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**New experiments physico-mechanicall, touching the spring of the air, and its effects (made, for the most part, in a new pneumatical engine) : written by way of letter to the Right Honorable Charles, Lord Vicount of Dungarvan, eldest son to the Earl of Corke**

Boyle, Robert, 1627-1691.

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NEW EXPERIMENTS Physico-Mechanicall Touching the Air.

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NEW EXPERIMENTS Physico-Mechanicall, Touching The SPRING of the AIR, and its EFFECTS, (Made, for the most part, in a New PNEUMATICAL ENGINE) Written by way of LETTER To the Right Honorable *Charles* Lord Vicount of *Dungarvan,* Eldest Son to the EARL of *CORKE.*

By the Honorable *Robert Boyle* Esq

*OXFORD:* Printed by *H: Hall,* Printer to the University, for *Tho: Robinson.* 1660.

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## To the Reader.

**A**Lthough the following Trea∣tise being far more prolix then becomes a Letter, and then I at first intended it; I am very unwilling to en∣crease the already excessive bulk of the Book by a Preface, yet there are some par∣ticulars that I think my self oblig'd to take notice of to the Reader, as things, that will either concern him to know, or me to have known.

In the first place then: If it be demand∣ed why I publish to the World a Letter, which by its Stile and diverse Passages, appears to have been written as well For, as To a particular Person; I have chiefly these two things to answer: The one, That the Ex∣periments therein related, having been ma∣ny of them try'd in the presence of Ingeni∣ous Men; and by that means having made [Page  [unnumbered]](https://quod.lib.umich.edu/e/eebo/A29003.0001.001/7?vid=56393) some noise among the *Virtuosi* (insomuch that some of them have been sent into Fo∣reign Countries, where they have had the luck not to be despis'd) I could not without quite tyring more then one *Amanuensis,* give out half as many Copies of them as were so earnestly desired, that I could not civilly refuse them. The other, That intelligent Persons in matters of this kinde perswaded me, that the publication of what I had ob∣serv'd touching the Nature of the Air, would not be useless to the World; and that in an Age so taken with Novelties as is ours, these new Experiments would be grateful to the Lovers of free and real Learning: So that I might at once comply with my grand Design of promoting Experimental and Useful Philosophy, and obtain the great sa∣tisfaction of giving some to ingenious Men; the hope of which, is, I confess, a tempta∣tion that I cannot easily resist.

Of my being somewhat prolix in many of my Experiments, I have these Reasons to render, That some of them being altoge∣ther new, seem'd to need the being circum∣stantially related, to keep the Reader from distrusting them: That divers Circum∣stances I did here and there set down for fear of forgetting them, when I may hereafter [Page  [unnumbered]](https://quod.lib.umich.edu/e/eebo/A29003.0001.001/8?vid=56393) have occasion to make use of them in my o∣ther Writings: That in divers cases I thought it necessary to deliver things cir∣cumstantially, that the Person I addressed them to, might without mistake, and with as little trouble as is possible, be able to re∣peat such unusual Experiments: and that after I consented to let my Observations be made publick, the most ordinary Reason of my prolixity was, That foreseeing that such a trouble as I met with in making those try∣als carefully, and the great expence of time that they necessarily require, (not to mention the charges of making the Engine, and im∣ploying a man to manage it) will probably keep most men from trying again those Ex∣periments; I thought I might doe the gene∣rality of my Readers no unacceptable peice of service, by so punctually relating what I carefully observ'd, that they may look up∣on these Narratives as standing Records in our new Pneumaticks, and need not reite∣rate themselves an Experiment to have as distinct an Idea of it, as may suffice them to ground their Reflections and Speculations upon.

And because sometimes 'tis the Discourse made upon the Experiment that makes it appear prolix, I have commonly left a con∣spicuous [Page  [unnumbered]](https://quod.lib.umich.edu/e/eebo/A29003.0001.001/9?vid=56393) interval betwixt such Discourses, and the Experiments whereunto they belong, or are annexed; that they who desire onely the Historical part of the account we give of our Engine, may read the Narra∣tives, without being put to the trouble of reading the Reflections too: Which I here take notice of, for the sake of those that are well vers'd in the New Philosophy, and in the Mathematicks; that such may skip what was design'd, but for such Persons as may be less acquainted even then I, with matters of this nature (scarce so much as mention'd by any Writer in our Language) and not for them from whom I shall be much more forward to learn, then to pretend to teach them. Of my being wont to speak rather doubtfully, or hesitant∣ly, then resolvedly, concerning matters wherein I apprehend some difficulty, I have in another Treatise (which may, through Gods Assistance, come abroad ere long) given a particular, and I hope a satisfacto∣ry account: Wherefore I shall now d•fend my Practice but by the Observation of *Ari∣stotle,* who somewhere notes, That to seem to know all things certainly, and to speak positively of them, is a trick of bold and yong Fellows: Whereas those that are in∣deed [Page  [unnumbered]](https://quod.lib.umich.edu/e/eebo/A29003.0001.001/10?vid=56393) intelligent and considerate, are wont to imploy more wary and diffident Expressi∣ons, or (as he speaks) 〈 in non-Latin alphabet 〉.

There are divers Reflections, and other Passages in the following Epistle, and even some Experiments (occasionally mention'd) which may seem either impertinent or su∣perfluous, but are not so: Being purposely written, either to evince some truth oppos'd, or disprove some erroneous conceit main∣tain'd, by some eminent New Philosopher, or by some other Ingenious Men, who, I presum'd, would easily forgive me the ha∣ving on such occasions purposely omitted their Names; though an inquisitive Person will probably discover divers of them, by the mention of the Opinions disprov'd in the Experiments I am excusing.

Ever since I discern'd the usefulness of speculative Geometry to Natural Phi∣losophy, the unhappy Distempers of my Eyes, have so far kept me from being much con∣versant in it, that I fear I shall need the par∣don of my Mathematical Readers, for some Passages, which if I had been deeply skill'd in Geometry, I should have treated more ac∣curately.

[Page  [unnumbered]](https://quod.lib.umich.edu/e/eebo/A29003.0001.001/11?vid=56393)And indeed, having, for Reasons else∣where deduc'd, purposely kept my self a stranger to most of the new *Hypotheses* in Philosophy, I am sensible enough that the Engine I treat of has prevail'd with me to write of some subjects which are sufficient∣ly remote from those I have been most con∣versant in. And having been reduc'd to write the greatest part of the ensuing Letter at a distance, not onely from my Library, but from my own Manuscripts, I cannot but fear that my Discourses do not onely want many choice things wherewith the Learned Writings of others might have en∣riched or imbellished them: But that partly for this Reason, and partly for that touch'd upon a little before, It is possible I may have mention'd some Notions already pub∣lish'd by others, without taking notice of the Authors, not out of any design to defraud deserving Men, but for want of knowing such particulars to have been already pub∣lish'd by them: Especially the Experiments of our Engine being themselves sufficient to hint such Notions as we build upon them.

The order of the Experiments every Reader may alter, as suits best with his own Design in perusing them: For not onely all [Page  [unnumbered]](https://quod.lib.umich.edu/e/eebo/A29003.0001.001/12?vid=56393) those betwixt whom there is an Affinity in Nature (by belonging to one subject) are not always plac'd one by another, but they are not still set down so much as in the order wherein they were made; but most common∣ly in that casual one wherein my occasions in∣duc'd me to dispatch them to the Press. And, which is worse, I did usually send quite a∣way the former Experiments, before the later were written, or perhaps so much as made: Whereby I lost the advantage of cor∣recting and supplying the Imperfections of what I had formerly written, by the light of my subsequent Tryals and Discoveries.

Besides all this, the distemper in my eyes forbidding me not onely to write my self so much as one Experiment, but even to read over my self what I dictated to others. I can∣not but fear, that besides the Authors mistakes, this Edition may be blemish'd by many, that may be properly imputed to a very unskil∣ful Writer (whom I was often times by haste reduc'd against my custom to imploy) and may have escaped the Diligence of that Learned Friend, that does me the favor to over-see the Press; especially there being the distance of two days Iourney betwixt it and me.

I need not perhaps represent to the equi∣table [Page  [unnumbered]](https://quod.lib.umich.edu/e/eebo/A29003.0001.001/13?vid=56393) Reader, how much the strange Confu∣sions of this unhappy Nation, in the midst of which I have made and written these Experiments, are apt to disturb that calm∣ness of Minde, and •ndistractedness of Thoughts, that are wont to be requisite to Happy Speculations. But I presume, that by all these things put together, he will readily perceive, That I have been so far from following the Poets prudent Counsel touching the slow Publication of Books design'd to purchase credit by,

— Nonumque prematur in Annum

that I suffer this Treatise to come abroad into the World with a multitude of Disad∣vantages.

But if it be demanded, why then I did not make it fitter for the Press before I sent it thither? my Answer must be, That not at first imagining that this sort of Experi∣ments would prove any thing near so trouble∣some, either to make, or to Record, as I afterwards found them, I did, to engage the Printer to dispatch, promise him to send him the whole Epistle in a very short time: So that although now and then the occasional vacations of the Press, by reason of Festi∣vals, [Page  [unnumbered]](https://quod.lib.umich.edu/e/eebo/A29003.0001.001/14?vid=56393) or the absence of the Corrector, gave me the leisure to exspaciate upon some sub∣ject; yet being oftentimes call'd upon to dis∣patch the Papers to the Press, my promise, and many unexpected Avocations, obliged me to a haste, which, though it have detract∣ed nothing from the Faithfulness of the Historical part of our Book, has (I fear) been disadvantageous enough to all the rest. And I made the less scruple to let the fol∣lowing Papers pass out of my hands, with all their Imperfections; because, as the publick Affairs, and my own, were then circumstanc'd, I knew not when (if at all) I should be again in a condition to prosecute Experiments of this kinde; especially, since (to omit my being almost weary of be∣ing, as it were, confin'd to one sort of Ex∣periments) I am pre-ingag'd (if it please God to vouchsafe me Life and Health) to imploy my first leisure in the publication of some other Physiological Papers, which I thought 'twould make me much the fitter to take in hand, if I first dispatch'd all that I had at this time to write touching our Engine.

I have this further to adde, by way of Excuse, That as it has been my design in publishing these Experiments to gratifie [Page  [unnumbered]](https://quod.lib.umich.edu/e/eebo/A29003.0001.001/15?vid=56393) Ingenious men; so, if I have not been much flattered, I may hope that the vari∣ous hints to be met with in the following Letter, will (at least) somewhat awaken mens thoughts, & excite them to new specula∣tions (such as perhaps even inquisitive men would scarce else light upon) and I need not despair, that even the examination of such new Suspicions and Enquiries will hence al∣so, at least Occasionally, be facilitated: I said Occasionally, because it being, as 'tis proverbially said, *Facile Inventis addere.* It seems not irrational to expect, that our Engine it self, and divers of our Experi∣ments, will be much promoted by the Indu∣stry of Inventive and Mathematical Wits, whose contrivances may easily either correct or supply, and consequently surpass many of those we have made use of. And, particu∣larly, if Men by skill and patience can ar∣rive both to evacuate such Receivers as ours, till there be no more Air left in them, then there seems to have remain'd in the Glasses made use of about the Magdebur∣gick Experiment (hereafter to be mention∣ed) and to keep out the Air for a competent while, the Usefulness and Discoveries of our Engine, will not be a little advanc'd. And perhaps that may belong to it, which I re∣member [Page  [unnumbered]](https://quod.lib.umich.edu/e/eebo/A29003.0001.001/16?vid=56393)*Seneca* speaks of Nature, *Initia∣tos* (says he) *nos credimus, in Vestibulo ejus haeremus:* For being now in a place where we are not quite destitute of moderate∣ly skilful Artificers, we have, since the Conclusion of the following Letter, made some Additions to our Engine, by whose help we finde (upon some new tryals) that we may be able, without much of new trouble, to keep the ambient Air out of the exhau∣sted Receiver for a whole day; and perhaps we should be able to keep it out much longer, if before we shall have dispatch'd some ur∣gent Affairs, and publish'd some Papers for which a kinde of Promise is thought to make us Debtors to the Press, we could be at lei∣sure to prosecute such Experiments, as may possibly afford a Supplement to the follow∣ing Treatise, from which I shall now no lon∣ger detain the Reader.

