, and the like; whereas, both before thoſe watery parts are flying away, and after they are quite gone; that is, before and after it have done boyling, all thoſe effects ceaſe, and a ſtick is as difficultly moved to and fro in it as in ſand, or the like. Which Explication I could eaſily prove, had I time; but this is not a fit place for it.

To proceed therefore, I ſay, that the dropping of this expanded Body into cold Water, does make the parts of the Glaſs ſuffer a double contraction: The firſt is, of thoſe parts which are neer the Surface of the Drop. For Cold, as I ſaid before, contracting Bodies, that is, *by the abatement of the agitating faculty the parts falling neerer together*; the parts next adjoying to the Water muſt needs loſe much of their motion, and impart it to the Ambient-water (which the Ebullition and commotion of it manifeſts) and thereby become a ſolid and hard cruſt, whilſt the innermoſt parts remain yet fluid and expanded; whence, as they grow cold alſo by degrees, their parts muſt neceſſarily be left at liberty to be condenſed, but becauſe of the hardneſs of the outward cruſt, the contraction cannot be admitted that way; but there being many very ſmall, and before inconſpicuous, bubbles in the ſubſtance of the Glaſs, upon the ſubſiding of the parts of the Glaſs, the agil ſubſtance contained in them has liberty of expanding it ſelf a little, and thereby thoſe bubbles grow much bigger, which is the ſecond Contraction. And both theſe are confirmed from the appearance of the Drop it ſelf: for as for the outward parts, we ſee, firſt, that it is irregular and ſhrunk, as it were, which is cauſed by the yielding a little of the hardened Skin to a Contraction, after the very outmoſt Surface is ſettled; and as for the internal parts, one may with ones naked Eye perceive abundance of very conſpicuous bubbles, and with the *Microſcope* many more.

The Conſideration of which Particulars will eaſily make the Third Poſition probable, that is, that the parts of the drop will be of a very hard, though of a rarified Texture; for if the outward parts of the Drop, by reaſon of its hard cruſt, will indure very little Contraction, and the agil Particles, inclu-

ded in those bubbles, by the losing of their agitation, by thedecrease of the Heat,lose also most part of their Spring and Expansive power;it follows (the withdrawing of the heat being very sudden) that the parts must be left in a very loose Texture, and by reason of the implication of the parts one about another,which from their sluggishnes and glutinousnes I suppose to be much after the manner of the sticks in a Thorn-bush,or a Lock of Wool;It will follow, I say, that the parts will hold each other very strongly together,and indeavour to draw each other neerer together, and consequently their Texture must be very hard and stiff, but very much rarified.

And this will make probable my next Position, That *the parts of the Glass are under a kind of tension or flexure,out of which they indeavour to extricate and free themselves*,and thereby all the parts draw towards the Center or middle, and would, if the outward parts would give way, as they do when the outward parts cool leisurely (as in baking of Glasses) contract the bulk of the drop into a much less compass. For since,as I proved before,the Internal parts of the drop, when fluid,were of a very rarified Texture and,as it were,tos'd open like a Lock of Wool,and if they were suffered leisurely to cool, would be again prest, as it were,close together: And since that the heat,which kept them bended and open, is removed, and yet the parts not suffered to get as neer together as they naturally would; It follows,that the Particles remain under a kind of *tension* and *flexure*, and consequently have an indeavour to free themselves from that *bending* and *distension*, which they do, as soon as either the tip be broken, or as soon as by a leisurely heating and cooling, the parts are nealed into another posture.

And this will make my next Position probable,that *the parts of the Glass drops are contignated together in the form of an Arch*,and cannot any where yield or be drawn inwards,till by the removing of some one part of it(as it happens in the removing one of the stones of an Arch)the whole Fabrick is shatter'd,and falls to pieces,and each of the Springs is left at liberty,suddenly to extricate it self: for since I have made it probable,that the internal parts of the Glass have a contractive power inwards, and the external parts are incapable of such a Contraction,and the figure of it being spherical;it follows,that the superficial parts must bear against each other, and keep one another from being condens'd into a less room, in the same manner as the stones of an Arch conduce to the upholding each other in that Figure.And this is made more probable by another Experiment which was communicated to me by an excellent Person,whose extraordinary Abilities in all kind of Knowledg, especially in that of Natural things,and his generous Disposition in communicating,incouraged me to have recourse to him on many occasions. The Experiment was this: Small Glass-balls (about the bignes of that represented in the *Figure &c.*) would,upon rubbing or scratching the inward Surface, fly all insunder, with a pretty brisk noise; whereas neither before nor after the inner Surface had been thus scratcht, did there appear any flaw or crack. And putting the pieces of one of those broken ones together again, the flaws appeared much after the manner of the black lines on the Figure, *&c.* These Balls were small, but exceeding thick bubbles of Glass, which being crack'd off from the *Puntilion* whilst very hot, and so suffered to cool without nealing them in the

the Oven over the Furnace, do thereby (being made of white Glaſs, which cools much quicker then green Glaſs, and is thereby made much brittler) acquire a very *porous* and very brittle *texture*: ſo that if with the point of a Needle or Bodkin, the inſide of any of them be rubbed prety hard, and then laid on a Table, it will, within a very little while, break into many pieces with a brisk noiſe, and throw the parts above a ſpan aſunder on the Table: Now though the pieces are not ſo ſmall as thoſe of a *fulminating* drop, yet they as plainly ſhew, that the outward parts of the Glaſs have a great *Conatus* to fly aſunder, were they not held together by the *tenacity* of the parts of the inward Surface: for we ſee as ſoon as thoſe parts are crazed by hard rubbing, and thereby their tenacity ſpoiled, the ſpringineſs of the more outward parts quickly makes a divulſion, and the broken pieces will, if the concave Surface of them be further ſcratcht with a Diamond, fly again into ſmaller pieces.