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Friendly Reader,

**I** Know all Persons that have a publick Spirit for the Ad∣vancement of Lear∣ning, will think much that this piece came not out in a Lan∣guage of more general Vse, then this you see it now attir'd in; especially since the Excel∣lent Noble Person, who is the Author, is known to be well a∣ble himself (being almost uni∣versally a Linguist) to have gi∣ven it either the Old Latin, or [Page  [unnumbered]](https://quod.lib.umich.edu/e/eebo/A29003.0001.001/19?vid=56393) the newer French Dress.

But if it be an Honor to a Language to be preferr'd, and this Honor breeds sometimes an Emulation, as anciently it did between the *Greeks* and *Ro∣mans,* it cannot be thought unhandsome for an English Nobleman to have preferr'd his own: And it may be a suf∣ficient Reason for the Gentry of Forein Parts to learn our Speech, or keep Interpreters, that they are sure to have for their requital, from many of our English Writers (as here from this piece) much curiously ingenious, and profitable Lear∣ning.

[Page  [unnumbered]](https://quod.lib.umich.edu/e/eebo/A29003.0001.001/20?vid=56393)But as to this particular (give me leave to use Words from a Story) *Since the Mountain cannot come to* Mahomet, Mahomet *will go to the Mountain*: I mean thus; Because many witty Men, Per∣sons of Honor and Estate espe∣cially, may be suppos'd to be a∣ble to make a better account, by employing their Studies and Time on Matter then Words, and so are justly impeded from learning Languages; And be∣cause (as I may judge) the no∣ble Author is willing to oblige all Men, He has already provi∣ded, that this piece shall short∣ly be done into Latine, that so [Page  [unnumbered]](https://quod.lib.umich.edu/e/eebo/A29003.0001.001/21?vid=56393) it may come home to divers wor∣thy Persons in its Stream, who cannot travel to finde it out in its first Origine.

Having therefore leave so to do, I cannot forbear to give the World the Advertisement of this Latine Edition, lest some skilful Artist should take needless pains about a Work, which will, ere long (by Gods furtherance) be done to his Hands; For such unprofitable expences of Study have too fre∣quently happened, and too much to the disadvantage of Learn∣ing, for want of a sufficient Correspondence and Intercourse between such as are exercised [Page  [unnumbered]](https://quod.lib.umich.edu/e/eebo/A29003.0001.001/22?vid=56393) in the Mines of Wisdome.

This is all the trouble I shall at present give you: Nor shall I need minde thee, if you have a true gust for the Book you read, to have an honor and thankful regard to the Person that has favor'd us with the Communi∣cation of these his Tryals, & is manifestly so great a Patron and Friend to Experimental Learning, and all true Wisdom; for should you fail in this, you might deservedly be depriv'd of some other Observations on the same subject, which the Au∣thor, I heare, has made since the finishing of this Treatise.

I desire to be excused that I doe [Page  [unnumbered]](https://quod.lib.umich.edu/e/eebo/A29003.0001.001/23?vid=56393) not make Excuses for the slow∣ness of the Publication, hoping that the long expectation you have had of it, will enhance, and not diminish your delight in the enjoyment of a piece like to be, amongst the students in accurate Philosophy, of so generall accep∣tance. Farewel.

R: Sh.

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## A Summary of the chief Matters treated of in this Epistolical Discourse.

THe *Proaemium,* wherein is set down the oc•asion of this Discourse, *1.* The mo∣tives that induc'd the Author thereunto, *2 &c.* The hints he received, *5.* The things where∣in this Engine excels any that have yet been made use of, *6 &c.* The description of the Engine and its parts, *8 &c.* The way of pre∣paring and using it, *15 &c.* The division of the Experiments tryable thereby into two sorts, and the difficulty of excluding the Air.

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*62 &c.*

The eighth Experiment, tending to a fur∣ther Demonstration of the former, from the breaking of glass a Helmet inward.

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The *29* Experiment, touching the cause of the ascent of Fumes and Vapors, wherein 'tis prov'd (from the several motions, which the Fumes of a strange smoaking Liquor, of the Authors, were observ'd to have in the Re∣ceiver, upon the exsuction of the Air) that the reason of their ascent proceeds from the gravity of the ambient air, and not from any positive levity of their own.

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[Page  [unnumbered]](https://quod.lib.umich.edu/e/eebo/A29003.0001.001/30?vid=56393)The *30* Experiment, concerning the na∣ture of a fluid Body, illustrated by the exam∣ple of smoak which in several circumstances seems very much to resemble the property of a fluid Body, *224 &c.* A conjecture of the cause of the Suns undulation.

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The *31* Experiment, concerning the *Phae∣nomena* of two flat Marbles exactly plain'd and wrought together, and the true reason thereof, *229.* The Authors intention for the further prosecution thereof, & what hindred him; the reason why the under Marble did not fal from the upper (being onely conjoynd with Spirit of Wine) when the Receiver was evacuated. And a notable relation concern∣ing the cohesion of flat Bodies.

*231 &c.*

The *32* Experiment, touching the forcible pressure of the Air against the outward su∣perficies of a Valve, fasten'd upon the stop∣cock of the Receiver. The Diameter of it, and the weight it sustain'd.

*233 &c.*

The *33* experiment, touching the great pres∣sure of the Air against the under superficies of the Sucker, *236 &c.* what weight was re∣quisite to depress it, & what weight it would lift and carry up with it, *239 &c.* what im∣provement & use there may be made of this experiment, *242.* A Discourse touching the nature of Suction, proving that *fuga vacui* is not the adequate cause thereof.

*243 &c.*

[Page  [unnumbered]](https://quod.lib.umich.edu/e/eebo/A29003.0001.001/31?vid=56393)The *34th* Experiment, containing several attempts for the weighing of light Bodies in the exhausted Receiver.

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*267 &c.*

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*299 &c.*

The *37th* Experiment, touching the strange and odde *Phaenomenon,* of the sudden flash∣es of light in the cavity of the Receiver; the several circumstances and difficulties of it,[Page  [unnumbered]](https://quod.lib.umich.edu/e/eebo/A29003.0001.001/33?vid=56393)with some attempts towards the rendering at reason thereof, *301, &c.* The Difficulty of so doing fur∣ther shewn from the consideration of the various changes of Air which doe not immediatly fall un∣der our senses, *315.* this last proposition prou'd by severall observations.

*316.*

The *38.* Experiment, touching the freezing of water, *319. &c.* A problem, (concerning the great force wherewith a freezing Liquor extends its selfe,) propos'd upon the Consideration of divers admirable effects wrought th•reby.

*320 &c.*

The *39.* Experiment, containing an inquisition after the temperature of the substance that remain'd in the cavity of the Receiver, after the Air was well exhausted. The relation of a *Phaenomenon,* seeming to proceed from the sw•lling of the Glass. With an advertisement concerning the pliableness of Glass in small prices.

*322. &c.*

The *40.* Experiment, touching the difficulty that occur'd in making tryall whether rarified Air were able to sustaine flying insects.

*326. &c*

The *41.* Experiment, Exhibiting severall try∣alls touching the respiration of divers sorts of ani∣malls included in the Receiver, *328, &c.* With a digression conteining some doubts touching respira∣tion wherein are delivere• severall Experiments re∣lating thereunto.

*335 &c.*

The *42.* Experiment, touching the differing o∣peration▪ of corrosive Liquors in the emptied Receiver and in the open Air.

*384*

The *43.* Experiment, touching the spontaneous E∣bullition of warm Liquors in the exhausted Receiver.

*388*

The Conclusion.

*394*

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## TO THE LORD OF DVNGARVAN, My Honoured and Dear NEPHEW.

My Dear Lord,

**R**Eceiving in your last from *Paris,* a desire that I would adde some more Experi∣ments to those I formerly sent You over: I could not be so much your Servant as I am, without looking upon that Desire as a Com∣mand; and consequently, without think∣ing my self obliged to consider by what sort of Experiments it might the most ac∣ceptably be obey'd. And at the same [Page  2](https://quod.lib.umich.edu/e/eebo/A29003.0001.001/37?vid=56393) time, perceiving by Letters from some other Ingenious Persons at *Paris,* that se∣veral of the *Virtuosi* there, were very intent upon the examination of the Inte∣rest of the Ayr, in hindring the descent of the Quick-silver, in the famous Expe∣riment touching a *Vacuum:* I thought I could not comply with your Desires in a more fit and seasonable manner, then by prosecuting and endeavoring to promote that noble Experiment of *Torricellius*: and by presenting your Lordship an ac∣count of my attempts to illustrate a sub∣ject, about which, it's being so much dis∣cours'd of where you are, together with your inbred Curiosity, and love of Ex∣perimental Learning, made me suppose you sufficiently inquisitive.

And though I pretend not to acquaint you, on this occasion, with any store of new Discoveries, yet possibly I shall be so happy, as to assist you to *know* somethings which you did formerly but *suppose*; and shall present you, if not with new Theo∣ries, at least with new *Proofs* of such as are not yet become unquestionable. And if what I shall deliver, have the good for∣tune to encourage and assist you to prose∣cute the Hints it will afford, I shall ac∣count [Page  3](https://quod.lib.umich.edu/e/eebo/A29003.0001.001/38?vid=56393) my self, in paying of a duty to you, to have done a piece of Service to the Commonwealth of Learning. Since it may highly conduce to the advance∣ment of that Experimental Philosophy, the effectual pursuit of which, requires as well a Purse as a Brain, to endeere it to *hopeful* Persons of your Quality: who may accomplish many things which o∣thers can but *wish* or, at most, but *design,* by being able to imploy the Presents of Fortune in the search of the Mysteries of Nature.

And I am not faintly induc'd to make choice of this Subject, rather then any of the expected Chymical ones, to enter∣tain your Lordship upon, by these two Considerations: The one, That the Ayr being so necessary to humane Life, that not onely the generality of Men, but most other Creatures that breath, can∣not live many *minutes* without it; any considerable discovery of its Nature, seems likely to prove of moment to Man-kinde. And the other is, That the Ambient Ayr, being that whereto both our own Bodies, and most of the others we deal with here below, are almost per∣petually contiguous; not onely its alte∣rations [Page  4](https://quod.lib.umich.edu/e/eebo/A29003.0001.001/39?vid=56393) have a notable and manifest share in those obvious effects, that men have already been invited to ascribe thereunto such as are the various distempers inci∣dent to humane Bodies, especially if cra∣zy, in the Spring, the Autumn, and also on most of the great and sudden changes of Weather) but likewise, that the fur∣ther discovery of the nature of the Ayr, will probably discover to us, that it con∣curs more or less to the exhibiting of ma∣ny *Phaenomena,* in which it hath hither∣to scarce been suspected to have any inte∣rest. So that a True Account of any Experiment that is New concerning a thing, wherewith we have such constant and necessary intercourse, may not one∣ly prove of some advantage to humane Life, but gratifie Philosophers, by pro∣moting their Speculations on a Subject which hath so much oppurtunity to solli∣cite their Curiosity.

And I should immediately proceed to the mention of my Experiments, but that I like too well that worthy saying of the Naturalist *Pliny, Benignum est & plenum ingenui pudoris,*[\*](https://quod.lib.umich.edu/e/eebo/A29003.0001.001?id=DLPS1;lvl=1;note=inline;rgn=main;view=trgt)*fateri per quos profeceris,* not to con∣form to it, by acquainting your Lord∣ship, [Page  5](https://quod.lib.umich.edu/e/eebo/A29003.0001.001/40?vid=56393) in the first place, with the Hint I had of the Engine I am to entertain you of. You may be pleas'd to remember, that a while before our separation in *Eng∣land,* I told you of a Book that I had heard of, but not perus'd, publish'd by the industrious Jesuit *Schottus,* wherein 'twas said, He related how that ingenious Gentleman *Otto Gericke,* Consul of *Mag∣deburg,* had lately practiced in *Germany* a way of emptying Glass Vessels, by suck∣ing out the Ayr at the mouth of the Ves∣sel, plung'd under water: And you may also perhaps remember, that I express'd my self much delighted with this Expe∣riment, since thereby the great force of the external Air (either rushing in at the open'd Orifice of the empty'd Vessel, or violently forcing up the Water into it) was rendred more obvious and conspicu∣ous, than in any Experiment that I had formerly seen. And though it may appear by some of those Writings I sometimes •hew'd your Lordship, that I had been sol∣licitous to try things upon the same ground; yet in regard this Gentleman was before-hand with me in producing such considerable effects, by means of the exsuction of Air, I think my self oblig'd [Page  6](https://quod.lib.umich.edu/e/eebo/A29003.0001.001/41?vid=56393) to acknowledge the Assistance, and En∣couragement the Report of his perfor∣mances hath afforded me.

But as few inventions happen to be at first so compleat, as not to be either ble∣mishd with some deficiencies needful to be remedy'd, or otherwise capable of im∣provement: so when the Engine we have been speaking of, comes to be more attentively consider'd, there will appear two very considerable things to be de∣sir'd in it. For first, the *Wind-Pump* (as some body not improperly calls it) is so contriv'd, that to evacuate the Vessel there is requir'd the continual labor of two strong men for divers hours. And next (which is an imperfection of much greater moment) the Receiver, or Glass to be empty'd, consisting of one entire and uninterrupted Globe and Neck of Glass; the whole Engine is so made, that things cannot be convey'd into it, where∣on to try Experiments: So that there seems but little (if any thing) more to be expected from it, then those very few *Phaenomena* that have been already ob∣serv'd by the Author, and Recorded by *Schottus.* Wherefore to remedy these Inconveniences, I put both Mr. *G.*[Page  7](https://quod.lib.umich.edu/e/eebo/A29003.0001.001/42?vid=56393) and *R. Hook* (who hath also the Honor to be known to your Lordship, and was with me when I had these things under consi∣deration) to contrive some Air Pump, that might not, like the other, need to be kept under water (which on divers oc∣casions is inconvenient) & might be more easily manag'd: And after an unsuccessful tryall or two of ways propos'd by o∣thers, the last nam'd Person fitted me with a Pump, anon to be describ'd. And thus the first Imperfection of the *German* Engine, was in good measure, though not perfectly, remedy'd: And to supply the second desect, it was considered that it would not perhaps prove impossible to leave in the Glass to be empty'd, a hole large enough to put in a Mans Arm cloath'd; and consequently other Bodies, not bigger then it, or longer then the in∣side of the Vessel. And this Design seem'd the more hopefull, because I re∣membred, that having several years be∣fore often made the Experiment *De Va∣cuo* with my own hands; I had, to exa∣mine some conjectures that occurr'd to me about it, caused Glasses to be made with a hole at that end, which uses to be seal'd up, and had nevertheless been able, [Page  8](https://quod.lib.umich.edu/e/eebo/A29003.0001.001/43?vid=56393) as occasion requir'd, to make use of such Tubes, as if no such holes had been left in them; by devising stopples for them, made of the common Plaister call'd *Dia∣chylon:* which I rightly enough ghess'd, would, by reason of the exquisite com∣mixtion of its small parts, and closeness of its texture, deny all access to the ex∣ternal Air. Wherefore, supposing that by the help of such Plaisters, carefully laid upon the commissures of the stopple and hole to be made in the Receiver, the external Air might be hindred from insi∣nuating it self between them into the Ves∣sel, we caus'd several such Glasses, as you will finde describ'd a little lower, to be blown at the Glass-house; and though we could not get the Work-men to blow any of them so large, or of so conveni∣ent a shape as we would fain have had; yet finding one to be tolerably fit, and less unfit then any of the rest, we were con∣tent to make use of it in that En∣gine: Of which, I suppose, you by this time expect the Description, in order to the Recital of the *Phaenomena* exhibited by it.

To give your Lordship then, in the first place, some account of the Engine it [Page  9](https://quod.lib.umich.edu/e/eebo/A29003.0001.001/44?vid=56393) self: It consists of two principal parts, a glass Vessel, and a Pump to draw the Air out of it.

The former of these (which we, with the Glass-men, shall often call a Receiver, for its affinity to the large Vessels of that name, used by Chymists) consists of a Glass with a wide hole at the top, of a cover to that hole, and of a stop-cock fastned to the end of the neck, at the bottom.

The shape of the Glass, you will find express'd in the first Figure of the annex∣ed Scheme. And for the size of it, it contain'd about 30 Wine Quarts, each of them containing near two pound (of 16 Ounces to the pound) of water: We should have been better pleas'd with a more capacious Vessel, but the Glass-men professed themselves unable to blow a larger, of such a thickness and shape as was requisite to our purpose.

At the very top of the Vessel, (A) you may observe a round hole, whose Dia∣meter (BC) is of about four inches; and whereof, the Orifice is incircled with a lip of Glass, almost an inch high: For the making of which lip, it was requisite (to mention that upon the by, in case [Page  10](https://quod.lib.umich.edu/e/eebo/A29003.0001.001/45?vid=56393) your Lordship should have such another Engine made for you) to have a hollow and tapering Pipe of Glass drawn out, whereof the Orifice above mentioned was the Basis, and then to have the cone cut off with a hot Iron, within about an Inch of the Points (BC.)

The use of the lip, is to sustain the cover delineated in the second Figure; where (DE) points out a brass Ring, so cast, as that it doth within and without cover the lip (BC) of the first Figure, and is cemented on upon it with a strong and close Cement. To the inward taper∣ing Orifice of this Ring (which is about three Inches over) are exquisitely ground the sides of the Brass stopple (FG;) so that the concave superficies of the one, and the convex of the other, may touch one another in so many places, as may leave as little access, as possible, to the ex∣ternal Air: And in the midst of this cover is left a hole (HI) of about half an inch over, invironed also with a ring or socket of the same mettal, and fitted likewise with a brass stopple (K) made in the form of the Key of a stop-cock, and exactly ground into the hole (HI) it is to fill; so as that though it be turn'd round in the [Page  11](https://quod.lib.umich.edu/e/eebo/A29003.0001.001/46?vid=56393) cavity it possesses, it will not let in the Air, and yet may be put in or taken out at pleasure, for uses to be hereafter men∣tioned. In order to some of which, it is perforated with a little hole, (8) traversing the whole thickness of it at the lower end; through which, and a little brass Ring (L) fastned to one side, (no matter which) of the bottom of the stopple (FG) a string (8, 9, 10) might pass, to be imploy'd to move some things in the capacity of the empty'd Vessel; without any where unstopping it.

The last thing belonging to our Recei∣ver, is the stop-cock designed in the first Figure by (N.) for the better fastening of which to the neck, and exacter exclusi∣on of the Air, there was soder'd on to the shank of the Cock (X) a Plate of Tin, (MTUW) long enough to cover the neck of the Receiver. But because the cementing of this was a matter of some difficulty, it will not be amiss to mention here the manner of it, which was, That the cavity of the tin Plate was fill'd with a melted Cement, made of Pitch, Rosin, and Wood-ashes, well in∣corporated; and to hinder this liquid Mixture from getting into the Orifice (Z) [Page  12](https://quod.lib.umich.edu/e/eebo/A29003.0001.001/47?vid=56393) of the shank, (X) that hole was stopt with a Cork, to which was fastned a string, whereby it might be pull'd out of the up∣per Orifice of the Receiver; and then, the glass neck of the Receiver being well warm'd, was thrust into this Cement, and over the shank whereby it was effected, that all the space betwixt the tin Plate and the Receiver, and betwixt the internal superficies of the Receiver, and the shanck of the Cock, was filld with the Cement; and so we have dispach'd the first and upper part of the Engine.

The undermost remaining part consists of a Frame, and of a sucking Pump, or as we formerly call'd it, an Air Pump, sup∣ported by it: The Frame is of Wood, small, but very strong, consisting of three legs, (111) so plac'd, that one side of it may stand perpendicular, that the free motion of the hand may not be hindered. In the midst of which frame, is transversly nail'd a board, (222) which may not im∣properly be call'd a Midriff, upon which rests, and to which is strongly fastned, the main part of the Pump it self, which is the onely thing remaining to be descri∣bed.

The Pump consists of four parts, a [Page  13](https://quod.lib.umich.edu/e/eebo/A29003.0001.001/48?vid=56393) hollow Cylindre, a Sucker, a handle to move that Sucker, and a valve.

The Cylindre was (by a pattern) cast of brass; it is in length about 14 inches, thick enough to be very strong, notwith∣standing the Cylindrical cavity left with∣in it; this cavity is about three inches Diameter, and makes as exact a Cylin∣dre as the Artificer was able to bore. This hollow Cylindre is fitted with a suck∣er, (4455) consisting of two parts, the one (44) somewhat less in Diameter then the cavity of the Cylindre, upon which is nail'd a good thick piece of tan'd shoe Leather, which will go so close to the Cylindre, that it will need to be very forcibly knock'd and ram'd in, if at any time it be taken out, which is therefore done, that it may the more exactly hin∣der the Air from insinuating it self be∣twixt it and the sides of the Cylindre whereon it is to move.

To the midst of this former part of the Sucker is strongly fastned the other, namely a thick and narrow plate of Iron, (55) somewhat longer then the Cylindre, one of whose edges is smooth, but at the other edge it is indented (as I may so speak) with a row of teeth delineated in [Page  14](https://quod.lib.umich.edu/e/eebo/A29003.0001.001/49?vid=56393) the Scheme, into whose intervals are to be fitted, the teeth of a small Iron nut, (〈 in non-Latin alphabet 〉) (as Trades-men call it) which is fast∣ned by two staples (22) to the under side of the formerly mention'd transverse board (222) on which the Cylindre rests, and is turn'd to and fro by the third piece of this Pump, namely, the handle or *manubrium,* (7) of which the Figure gives a sufficient description.

The fourth and last part of this Cylin∣dre, is the Valve, (R) consisting of a hole bored through at the top of the Cy∣lindre, a little tapering towards the cavi∣ty; into which hole is ground a tapering Peg of brass, to be thrust in, and taken out at pleasure.

The Engine being thus describ'd, it will be requisite to adde, that something is wont to be done before it be set on work, for the more easie moving of the Sucker, and for the better exclusion of the outward Air: which when the Vessel begins to be exhausted, is much more dif∣ficult to be kept out then one would easi∣ly imagine.

There must then be first powr'd in at the top of the Receiver a little sallad oyl, partly to fill up any small intervalls that [Page  15](https://quod.lib.umich.edu/e/eebo/A29003.0001.001/50?vid=56393) may happen to be betwixt the contigu∣ous surfaces of the internal parts of the Stop-cock: And partly that it may be the more easie to turn the Key (S) back∣wards and forwards. Pretty store of oyl must also be pour'd into the Cylindre, both that the Sucker may slip up and down in it the more smoothly and freely, and that the Air might be the better hindred from getting in between them: And for the like reasons, a little oyl is to be used also about the Valve. Upon which occasion, it would not be omitted (for it is strange) that oftentimes, when neither the pouring in of water, nor even of oyl alone, prov'd capable to make the Sucker move easily enough in the Cylin∣der; a mixture of both those Liquors would readily (sometimes even to admi∣ration) perform the desired effect. And lastly, the brass cover of the Receiver, being put into the brass ring formerly de∣scrib'd, that no Air may get between them, it will be very requisite to plaister over very carefully the upper edges of both, with the plaister formerly mention∣ed, or some other as close, which is to be spread upon the edges with a hot Iron; that being melted, it may run into and [Page  16](https://quod.lib.umich.edu/e/eebo/A29003.0001.001/51?vid=56393) fill up all the crannies, or other little ca∣vities, at which the Air might otherwise get entrance.

All things being thus fitted, and the lower shank (O) of the stop-cock being put into the upper Orifice of the Cylin∣der (&), into which it was exactly ground; the Experimenter is first, by turning the handle, to force the Sucker to the top of the Cylinder, that there may be no Air left in the upper part of it▪ Then shut∣ting the Valve with the Plug, and turning the other way, he is to draw down the Sucker to the bottom of the Cylinder; by which motion of the Sucker, the Air that was formerly in the Cylinder being thrust out, and none being permitted to succeed in its room, 'tis manifest that the cavity of the Cylinder must be empty, in reference to the Air: So that if there∣upon the Key of the Stop-cock be so turn'd, as that through the perforation of it, a free passage be opened betwixt the Cylinder and the Receiver, part of the Air formerly contain'd in the Receiver, will nimbly descend into the Cylinder. And this Air, being by the turning back of the Key hinder'd from the returning into the Receiver, may, by the opening [Page  17](https://quod.lib.umich.edu/e/eebo/A29003.0001.001/52?vid=56393) of the Valve, and forcing up of the Suck∣er to the top of the Cylinder again, be driven out into the open Air. And thus by the repetition of the motion of the Sucker upward and downward, and by op∣portunely turning the Key, and stopping the Valve, as occasion requires, more or less Air may be suck'd out of the Recei∣ver, according to the exigency of the Ex∣periment, and the intention of him that makes it.