From which preceding conſiderations it will follow Sixthly, That the ſudden flying aſunder of the parts as ſoon as this Arch is any where diſordered or broken, proceeds from the ſpringing of the parts; which, indeavouring to *extricate* themſelves as ſoon as they get the liberty, they perform it with ſuch a quickneſs, that they throw one another away with very great violence: for the Particles that compoſe the Cruſt have a *Conatus* to lye further from one another, and therefore as ſoon as the external parts are looſened they dart themſelves outward with great violence, juſt as ſo many Springs would do, if they were detained and faſtened to the body, as ſoon as they ſhould be ſuddenly looſened; and the internal parts drawing inward, they contract ſo violently, that they rebound back again and fly into multitude of ſmall ſhivers or ſands. Now though they appear not, either to the naked Eye, or the *Microſcope*, yet I am very apt to think there may be abundance of ſmall flaws or cracks, which, by reaſon the ſtrong reflecting Air is not got between the *contiguous* parts, appear not. And that this may be ſo, I argue from this, that I have very often been able to make a crack or flaw, in ſome convenient pieces of Glaſs, to appear and diſappear at pleaſure, according as by preſſing together, or pulling aſunder the contiguous parts, I excluded or admitted the ſtrong reflecting Air between the parts: And it is very probable, that there may be ſome Body, that is either very rarified Air, or ſomething *analogous* to it, which fills the bubbles of theſe drops; which I argue, firſt, from the roundneſs of them, and next, from the vivid reflection of Light which they exhibite: Now though I doubt not, but that the Air in them is very much rarified, yet that there is ſome in them, to ſuch as well conſider this Experiment of the diſappearing of a crack upon the *extruding* of the Air, I ſuppoſe it will ſeem more then probable.

The Seventh and laſt therefore that I ſhall prove, is, *That the gradual heating and cooling of theſe ſo extended bodies does reduce the parts of the Glaſs to a looſer and ſofter temper.* And this I found by heating them, and keeping them for a prety while very red hot in a fire; for thereby I found them to grow a little lighter, and the ſmall Stems to be very eaſily broken and ſnapt any where, without at all making the drop fly; whereas

before they were ſo exceeding hard, that they could not be broken without much difficulty; and upon their breaking the whole drop would fly in pieces with very great violence. The Reaſon of which laſt ſeems to be, that the leiſurely heating and cooling of the parts does not only waſt ſome part of the Glaſs it ſelf, but ranges all the parts into a better order, and gives each Particle an opportunity of *relaxing* its ſelf, and conſequently neither will the parts hold ſo ſtrongly together as before, nor be ſo difficult to be broken: The parts now more eaſily yielding, nor will the other parts fly in pieces, becauſe the parts have no bended Springs. The *relaxation* alſo in the temper of hardned Steel, and hammered Metals, by nealing them in the fire, ſeems to proceed from much the ſame cauſe. For both by quenching ſuddenly ſuch Metals as have *vitrified* parts interſpers'd, as Steel has, and by hammering of other kinds that do not ſo much abound with them, as Silver, Braſs, *&c.* the parts are put into and detained in a bended poſture, which by the agitation of Heat are ſhaken, and looſened, and ſuffered to unbend themſelves.

Obſerv. VIII. *Of the fiery Sparks ſtruck from a Flint or Steel.*

Schem. 5. IT is a very common Experiment, by ſtriking with a Flint againſt a Steel, to make certain fiery and ſhining Sparks to fly out from between thoſe two compreſſing Bodies. About eight years ſince, upon caſually reading the Explication of this odd *Phænomenon*, by the moſt Ingenious *Des Cartes*, I had a great deſire to be ſatisfied, what that Subſtance was that gave ſuch a ſhining and bright Light: And to that end I ſpread a ſheet of white Paper, and on it, obſerving the place where ſeveral of theſe Sparks ſeemed to vaniſh, I found certain very ſmall, black, but gliſtering Spots of a movable Subſtance, each of which examining with my *Miſcrocope*, I found to be a ſmall round *Globule*; ſome of which, as they looked prety ſmall, ſo did they from their Surface yield a very bright and ſtrong reflection on that ſide which was next the Light; and each look'd almoſt like a prety bright Iron-Ball, whoſe Surface was prety regular, ſuch as is repreſented by the Figure A. In this I could perceive the Image of the Window prety well, or of a Stick, which I moved up and down between the Light and it. Others I found, which were, as to the bulk of the Ball, prety regularly round, but the Surface of them, as it was not very ſmooth, but rough, and more irregular, ſo was the reflection from it more faint and confuſed. Such were the Surfaces of B. C. D. and E. Some of theſe I found cleft or cracked, as C, others quite broken in two and hollow, as D. which ſeemed to be half the hollow ſhell of a Granado, broken irregularly in pieces. Several others I found of other ſhapes; but that which is repreſented by E, I obſerved to be a very big Spark of Fire, which went out upon one ſide of the Flint that I ſtruck fire withall, to which