Your Lordship will, perhaps, think that I have been unnecessarily prolix in this first part of my Discourse: But if you had seen how many unexpected difficul∣ties we found to keep out the externall Air, even for a little while, when some considerable part of the internal had been suckt out; You would peradventure al∣low that I might have set down more circumstances then I have, without set∣ting down any, whose knowledge, he that shall try the Experiment may not have need of. Which is so true, that, before we proceed any further, I cannot think it un∣seasonable to advertise Your Lordship, that there are two chief sorts of Experi∣ments, which we design'd in our Engine to make tryal of: The one, such as may [Page  16](https://quod.lib.umich.edu/e/eebo/A29003.0001.001/53?vid=56393)〈1 page duplicate〉[Page  17](https://quod.lib.umich.edu/e/eebo/A29003.0001.001/54?vid=56393)〈1 page duplicate〉[Page  18](https://quod.lib.umich.edu/e/eebo/A29003.0001.001/55?vid=56393) be quickly dispatcht, and therefore may be try'd in our Engine, though it leak a little; because the Air may be faster drawn out, by nimbly plying the Pump, then it can get in at undiscern'd leaks; I say at undiscern'd leaks, because such as are big enough to be discover'd can scarce be un∣easie to be stopt. The other sort of Ex∣periments consists of those that require not onely that the internal Air be drawn out of the Receiver, but that it be like∣wise for a long time kept out of it▪ Such are the preservation of Animal and o∣ther Bodies therein, the germination and growth of Vegetables, and other tryals of several sorts, which it is apparent can∣not be well made unless the external Air can, for a competent while, be excluded: Since even at a very small leak there may enough get in, to make the *Vacuum* soon loose that name; by which I here declare once for all, that I understand not a space wherein there is no body at all, but such as is either altogether, or almost totally void of Air.

Now this distinction of Experiments I thought fit to premise to the ensuing Narratives, because upon tryal, we found it so exceeding (and scarce imaginable) dif∣ficult [Page  19](https://quod.lib.umich.edu/e/eebo/A29003.0001.001/56?vid=56393) a matter, to keep out the Air from getting at all in at any imperceptible hole or flaw whatsoever, in a Vessel immedi∣ately surrounded with the compressed At∣mosphere, that in spight of all our care and diligence, we never were able totally to exhaust the Receiver, or keep it when it was almost empty, any considerable time, from leaking more or less: although (as we have lately intimated) by unwearyed quickness in plying the Pump, the inter∣nall Air can be much faster drawn out then the external can get in, till the Re∣ceiver come to be almost quite empty. And that's enough to enable men to dis∣cover hitherto unobserved *Phaenomena* of Nature.

The Experiments therefore of the first sort, will, I fear, prove the onely ones wherewith my Avocations will allow me to entertain Your Lordship in this Letter. For till your further Commands shall en∣gage me to undertake, by Gods permis∣sion, such an Employment, and more lea∣sure shall better fit me for it, I know not whether I shall be in a condition to try what may be done, to enable me to give you some account of the other sort of Experiments also.

[Page  20](https://quod.lib.umich.edu/e/eebo/A29003.0001.001/57?vid=56393)[\*](https://quod.lib.umich.edu/e/eebo/A29003.0001.001?id=DLPS2;lvl=1;note=inline;rgn=main;view=trgt)TO proceed now to the *Phaenomena,* exhibited to us by the Engine above described; I hold it not unfit to begin with what does constantly and regularly offer it self to our observation, as depend∣ing upon the Fabrick of the Engine it self, and not upon the nature of this or that particular Experiment which 'tis employ∣ed to try.

First, Then upon the drawing down of the Sucker, (the Valve being shut) the Cylindrical space, deserted by the Sucker, is left devoid of Air; and therefore, up∣on the turning of the Key, the Air con∣tained in the Receiver rushes into the em∣ptyed Cylinder, till the Air in both those Vessels be brought to about an equal measure of dilatation. And therefore, upon shutting the Receiver by returning the Key, if you open the Valve, and force up the Sucker again, you will finde, that after this first exsuction you will drive out almost a whole Cylinder full of Air: But at the following exsuctions, you will draw less and less of Air out of the Recei∣ver into the Cylinder, because that there will still remain less and less Air in the [Page  21](https://quod.lib.umich.edu/e/eebo/A29003.0001.001/58?vid=56393) Receiver it self; and consequently, the Particles of the remaining Air, having more room to extend themselves in, will less press out one another. This you will easily perceive, by finding, that you still force less and less Air out of the Cylin∣der; so that when the Receiver is almost exhausted, you may force up the Sucker almost to the top of the Cylinder, be∣fore you will need to unstop the Valve to let out any Air: And if at such time, the Valve being shut, you let go the handle of the Pump, you will finde the Sucker for∣cibly carryed up to the top of the Cylin∣der, by the protrusion of the external Air; which, being much less rarified then that within the Cylinder, must have a more forcible pressure upon the Sucker, then the internal is able to resist: And by this means you may know how far you have emptyed the Receiver. And to this we may adde, on this occasion, that constant∣ly upon the turning of the Key to let out the Air from the Receiver, into the em∣ptied Cylinder, there is immediately pro∣duced a considerably brisk noise, especi∣ally whil'st there is any plenty of Air in the Receiver.

[Page  22](https://quod.lib.umich.edu/e/eebo/A29003.0001.001/59?vid=56393)For the more easie understanding of the Experiments tryable by our Engine, I thought it not superfluous, nor unseason∣able in the recital of this first of them, to insinuate that notion by which it seems likely that most, if not all, of them will prove explicable. Your Lordship will easily suppose, that the Notion I speak of is, That there is a Spring, or Elasti∣cal power in the Air we live in. By which 〈 in non-Latin alphabet 〉 or Spring of the Air; that which I mean is this: That our Air either con∣sists of, or at least abounds with, parts of such a nature, that in case they be bent or compress'd by the weight of the incum∣bent part of the Atmosphere, or by any o∣ther Body, they do endeavor, as much as in them lies, to free themselves from that pressure, by bearing against the contigu∣ous Bodies that keep them bent; and, assoon as those Bodies are remov'd or reduced to give them way, by presently unbending and stretching out themselves, either quite, or so far forth as the con∣tiguous Bodies that resist them will per∣mit, and thereby expanding the whole parcel of Air, these elastical Bodies com∣pose.

[Page  23](https://quod.lib.umich.edu/e/eebo/A29003.0001.001/60?vid=56393)This Notion may perhaps be some∣what further explain'd, by conceiving the Air near the Earth to be such a heap of little Bodies, lying one upon another, as may be resembled to a Fleece of Wooll. For this (to omit other likenesses betwixt them) consists of many slender and flexi∣ble Hairs; each of which, may indeed, like a little Spring, be easily bent or roul∣ed up; but will also, like a Spring, be still endeavouring to stretch it self out again. For though both these Haires, and the Aerial Corpuscles to which we liken them, do easily yield to externall pressures; yet each of them (by vertue of its structure) is endow'd with a Power or Principle of self-Dilatation; by vertue whereof, though the hairs may by a Mans hand be bent and crouded closer together, and into a narrower room then suits best with the nature of the Body: Yet whil'st the compression lasts, there is in the fleece they compose an endeavour outwards, whereby it continually thrusts against the hand that opposes its Expansion. And upon the removall of the external pres∣sure, by opening the hand more or less, the compressed Wooll does, as it were, spon∣taneously expand or display it self towards [Page  24](https://quod.lib.umich.edu/e/eebo/A29003.0001.001/61?vid=56393) the recovery of its former more loose and free condition, till the Fleece have ei∣ther regain'd its former Dimensions, or at least, approach'd them as near as the compressing hand (perchance not quite open'd) will permit. This Power of self-Dilatation, is somewhat more conspi∣cuous in a dry Spunge compress'd, then in a Fleece of Wooll. But yet we ra∣ther chose to imploy the latter, on this occasion, because it is not like a Spunge, an entire Body, but a number of slen∣der and flexible Bodies, loosely com∣plicated, as the Air it self seems to be.

There is yet another way to explicate the Spring of the Air, namely, by suppo∣sing with that most ingenious Gentleman, Monsieur *Des Cartes,* That the Air is no∣thing but a Congeries or heap of small and (for the most part) of flexible Parti∣cles; of several sizes, and of all kinde of Fi∣gures which are rais'd by heat (especially that of the Sun) into that fluid and subtle Etheriall Body that surrounds the Earth; and by the restlesse agi∣tation of that Celestial Matter where∣in those Particles swim, are so whirl'd [Page  25](https://quod.lib.umich.edu/e/eebo/A29003.0001.001/62?vid=56393) round, that each Corpuscle endeavours to beat off all others from coming within the little Sphear requisite to its motion about its own Center; and (in case any, by intruding into that Sphear shall op∣pose its free Rotation) to expell or drive it away: So that according to this Do∣ctrine, it imports very little, whether the particles of the Air have the structure re∣quisite to Springs, or be of any other form (how irregular soever) since their Elastical power is not made to depend upon their shape or structure, but upon the vehement agitation, and (as it were) brandishing motion, which they receive from the fluid *Ether* that swiftly flows between them, and whirling about each of them (independently from the rest) not onely keeps those slender Aërial Bodies separated and stretcht out (at least, as far as the Neighbouring ones will per∣mit) which otherwise, by reason of their flexibleness and weight, would flag or curl; but also makes them hit against, and knock away each other, and consequently require more room, then that which if they were compress'd, they would take up.

[Page  26](https://quod.lib.umich.edu/e/eebo/A29003.0001.001/63?vid=56393)By these two differing ways, my Lord, may the Spring of the Air be explicated. But though the former of them be that, which by reason of its seeming somewhat more easie, I shall for the most part make use of in the following Discourse: yet am I not willing to declare peremptorily for either of them, against the other. And indeed, though I have in another Treatise endeavoured to make it probable, that the returning of Elastical Bodies (if I may so call them) forcibly bent, to their former position, may be Mechanically explica∣ted: Yet I must confess, that to deter∣mine whether the motion of Restitution in Bodies, proceed from this, That the parts of a Body of a peculiar Structure are put into motion by the bending of the spring, or from the endeavor of some sub∣tle ambient Body, whose passage may be oppos'd or obstructed, or else it's pressure unequally resisted by reason of the new shape or magnitude, which the bending of a Spring may give the Pores of it: To determine this, I say, seems to me a mat∣ter of more difficulty, then at first sight one would easily imagine it. Wherefore I shall decline medling with a subject, which is much more hard to be explica∣ted, [Page  27](https://quod.lib.umich.edu/e/eebo/A29003.0001.001/64?vid=56393) then necessary to be so, by him, whose business it is not, in this Letter, to assign the adequate cause of the Spring of the Air, but onely to manifest, That the Air has a Spring, and to relate some of its effects.

I know not whether I need annex that, though either of the above-mention'd Hypotheses, and perhaps some others, may afford us an account plausible enough of the Air-spring; yet I doubt, whether any of them gives us a sufficient account of its Nature. And of this doubt, I might here mention some Reasons, but that, peradventure, I may (God permit∣ting) have a fitter occasion to say some∣thing of it elsewhere. And therefore I should now proceed to the next Experi∣ment, but that I think it requisite, first, to suggest to your Lordship what comes into my thoughts, by way of Answer to a plausible Objection, which I foresee you may make against our propos'd Doctrine, touching the Spring of the Air. For it may be alleadged, that though the Air were granted to consist of Springy Par∣ticles (if I may so speak) yet thereby we could onely give an account of the Dilatation of the Air in Wine-Guns and [Page  28](https://quod.lib.umich.edu/e/eebo/A29003.0001.001/65?vid=56393) other pneumatical Engines wherein the Air has been compress'd, and its Springs violently bent by an apparent externall force; upon the removall of which, 'tis no wonder that the Air should, by the motion of restitution, expand it self till it have recovered its more natural dimen∣sions: whereas in our above mentioned first Experiment, and in almost all others tryable in our Engine, it appears not that any compression of the Air prece∣ded its spontaneous Dilatation or Expan∣sion of it self. To remove this difficul∣ty, I must desire Your Lordship to take notice, that of whatever nature the Air, very remote from the Earth, may be, and whatever the Schools may confidently teach to the contrary, yet we have divers Experiments to evince, that the Atmos∣phere we live in is not (otherwise then comparatively to more ponderous Bodies) light, but heavy: And did not their gravity hinder them, it appears not why the steams of the Terraqueous Globe, of which our Air in great part consists, should not rise much higher then the Re∣fraction of the Sun, and other Stars give men ground to think, that the At∣mosphere, even in the judgement of those [Page  29](https://quod.lib.umich.edu/e/eebo/A29003.0001.001/66?vid=56393) Recent Astronomers, who seem willing to enlarge its bounds as much as they dare, does reach.

But lest you should expect my seconding this Reason by Experience; and lest you should object, That most of the Experi∣mēts that have been propos'd to prove the gravity of the Air, have been either barely propos'd, or perhaps not accuratly try'd; I am content, before I pass further, to menti∣on here, That I found a dry lambs-bladder containing near about two thirds of a pint, and compress'd by a packthred tyed about it, to loose a grain and the eighth part of a grain of its former weight, by the recess of the Air upon my having prickt it: And this with a pair of Scales, which when the full Bladder and the correspondent weight were in it, would manifestly turn either way with the 32 part of a grain. And if it be further objected, That the Air in the Bladder was violently compress'd by the Pack-thred and the sides of the Bladder, we might probably (to wave prolix answers) be furnish'd with a Re∣ply, by setting down the differing weight of our Receiver, when empty'd and when full of uncompress'd Air, if we could here procure scales fit for so nice an experiment; [Page  30](https://quod.lib.umich.edu/e/eebo/A29003.0001.001/67?vid=56393) since we are informed, that in the *German* Experiment, commended at the begin∣ning of this Letter, the Ingenious Tryers of it found, That their Glass Vessel, of the capacity of 32 measures, was lighter when the Air had been drawn out of it, then before, by no less then one ounce and 1/10 that is, an ounce and very near a third: But of the gravity of the Air, we may elsewhere have occasion to make fur∣ther mention.

Taking it then for granted that the Air is not devoid of weight, it will not be uneasie to conceive, that that part of the Atmosphere wherein we live, being the lower part of it, the Corpuscles that com∣pose it, are very much compress'd by the weight of all those of the like nature that are directly over them, that is, of all the Particles of Air, that being pil'd up up∣on them, reach to the top of the Atmos∣phere. And though the height of this Atmosphere, according to the famous *Kepler,* and some others, scarce exceeds eight common miles; yet other eminent and later Astronomers, would promote the confines of the Atmosphere, to ex∣ceed six or seven times that number of miles. And the diligent and learned [Page  31](https://quod.lib.umich.edu/e/eebo/A29003.0001.001/68?vid=56393)*Riviolo* makes it probable, that the At∣mosphere may, at least in divers places, be at least 50 miles high. So that according to a moderate estimate of the thickness of the Atmosphere, we may well suppose, that a Column of Air, of many miles in height, leaning upon some springy Cor∣puscles of Air here below, may have weight enough to bend their little springs, and keep them bent: As, to resume our former comparison, if there were fleeces of Wooll pil'd up to a mountainous height upon one another, the Hairs that com∣pose the lowermost locks which support the rest, would, by the weight of all the Wool above them, be as well strongly compressed, as if a man should squeeze them together in his hands, or imploy any such other moderate force to compress them. So that we need not wonder, that upon the taking off the incumbent Air from any parcel of the Atmosphere here below, the Corpuscles, whereof that un∣dermost Air consists, should display them∣selves, and take up more room then be∣fore.

And if it be objected, That in Water, the weight of the upper and of the lower part is the same: I answer, That besides [Page  32](https://quod.lib.umich.edu/e/eebo/A29003.0001.001/69?vid=56393) that it may be well doubted whether the observation, by reason of the great diffi∣culty have been exactly made, there is a manifest disparity betwixt the Air and Water: For I have not found, that upon an Experiment purposely made, (and in another Treatise Recorded) that Water will suffer any considerable compression; whereas we may observe in Wind-Guns (to mention now no other Engines) that the Air will suffer it self to be crouded in∣to a comparatively very little room; in so much, that a very diligent Examiner of the *Phaenomena* of Wind-Guns would have us believe, that in one of them, by condensation, he reduc'd the Air into a space at least eight times narrower then it before possest. And to this, if we adde a noble *Phaenomenon* of the Experiment *De Vacuo*; these things put together, may for the present suffice to countenance our Doctrine. For that noble Experimenter, Monsieur *Pascal*(the Son) had the com∣mendable Curiosity to cause the *Torri∣cellian* Experiment to be try'd at the foot, about the middle, and at the top of that high Mountain (in *Auvergne,* if I mistake not) commonly call'd *Le Puy de Domme*; whereby it was found, That the *Mercury*[Page  33](https://quod.lib.umich.edu/e/eebo/A29003.0001.001/70?vid=56393) in the Tube fell down lower, about three inches, at the top of the Mountain then at the bottom. And a Learned Man a while since inform'd me, That a great *Virtuoso,* friend to us both, has, with not unlike success, tryed the same Experi∣ment in the lower and upper parts of a Mountain in the West of *England*: Of which, the reason seems manifestly enough to be this, That upon the tops of high Mountains, the Air which bears against the restagnant Quick-silver, is less press'd by the less ponderous incumbent Air; and consequently is not able totally to hinder the descent of so tall and heavy a Cylin∣der of Quick-silver, as at the bottom of such Mountains did but maintain an *Aequi∣librium* with the incumbent Atmosphere.

And if it be yet further Objected a∣gainst what hath been propos'd touching the compactness and pressure of the Infe∣rior Air; That we finde this very Air to yield readily to the motion of little Flies, and even to that of Feathers, and such o∣ther light and weak Bodies; which seems to argue, that the particles of our Air are not so compress'd as we have represented them, especially, since by our former Experiment it appears, that the Air rea∣dily [Page  34](https://quod.lib.umich.edu/e/eebo/A29003.0001.001/71?vid=56393) dilated it self downward, from the Receiver into the Pump, when 'tis plain, that it is not the incumbent Atmosphere, but onely the subjacent Air in the brass Cylinder that has been remov'd: If this, I say, be objected, we may reply, That when a man squeezes a Fleece of Wool in his hand, he may feel that the Wool in∣cessantly bears against his hand, as that which hinders the hairs it consists of, to recover their former and more natural ex∣tent. So each parcel of the Air about the Earth, does constantly endeavour to thrust away all those contiguous Bodies, whe∣ther Aërial or more gross, that keep them bent, and hinder the expansion of its parts, which will dilate themselves or flie abroad towards that part, whether up∣wards or downwards, where they finde their attempted Dilatation of themselves less resisted by the neihgboring Bodies. Thus the Corpuscles of that Air we have been all this while speaking of, being un∣able, by reason of their weight, to ascend above the Convexity of the Atmosphere, and by reason of the resistance of the sur∣face of the Earth and Water, to fall down lower, they are forced, by their own gra∣vity and this resistance, to expand and [Page  35](https://quod.lib.umich.edu/e/eebo/A29003.0001.001/72?vid=56393) diffuse themselves about the Terrestial Globe; whereby it comes to pass, that they must as well press the contiguous Corpuscles of Air that on either side op∣pose their Dilatation, as they must press upon the surface of the Earth, and, as it were recoyling thence, endeavor to thrust away those upper particles of Air that lean upon them.

And as for the easie yielding of the Air to the Bodies that move in it, if we con∣sider that the Corpuscles whereof it con∣sists, though of a springy nature, are yet so very small, as to make up (which 'tis manifest they doe) a fluid Body, it will not be difficult to conceive, that in the Air, as in other Bodies that are fluid, the little Bodies it consists of are in an almost restless motion, whereby they become (as we have more fully discoursed in ano∣ther Treatise) very much disposed to yield to other Bodies,[\*](https://quod.lib.umich.edu/e/eebo/A29003.0001.001?id=DLPS3;lvl=1;note=inline;rgn=main;view=trgt) or easie to be dis∣plac'd by them, and that the same Cor∣puscles are likewise so variously mov'd, as they are intire Corpuscles, that if some strive to push a Body plac'd among them towards the right hand (for instance) others, whose motion has an opposite de∣termination, as strongly thrust the same [Page  36](https://quod.lib.umich.edu/e/eebo/A29003.0001.001/73?vid=56393) Body towards the left; whereby neither of them proves able to move it out of its place, the pressure on all hands being reduced as it were to an *Aequilibrium*: so that the Corpuscles of the Air must be as well sometimes considered under the no∣tion of little Springs, which remaining bent, are in their entire bulk transported from place to place; as under the notion of Springs displaying themselves, whose parts flie abroad whilst as to their entire bulk they scarce change place: As the two ends of a Bow, shot off, fly from one another, whereas the Bow it self may be held fast in the Archers hand; and that it is the equal pressure of the Air on all sides upon the Bodies that are in it, which cau∣ses the easie Cession of its parts, may be argu'd from hence: That if by the help of our Engine the Air be but in great part, though not totally drawn away from one side of a Body without being drawn away from the other; he that shall think to move that Body too and fro, as easily as before, will finde himself much mistaken.

In verification of which we will, to di∣vert your Lordship a little, mention here a *Phaenomenon* of our Engine, which even [Page  37](https://quod.lib.umich.edu/e/eebo/A29003.0001.001/74?vid=56393) to divers ingenious persons has at first sight seem'd very wonderful.

THe thing that is wont to be admired,[\*](https://quod.lib.umich.edu/e/eebo/A29003.0001.001?id=DLPS4;lvl=1;note=inline;rgn=main;view=trgt) and which may pass for our second Experiment is this, That if, when the Receiver is almost empty, a By-stander be desired to lift up the brass Key (former∣ly described as a stopple in the brass Co∣ver) he will finde it a very difficult thing to do so, if the Vessel be well exhausted; and even when but a moderate quantity of Air has been drawn out, he will, when he has lifted it up a little, so that it is some∣what loose from the sides of the lip or socket, which (with the help of a little oyl) it exactly filled before, he will (I say) finde it so difficult to be lifted up, that he will imagine there is some great weight fastned to the bottom of it. And if (as sometimes has been done for merriment) onely a Bladder be tyed to it, it is plea∣sant to see how men will marvail that so light a Body, filled at most but with Air, should so forcibly draw down their hand as if it were fill'd with some very ponder∣ous thing: whereas the cause of this pret∣ty *Phaenomenon* seems plainly enough to [Page  38](https://quod.lib.umich.edu/e/eebo/A29003.0001.001/75?vid=56393) be onely this, That the Air in the Recei∣ver, being very much dilated, its Spring must be very much weakn'd, and conse∣quently it can but faintly press up the lower end of the stopple, whereas the Spring of the external Air being no way debilitated, he that a little lifts up the stopple must with his hand support a pres∣sure equal to the disproportion betwixt the force of the internal expanded Air, and that of the Atmosphere incumbent upon the upper part of the same key or stopple: And so men being unus'd to finde any re∣sistance, in lifting things up, from the free Air above them, they are forward to conclude that that which depresses their hands must needs be some weight, though they know not where plac'd, drawing be∣neath it.

And that we have not mis-assign'd the cause of this *Phaenomenon* seems evident enough by this; That as Air is suffer∣ed by little and little to get into the Re∣ceiver, the weight that a man fancies his hand supports is manifestly felt to decrease more and more, the internal Air by this recruit approaching more to an *Aequili∣brium* with the external, till at length the Receiver growing again full of Air, the [Page  39](https://quod.lib.umich.edu/e/eebo/A29003.0001.001/76?vid=56393) stopple may be lifted up without any dif∣ficulty at all.

By several other of the Experiments afforded us by our Engine, the same no∣tion of the great and equal pressure of the free Air upon the Bodies it environs, might be here manifested, but that we think it not so fit to anticipate such Ex∣periments: And therefore shall rather employ a few lines to clear up a difficulty touching this matter, which we have ob∣serv'd to have troubled some even of the Philosophical and Mathematical Specta∣tors of our Engine, who have wonder'd that we should talk of the Air exquisitely shut up in our Receiver, as if it were all one with the pressure of the Atmosphere; whereas the thick and close body of the Glass, wholly impervious to the Air, does manifestly keep the incumbent Pillar of the Atmosphere from pressing in the least upon the Air within the Glass, which it can no where come to touch. To eluci∣date a little this matter, let us consider, That if a man should take a fleece of Wool, and having first by compressing it in his hand reduc'd it into a narrower com∣pass, should nimbly convey and shut it close up into a Box just fit for it, though [Page  40](https://quod.lib.umich.edu/e/eebo/A29003.0001.001/77?vid=56393) the force of his hand would then no lon∣ger bend those numerous springy Body's that compose the Fleece, yet they would continue as strongly bent as before, be∣cause the Box they are inclos'd in would as much resist their re-expanding of themselves, as did the hand that put them in. For thus we may conceive, that the Air being shut up, when its parts are bent by the whole weight of the incumbent Atmosphere, though that weight can no longer lean upon it, by reason it is kept off by the Glass, yet the Corpuscles of the Air within that Glass continue as forcibly bent as they were before their in∣clusion, because the sides of the Glass hinder them from displaying or stretch∣ing out themselves. And if it be ob∣jected that this is unlikely, because ev'n Glass bubles, such as are wont to be blown at the flame of a Lamp, exceeding thin and Hermetically seal'd will not break; whereas it cannot be imagin'd that so thin a Prison of Glass could re∣sist the Elastical force of all the included Air, if that Air were so compress'd as we suppose. It may be easily reply'd, That the pressure of the inward Air against the Glass, is countervail'd by the equal pres∣sure [Page  41](https://quod.lib.umich.edu/e/eebo/A29003.0001.001/78?vid=56393) of the outward against the same Glass. And we see in bubles, that by reason of this an exceeding thin film of Water is often able, for a good while, to hinder the eruption of a pretty quantity of Air. And this may be also more conspicuous in those great Spherical bubles that boyes sometimes blow with Water, to which Sope has given a Tenacity. But that, if the pressure of the ambient Air were remov'd, the internal Air may be able to break thicker Glasses then those lately men∣tion'd, will appear by some of the follow∣ing Experiments; to which we shall there∣fore now hasten, having, I fear, been but too prolix in this Excursion, though we thought it not amiss to annex to our first Experiments some general Considerati∣ons touching the Spring of the Air, be∣cause (this Doctrine being yet a stranger to the Schools) not onely we finde not the thing it self to be much taken notice of; but of those few that have heard of it, the greater part have been forward to re∣ject it, upon a mistaken Perswasion, that those *Phaenomena* are the effects of natures abhorrency of a *Vacuum,* which seem to be more fitly ascribeable to the weight and Spring of the Air.

[Page  42](https://quod.lib.umich.edu/e/eebo/A29003.0001.001/79?vid=56393)[\*](https://quod.lib.umich.edu/e/eebo/A29003.0001.001?id=DLPS5;lvl=1;note=inline;rgn=main;view=trgt)WE will now proceed to observe that though, by the help of the handle, the Sucker be easily drawn down to the bottom of the Cylinder; yet, without the help of that Leaver, there would be required to the same effect, a force or weight great enough to surmount the pressure of the whole Atmosphere: Since otherwise the Air would not be driven out of its place, when none is permitted to succeed into the place deserted by the Sucker. This seems evident, from the known *Torricellian* Experiment, in which, if the inverted Tube of *Mercury* be but 25 Digits high, or somewhat more, the Quick-silver will not fall but remain sus∣pended in the Tube; because it cannot press the subjacent *Mercury* with so great a force, as does the incumbent Cylinder of the Air reaching thence to the top of the Atmosphere: Whereas, if the Cy∣linder of *Mercury* were three or four digits longer, it would over-power that of the external Air, and run out into the Vessel'd *Mercury,* till the two Cylinders came to an *Aequilibrium,* and no further. Hence we need not wonder, that though the [Page  43](https://quod.lib.umich.edu/e/eebo/A29003.0001.001/80?vid=56393) Sucker move easily enough up and down in the Cylinder by the help of the *Manu∣brium*; yet if the *Manubrium* be taken off, it will require a considerable strength to move it either way. Nor will it seem strange, that if, when the Valve and Stop-cock are well shut, you draw down the Sucker, and then let go the *Manubri∣um*; the Sucker will, as it were of it self, re-ascend to the top of the Cylinder, since the spring of the external Air findes no∣thing to resist its pressing up the Sucker. And for the same reason, when the Re∣ceiver is almost evacuated, though, ha∣ving drawn down the Sucker, you open the way from the Receiver to the Cylin∣der, and then intercept that way again by returning the Key; the Sucker will, up∣on the letting go the *Manubrium,* be forcibly carried up almost to the top of the Cylinder: Because the Air within the Cylinder, being equally dilated and weak∣ned with that of the Glass, is unable to withstand the pressure of the external Air, till it be driven into so little space, that there is an *Aequilibrium* betwixt its force and that of the Air without. And con∣gruously hereunto we finde, that in this case, the Sucker is drawn down with little [Page  44](https://quod.lib.umich.edu/e/eebo/A29003.0001.001/81?vid=56393) less difficulty, then if the Cylinder, be∣ing devoid of Air, the Stop-cock were exactly shut: We might take notice of some other things, that depend upon the Fabrick of our Engine it self; but to shun prolixity, we will, in this place, content our selves to mention one of them, which seems to be of greater moment then the rest, and it is this; that when the Sucker has been impell'd to the top of the Cylin∣der, and the Valve is so carefully stopp'd, that there is no Air left in the Cylinder a∣bove the Sucker: If then the Sucker be drawn to the lower part of the Cylinder, he that manages the Pump findes not any sensibly greater difficulty to depress the Sucker, when it is nearer the bottom of the Cylinder, then when it is much further off. Which circumstance we therefore think fit to take notice of, because an eminent Mo∣dern Naturalist hath taught, that, when the Air is sucked out of a Body, the violence wherewith it is wont to rush into it again, as soon as it is allow'd to re-enter, pro∣ceeds mainly from this; That the pressure of the ambient Air is strengthned upon the accession of the Air suck'd out; which, to make it self room, forces the neighbor∣ing Air to a violent-subingression of its parts: which, if it were true, he that draws [Page  45](https://quod.lib.umich.edu/e/eebo/A29003.0001.001/82?vid=56393) down the Sucker, would finde the resist∣ance of the external Air increas'd as he draws it lower, more of the displaced Air being thrust into it to compress it. But, by what has been discours'd upon the first Experiment, it seems more probable, that without any such strengthning of the pres∣sure of the outward Air, the taking quite away or the debilitating of the resistance from within, may suffice to produce the effects under consideration. But this will perhaps be illustrated by some or other of our future Experiments, and therefore shall be no longer insisted on here.

HAving thus taken notice of some of the constant *Phaenomena* of our En∣gine it self,[\*](https://quod.lib.umich.edu/e/eebo/A29003.0001.001?id=DLPS6;lvl=1;note=inline;rgn=main;view=trgt) let us now proceed to the Ex∣periments tryable in it.

We took then a Lambs Bladder large, well dry'd, and very limber, and leaving in it about half as much Air as it could con∣tain, we caus'd the neck of it to be strong∣ly ty'd, so that none of the included Air, though by pressure, could get out. This Bladder being convey'd into the Receiver, and the Cover luted on, the Pump was set awork, and after two or three exsuctions of the ambient Air (where∣by the Spring of that which remain'd in [Page  46](https://quod.lib.umich.edu/e/eebo/A29003.0001.001/83?vid=56393) the Glass was weaken'd) the Imprison'd Air began to swell in the Bladder, and as more and more of the Air in the Recei∣ver was, from time to time, drawn out; so did that in the Bladder more and more ex∣pand it self, and display the folds of the formerly flaccid Bladder: so that before we had exhausted the Receiver near so much as we could, the Bladder appear'd as full and stretched, as if it had been blown up with a Quill.

And that it may appear that this plump∣ness of the Bladder proceeded from the surmounting of the debilitated Spring of the ambient Air remaining in the Vessel, by the stronger Spring of the Air remain∣ing in the Bladder; we Return'd the Key of the Stop-cock, and by degrees allow'd the external Air to return into the Recei∣ver: Whereupon it happen'd, as was ex∣pected, that as the Air came in from with∣out, the disturb'd Air in the Bladder, was proportionably compress'd into a narrow∣er room, and the sides of the Bladder grew flaccid, till the Receiver having re-admitted its wonted quantity of Air, the Bladder appear'd as full of wrinkles and cavities as before.

[Page  47](https://quod.lib.umich.edu/e/eebo/A29003.0001.001/84?vid=56393)This Experiment is much of the same nature with that which was some years agoe said to be made by that eminent Ge∣ometrician Monsieur *Roberval,* with a Carps Bladder empty'd and convey'd into a Tube, wherein the Experiment *De Va∣cuo* was afterwards try'd, which ingeni∣ous Experiment of his justly deserves the thanks of those that have been, or shall be solicitous to discover the nature of the Air.

But to return to our Experiment, we may take notice of this Circumstance in it, That after the Receiver has been in some measure empty'd, the Bladder do's, at each exsuction, swell much more con∣spicuously then it did at any of the first Exsuctions; insomuch that towards the end of the pumping, not onely a great fold or cavity in the surface of the Blad∣der may be made, even by the stretching of the inward self-expanding Air: But we have sometimes seen, upon the turn∣ing of the Key to let the ambient Air pass out of the Receiver into the Cylin∣der, we have seen (I say) the Air in the Bladder suddenly expand it self so much and so briskly, that it manifestly lifted up some light Bodies that lean'd upon it, [Page  48](https://quod.lib.umich.edu/e/eebo/A29003.0001.001/85?vid=56393) and seem'd to lift up the Bladder it self.

Now because it has by very Learned Men been doubted whether the swelling of the Bladder may not have proceeded from the Dilatation of the included Air, but from the Texture of the Fibres, which, being wont to keep the Bladder extended when the Animal to whom it belong'd was alive, may be suppos'd in our Experiment to have return'd, like so many Springs to their wonted extent, up∣on the removal of the Ambient Air that compress'd and bent them: because this, I say, has been doubted, we thought fit to make this further tryall.

We let down into the Receiver with the fore-mentioned Bladder two other much smaller, and of the same kinde of Animal; the one of these was not ty'd up at the neck that there might be liberty left to the Air that was not squeez'd out (which might amount to about a fifth part of what the Bladder held before) to pass out into the Receiver: The other had the sides of it stretch'd out and press'd to∣gether, almost into the form of a Cup, that they might intercept the less Air be∣twixt them, and then was strongly ty'd [Page  49](https://quod.lib.umich.edu/e/eebo/A29003.0001.001/86?vid=56393) up at the neck: This done, and the Air being in some measure suck'd of the Pneumatical Glass (if I may so call it) the Bladder, mention'd at the beginning of our Experiment, appear'd extended e∣very way to its full Dimensions; whereas neither of the two others did remarkably swell, and that whose neck was not ty'd seem'd very little, if at all less wrinkl'd then when it was put in.

We made likewise a strong Ligature a∣bout the middle of a long Bladder part∣ly empty'd, and upon the drawing the Air out of the Receiver, could observe no such swelling betwixt the Ligature and the Ne•k of the Bladder, which had been purposely left open, as betwixt the same Ligature and the bottom of the Bladder, whence the included Air could no way get out.

But a further and sufficient manifestati∣on whence the intumes•ence of the Blad∣der proceeds, may be deduc'd from the following Experiment.

TO try then at once both what it was that expanded the Bladder,[\*](https://quod.lib.umich.edu/e/eebo/A29003.0001.001?id=DLPS7;lvl=1;note=inline;rgn=main;view=trgt) and what a powerful Spring there is ev'n in the Air [Page  50](https://quod.lib.umich.edu/e/eebo/A29003.0001.001/87?vid=56393) we are wont to think uncompress'd, we caus'd a Bladder dry, well ty'd and blown moderately full, to be hung in the Recei∣ver by one end of a string, whose other end was fastned to the inside of the Co∣ver: and upon drawing out the ambient Air, that press'd on the Bladder; the in∣ternal Air not finding the wonted resist∣ance, first swell'd and distended the Blad∣der, and then broke it, with so wide and crooked a rent, as if it had been forcibly torn assunder with hands. After which a second Bladder being convey'd in, the Ex∣periment was repeated with like success: And I suppose it will not be imagin'd that in this case the Bladder was broken by its own Fibres, rather then by the Impri∣son'd Air.

And of this Experiment these two *Phae∣nomena* may be taken notice of: The one, that the Bladder at its breaking gave a great report, almost like a Craker: And the other, That the Air contain'd in the Bladder, had the power to break it with the mention'd Impetuosity, long before the ambient Air was, all or near all, drawn out of the Receiver.

But, to verifie what we say in another Discourse, where we show, That even [Page  51](https://quod.lib.umich.edu/e/eebo/A29003.0001.001/88?vid=56393) true Experiments may, by reason of the easie mistake of some unheeded Circumstance, be unsuccessfully try'd; we will Advertise, on this occasion, that we did oftentimes in vain try the breaking of Bladders, after the manner above-mention'd: Of which the cause appear'd to be this, That the Bladders we could not break, having been brought us ready blown from those that sold them, were grown dry before they came to our hands: whence it came to pass, that, if we afterwards ty'd them very hard, they were apt to fret and so become unservice∣able; and if we ty'd them but moderate∣ly hard, their stiffness kept them from be∣ing clos'd so exactly, but that when the included Air had in the exhausted Recei∣ver distended them as much as easily it could, it would in part get out between the little wrinkles of the Sphincter of t•e Neck: Whence also it usually happen'd, that, upon the letting in the Air from without, the Bladders appear'd more flac∣cid and empty then before they were put in; whereas when the Bladders were brought us moist from the Butchers, we could, without injuring them, tye their necks so close, that none of the Air once [Page  52](https://quod.lib.umich.edu/e/eebo/A29003.0001.001/89?vid=56393) blown in, could get out of them, but by violently breaking them.

It will not be amiss on this occasion to point at something which may deserve a more deliberate Speculation then we can now afford it; namely that the Elastical Power of the s•me Quantity of Air may be as well Encreas'd by the Agitation of the Aërial Particles (whether onely mo∣ving them more swiftly and scattering them, or also extending or stretching them out, I determine not) within an every way inclosing and yet yielding Bo∣dy; as Display'd by the withdrawing of the Air that press'd it without. For we found that a Bladder, but moderately fill'd with Air and strongly ty'd, being a while held near the Fire, not onely grew exceeding turgid and hard, but after∣wards, being approach'd nearer to the Fire, suddenly broke with so loud and ve∣hement a noise, as stony'd those that were by, and made us, for a while after, almost deaf.

[\*](https://quod.lib.umich.edu/e/eebo/A29003.0001.001?id=DLPS8;lvl=1;note=inline;rgn=main;view=trgt)HAving thus seen that the Air has an Elastical Power, we were next desi∣rous to know in some measure how far a [Page  53](https://quod.lib.umich.edu/e/eebo/A29003.0001.001/90?vid=56393) parcel of Air might by this its own Spring be dilated. And though we were not pro∣vided of Instruments fit to measure the dilatation of the Air any thing accurately, yet because an imperfect measure of it was more desireable then none at all, we de∣vis'd the following Method as very easily practicable.

We took a limber Lambs Bladder which was thorowly wetted in fair Water, that the sides of it being squeez'd toge∣ther, there might be no Air left in its folds: (as indeed we could not afterwards upon tryal discern any) The neck of this Bladder was strongly tyed about that of a small Glass, (capable of holding five full drachmes of Water) the Bladder be∣ing first so compress'd, that all the inclu∣ded Air was onely in the Glass, without being press'd there; then the Pump be∣ing set awork after a few exsuctions, the Air in the little Viol began to dilate it self and produce a small Tumor in the Neck of the Bladder; and as the ambi∣ent Air was more and more drawn away, so the included Air penetrated further and further into the Bladder, and by degrees lifted up the sides and display'd its folds, till at length it seem'd to have blown it [Page  54](https://quod.lib.umich.edu/e/eebo/A29003.0001.001/91?vid=56393) up to its full extent: whereupon the ex∣ternal Air, being permitted to flow back into the Reciver, repuls'd the Air that had fill'd the Bladder into its former nar∣row receptacle, and brought the Bladder to be again flaccid and wrinkled as before: Then taking out the Bladder, but with∣out severing it from the Glass, we did by a hole made at the top of the Bladder fill the Vessel they both made up with Wa∣ter, whose weight was five Ounces five Drachmes and an half: Five Drachmes whereof were above-mention'd to be the contents of the Bottle. So that in this Ex∣periment, when the Air had most extend∣ed the Bladder, it possess'd in all above nine times as much room as it did when it was put into the Receiver. And it would probably have much inlarg'd its bounds, but that the Bladder by its weight and the sticking together of its sides did some∣what resist its expansion: And which was more considerable, the Bladder appear'd tumid enough, whilst yet a pretty deal of Air was left in the Receiver, whose ex∣suction would, according to our former Observation, probably have given way to a further expansion of the Air, especi∣ally [Page  55](https://quod.lib.umich.edu/e/eebo/A29003.0001.001/92?vid=56393) supposing the dilatation not to be re∣strain'd by the Bladder.

SInce we wrote the other day the former Experiment, we have met with some Glasses not very unfit for our purpose; by means of which we are now able, with a little more trouble, to measure the ex∣pansion of the Air a great deal more ac∣curately then we could by the help of the above-mention'd Bladder, which was much to narrow to allow the Air its ut∣most distention.

We took then first a Cylindrical Pipe of Glass, whose bore was about a quarter of an Inch in Diameter: this Pipe was so bent and doubled, that, notwithstanding its being about two foot in length, it might have been shut up into a small Re∣ceiver, not a Foot high: But by mis∣fortune it crack'd in the cooling, whereby we were reduced to make use of one part which was straight and intire, but exceed∣ed not six or seven Inches. This little Tube was open at one end; and at the other, where it was Hermetically seal'd, had a small Glass bubble to receive the Air whose dilatation was to be measur'd.

[Page  56](https://quod.lib.umich.edu/e/eebo/A29003.0001.001/93?vid=56393)Along the side of this Tube was past∣ed a straight narrow piece of Parchment, divided into twenty six equal parts, mark∣ed with black Lines and Figures, that by them might be measur'd both the inclu∣ded Air and its dilatation. Afterwards we fill'd the Tube with Water almost to the top, and stopping the open end with a Finger, and inverting the Tube, the Air was permitted to ascend to the above-mention'd Glass bubble. And by rea∣son this ascent was very slow, it gave us the opportunity to mark how much more or less then one of the twenty six divisi∣ons this Air took up. By this means, af∣ter a tryal or two, we were inabled to con∣vey to the top of the Glass a bubble of Air equal enough, as to sight, to one of those Divisions: Then the open end of the Tube being put into a small Viol, whose bottom was cover'd with Water about half an Inch high; we included both Glasses into a small and slender Re∣ceiver, and caused the Pump to be set a∣work. The event was, That at the first exsuction of the Air there appear'd not any expansion of the bubble, comparable to what appear'd at the second, and that upon a very few exsuctions the bubble [Page  57](https://quod.lib.umich.edu/e/eebo/A29003.0001.001/94?vid=56393) reaching as low as the surface of the sub∣jacent Water, gave us cause to think that if our Pipe had not been broken it would have expanded it self much fur∣ther: Wherefore we took out the little Tube, and found that besides the twenty six divisions formerly mention'd, the Glass bubble and some part of the Pipe to which the divided Parchment did not reach, amounted to six divisions more. Whereby it appears that the air had taken up one and thirty times as much room as before, and yet seem'd capable of a much greater expansion, if the Glass would have permitted it. Wherefore, after the former manner, we let in another bubble, that by our guess was but half as big as the former, and found, that upon the ex∣suction of the Air from the Receiver, this little bubble did not onely fill up the whole Tube, but (in part) break through the subjacent Water in the Viol, and thereby manifest it self to have possessed sixty and odde times its former room.

These two Experiments are mention'd to make way for the more easie belief of that which is now to follow. Finding then that our Tube was too short to serve our turn, we took a slender Quill of Glass [Page  58](https://quod.lib.umich.edu/e/eebo/A29003.0001.001/95?vid=56393) which happen'd to be at hand, though it were no so fit for our purpose as we could have wished, in regard it was three or four times as big at one end as the o∣ther. This Pipe which was thirty Inches long, being Hermetically seal'd at the slender end, was almost filled with Wa∣ter; and after the above-related manner a bubble was convey'd to the top of it, and the open extream was put into a Viol that had a little fair Water at the bottom: Then the Cover, by means of a small hole purposely made in it for the Glass Pipe to stand out at, was cemented on to the Re∣ceiver, and the Pump being set awork, after some exsuctions, not onely the Air manifestly appear'd extended below the surface of the subjacent Water; but one of the By-standers affirms, that he saw some bubbles come out at the bottom of the. Pipe and break through the Water. This done, we left off Pumping, and ob∣serv'd how at the unperceiv'd leaks of the Receiver the Air got in so fast, that it very quickly impell'd up the Water to the top of the Tube, excepting a little space whereinto that bubble was repuls'd, which had so lately possess'd the whole Tube; this Air at the slender end ap∣pear'd [Page  59](https://quod.lib.umich.edu/e/eebo/A29003.0001.001/96?vid=56393) to be a Cylinder of ⅚ parts of an Inch in length; but when the Pipe was taken out and turn'd upside down, it ap∣pear'd at the other end inferior in bulk to a Pea.

These things being thus done we took (to make the Experiment the more ex∣actly) a small pair of Scales, such as Gold-Smiths use to weigh Gold Coyn in; and weighing the Tube and Water in it, we found them to amount to one Ounce thir∣ty Grains and an half: Then we pour•d in as much Water as serv'd to fill up the Tube, wherein before we had left as much space unfill'd up as was possess'd by the bubble, and weighing again the Pipe and Water, we found the weight increas'd onely by one Grain. Lastly, pouring out the Water, and carefully freeing the Pipe from it (which yet we could not perfectly doe) we weighed the Glass alone, and found it to want two Drachmes and thirty two Grains of its former weight: So that the bubble of Air taking up the room but of one Grain in weight of Water, it appear'd that the Air by its own 〈 in non-Latin alphabet 〉 was so •arified, as to take up one hundred fifty two times as much room as it did be∣fore: though it were then compress'd by [Page  60](https://quod.lib.umich.edu/e/eebo/A29003.0001.001/97?vid=56393) nothing but the ordinary pressure of the contiguous Air. I know not whether it be requisite to take notice, that this Ex∣periment was made indeed in a moist Night, but in a Room, in whose Chim∣ney there was burning a good Fire, which did perhaps somewhat rarifie the Air of which the bubble consisted.

It has seem'd almost incredible which is related by the Industrious *Mersennus,* That the Air by the violence of heat, though as great as our Vessels can support with∣out fusion, can be so dilated as to take up seventy times as much room as before: Wherefore because we were willing to have a confirmation of so strange a *Phaeno∣menon*; we once more convey'd into the Tube a bubble of the bigness of the for∣mer, and prosecuting the Experiment as before with the same Water, we observed that the Air did manifestly stretch it self so far, as to appear several times a good way below the surface of the Water in the Viol, and that too with a surface very convex toward the bottom of the Pipe. Nay, the Pump being ply'd a little lon∣ger, the Air did manifestly reach to that place where the bottom of the Tube lean'd upon the bottom of the Viol, and [Page  61](https://quod.lib.umich.edu/e/eebo/A29003.0001.001/98?vid=56393) seem'd to knock upon it and rebound from it: Which Circumstances we adde, partly that the *Phaenomenon* we have been relating may not be imputed to the bare subsiding of the Water that fill'd the Tube, upon the taking off the pres∣sure of the ambient Air. And partly al∣so that it may appear that if our Expe∣riments have not been as accurately made as with fitter Instruments might perhaps be possible; yet the expansion of the Air is likely to be rather greater then lesser then we have made it: Since the Air was able to press away the Water at the bottom of the Pipe, though that were about two Inches below the surface of the Water that was then in the Viol, and would have been at least as high in the Pipe, if the Water had onely subsided and not been depressed: So that it seems not unlikely that if the Experiment could be so made, as that the expansion of the Air might not be resisted by the Neighboring Bodies, it would yet inlarge its bounds, and perhaps stretch it self to two hundred times its former bulk, if not more. How∣ever, what we have now try'd will, I hope, suffice to hinder divers of the *Phaenomena* of our Engine from being distrusted: [Page  62](https://quod.lib.umich.edu/e/eebo/A29003.0001.001/99?vid=56393) Since in that part of the Atmosphere we live in, that which we call the free Air (and presume to be so uncompress'd) is crouded into so very small a part of that space, which if it were not hindred it would pos∣sess. We would gladly have tryed also whether the Air at its greatest expansion could be further rarified by heat; but do what we could, our Receiver leak'd too fast to let us give our selves any satisfacti∣on in that particular.

[\*](https://quod.lib.umich.edu/e/eebo/A29003.0001.001?id=DLPS9;lvl=1;note=inline;rgn=main;view=trgt)TO discover likewise by the means of that pressure of the Air, both the strength of Glass, and how much inte∣rest the Figure of a Body may have in its greater or lesser Resistance to the pressure of other Bodys, we made these further tryals.

We causd to be blown with a Lamp • round Glass bubble, capable of contain∣ing, by guess, about five Ounces of Wa∣ter, with a slender neck about the bigness of a Swans Quill, and it was purposely blown very thin, as Viols made with Lamps are wont to be, that the thinness of the matter might keep the roundness of the Figure from making the Vessel too [Page  63](https://quod.lib.umich.edu/e/eebo/A29003.0001.001/100?vid=56393) strong. Then having moderately empty∣ed the Receiver, and taken it out of the Pump, we speedily applyed to the Ori∣fice of the bottom of it the Neck of the newly mention'd Glass, carefully stopping the Crannys with melted Plaister, that no Air might get in at them: And after turning the Key of the Stop-cock, we made a free passage for the Air to pass out of the bubble into the Receiver: which it did with great celerity, leaving the bub∣ble as empty as the Receiver it self; as ap∣pear'd to us by some Circumstances not now to be insisted on. Notwithstanding all which, the Vessel, continuing as intire as before, gave us cause to wonder that the bare Roundness of the Figure should inable a Glass, almost as thin as Paper, to resist so great a pressure as that of the whole incumbent Atmosphere. And ha∣ving reiterated the Experiment, we found again that the pressure of the ambient Body, thrusting all the parts inwards, made them, by reason of their arched Fi∣gure, so support one another, that the Glass remain'd as whole as at first.

Now that the Figure of the Glass is of great moment in this matter, may be evinced by this other Experiment.

[Page  64](https://quod.lib.umich.edu/e/eebo/A29003.0001.001/101?vid=56393)[\*](https://quod.lib.umich.edu/e/eebo/A29003.0001.001?id=DLPS10;lvl=1;note=inline;rgn=main;view=trgt)WE took a Glass Helmet or Alem∣bick (delineated by the seventh Figure) such as Chymists use in Distilla∣tions, and containing by conjecture be∣tween two and three Pints: The *Rostrum* or Nose of it mark'd with (*c*) was Herme∣tically closed; and at the top of it was a hole, into which was fitted and cemented one of the Shanks of a middle-siz'd Stop-cock; so that the Glass being turn'd up∣side-down, the wide Orifice (which in common Glass-Helmets is the onely one) was upwards; and to that wide Orifice was fitted a cast Cover of Lead, which was carefully cemented on to the Glass: Then the other Shank of the Stop-cock being with Cement likewise fasten'd into the upper part of the Pump, the exsucti∣on of the Air was endeavoured. But it was not long before, the remaining Air being made much too weak to ballance the pressure of the ambient Air, the Glass was not without a great noise crack'd al∣most half round, along that part of it where it began to bend inwards: As if in the Figure the crack had been made ac∣cording to the Line *(ab)*; and upon an [Page  65](https://quod.lib.umich.edu/e/eebo/A29003.0001.001/102?vid=56393) endeavour to pump out more of the Air, the crack once began, appear'd to run on further; though the Glass where it was broken seem'd to be by conjecture above ten, some thought above twenty times as thick as the bubble mention'd in the fore∣going Experiment.

This will perhaps make it seem strange, that having taken another Glass bubble blown at the same time, and like for ought we discern'd for size, thickness and Figure to that thin one formerly mention'd; and having seal'd it up Her∣metically, and suspended it in the Recei∣ver, the exsuction of the ambient Air did not enable the imprisoned Air to break, or in the least to crack the bubble; though the Experiment were laboriously try'd, and that several times with bubbles of o∣ther sizes: But that perhaps the heat of the Candle or Lamp wherewith such Glasses are Hermetically seal'd, (not to mention the warmth of his hands that seal'd it) might so rarifie the contained Air, as much to weaken its Spring, may seem probable by the following Expe∣riments.

[Page  66](https://quod.lib.umich.edu/e/eebo/A29003.0001.001/103?vid=56393)[\*](https://quod.lib.umich.edu/e/eebo/A29003.0001.001?id=DLPS11;lvl=1;note=inline;rgn=main;view=trgt)WE took a Glass Viol able to hold three or four Ounces of Water, and of the thickness usual in Glasses of that size; into the Neck of this was put a moderately slender Pipe of Glass, which was carefully fasten'd with a mixture of e∣qual parts of Pitch and Rosin to the Neck of the Viol, and which reach'd almost to the bottom of it, as the sixth Figure de∣clares.

This Viol being upon a particular de∣sign fill'd with Water, till that came up in it a pretty deal higher then the lower end of the Pipe, was put into one of our small Receivers, (containing between a Pint and a Quart) in such manner as that the Glass Pipe, passing through a hole made purposely for it in the Leaden-Cover of the Receiver, was for the most part of it without the Vessel, which being exactly closed, the Pump was set awork: But at the very first exsuction, and before the Sucker was drawn to the bottom of the Cylinder, there flew out of the Viol a piece of Glass half as broad as the Palm of a Mans Hand, and it was thrown out with such violence, that hitting against [Page  67](https://quod.lib.umich.edu/e/eebo/A29003.0001.001/104?vid=56393) the Neighboring side of the Receiver, it not onely dash'd it self to pieces, but crack'd the very Receiver in many places, with a great noise that much surprised all that were in the Room. But it seem'd that in so little a Receiver, the Air about the Viol being suddenly drawn out, the Air Imprison'd in the Vessel, having on it the whole pressure of the Atmosphere (to which by the Pipe open at both ends, It and the Water were expos'd) and not having on the other side the wonted pres∣sure of the Ambient Air to ballance that other pressure, the resistance of the Glass was finally surmounted, and the Viol once beginning to break where it was weakest, the external Air might rush in with vio∣lence enough to throw the crack'd parcel so forcibly against the Neighboring side of the Receiver, as to break that too.

And this may be presumed sufficient to verifie what we delivered in that part of our Appendix to the first Experiment, where we mention'd the almost equal pressure of the Air on either side of a thin Glass Vessel, as the cause of its not being broken by the forcible Spring of the contain'd Air. But yet that it be not suspected that chance had an interest in so [Page  68](https://quod.lib.umich.edu/e/eebo/A29003.0001.001/105?vid=56393) odde an Experiment as we have been Re∣lating, we will adde that for farther satis∣faction we reiterated it in a round Glasse containing by guesse about six ounces of water: this violl we put into such a small Receiver as was lately mention'd, in such manner as that the bottome of it rested upon the lower part of the Pneu∣maticall Glasse, and the Neck came out through the Leaden-Cover of the same at a hole made purposely for it. But be∣ing made circumspect by the foregoing mischance, we had put the violl into a Bladder, before we put it into the Re∣ceiver to hinder this last named Glasse from being endanger'd by the breaking of the other. Then the Pneumaticall vessell being clos'd so that no way was left for the outward Air to get into it, but by breaking through the Viol, into whose cavity it had free accesse by the mouth of it, (which was purposely left open,) the Sucker being nimbly drawn down, the external Air immediatly press'd forcibly as well upon the Leaden-Co∣ver as the Violl; and the Cover hap∣pening to be in one place a little narrow∣er then the edge of the Pneumatical Glass, was depress'd, and thrust into it so vio∣lently [Page  69](https://quod.lib.umich.edu/e/eebo/A29003.0001.001/106?vid=56393) by the incumbent Air, that get∣ting a little within the tapering Lip of the Glass, it did like a kinde of Wedge, thrust out that side where it was depress'd, so as, though the Receiver was new, to split it. This accident being thus mention'd upon the by to confirm what we formerly said touching the fitness or unfitness of Glasses of some Figures to resist the pressure of the Atmosphere; We will proceed to relate the remaining part of the Experi∣ment, namely, That having fitted on a wider Cover to the same Receiver, and closed both that and the crack with Ce∣ment, we prosecuted the Experiment in the manner above related, with this suc∣cess: That upon the quick depressing of the Sucker, the external Air burst the Body of the Viol in above a hundred pie∣ces, many of them exceeding small, and that with such violence that we found a wide rent, besides many holes, made in the Bladder it self.

And to evince that these *Phaenomena* were the effects of a limited and even moderate force, and not of such an ab∣horrency of a *Vacuum* as that to avoid it, many have been pleased to think that Na∣ture must, upon occasion, exercise an al∣most [Page  70](https://quod.lib.umich.edu/e/eebo/A29003.0001.001/107?vid=56393) boundless power; we afterwards pur∣posely try'd this Experiment with several Glasses somewhat thicker then those Vi∣ols, and found the event to verifie our con∣jecture, that it would not succeed: for the Glasses were taken out as intire as they were put in.

And here, My Lord, I hold it not un∣fit, upon occasion of the mention that has been made of our having employ'd small Receivers, and one of them, not∣withstanding its being crack'd, to annex these two Advertisements.

First then, besides the great Pneuma∣tical Glass so often mention'd, and the proportionate Stop-cock, we thought fit to provide our selves of some small Recei∣vers blown of Crystalline Glass, of seve∣rall Shapes, and furnished with smaller Stop-cocks purposely made; and this we did upon hopes that when we had sur∣mounted the difficulties to be met with in Cementing the Glasses to the Stop-cocks, and the Pneumatical Vessels to the Pump so exquisitely as is requisite for our purpose, we should from the smalness of our Receivers receive a four-fold Advan∣tage. The first, that by reason of the slenderness of the Vessels, and their be∣ing [Page  71](https://quod.lib.umich.edu/e/eebo/A29003.0001.001/108?vid=56393) made of much purer and clearer me∣tall, as the Glass-men speak, then the great Receiver, we might have a more perfect view of every thing happening within them. The next, that such small Vessels might be empty'd with less la∣bour and in much lesse time. The third, that this nimble exsuction of the ambient Air would make many changes in the Bodies shut up in these glasses more sud∣den and conspicuous then otherwise they would prove. And the last, that we should be able to draw and keep out the Air much more perfectly from such small Vessels then from our large Receiver. But though we were not much dis-appointed in the expectation of the three first advantages, yet we were in our hopes of the fourth. For besides the great difficulty we found in fitting together the Glasses, the Stop-cocks and the Covers; besides this I say, we found our selves seldom able to draw, and keep out the Air so far as to make the remaining Air in these Receivers weaker then the remaining Air in our great Recei∣ver. For though sometimes the Leaks of some of these little Receivers may be much either fewer or smaller then those of the larger Vessel; yet a little Air get∣ting [Page  72](https://quod.lib.umich.edu/e/eebo/A29003.0001.001/109?vid=56393) into one of these, wherein it had but little room to expand and display it self, might press as much upon all parts of the internal surface of the Vessel, and upon the included Bodies, as a greater quan∣tity of Air in a Vessel in whose capacity it might finde more room to expand it self.

The other thing that we were to ad∣vertise, is, That 'tis not every small crack that can make such a Receiver as is of a roundish Figure altogether useless to our Experiment, in regard that upon the ex∣suction of the internal Air, the ambient Air on all sides pressing the Glass inwards or towards the middle, does consequent∣ly thrust the Lips of the crack closer, and so rather close then increase it.

This I mention partly because Recei∣vers fit for our turn are more easily crack'd then procur'd, and therefore ought not to be unnecessarily thrown away as unserviceable: And partly because I think it becomes one that professes himself a faithful Relator of Experiments, not to conceal from Your Lordship, that after a few of the foregoing Experiments were made, there happen'd in the great Recei∣ver a crack of about a Span long, begin∣ning [Page  73](https://quod.lib.umich.edu/e/eebo/A29003.0001.001/110?vid=56393) at the upper Orifice, and occasion'd, as it seem'd, by the excessive heat of too large an Iron that was employ'd to melt the Cement about that Orifice. But ha∣ving laid upon this crack a broad Plaister, which in one of our Essays written some years since to your ingenious and hopeful Cousin *Iones,* we extoll for the mending of crack'd Receivers, and other Chymi∣cal Glasses; and having afterwards thick∣ly over-laid this Plaister with Diachylon, we neither could then, nor can yet per∣ceive that the Vessel leaks sensibly at that crack.

The Plaister was made of good quick Lime finely poudred, and nimbly ground with a Pestle in a Morter, with a quantity (I know not how much precisely, not ha∣ving those Essays in this place) of scra∣pings of Cheese and a little fair Water, no more then is just necessary to bring the mixture to a somewhat soft Paste, which when the Ingredients are exquisitely in∣corporated, will have a strong and stincking smell: Then it must be im∣mediately spread upon a Linnen Cloath three or four fingers breadth, and presently apply'd, lest it begin to harden. But if Your Lordship had seen how we mended [Page  74](https://quod.lib.umich.edu/e/eebo/A29003.0001.001/111?vid=56393) with it Receivers even for the most sub∣tle Chymical Spirits, You would scarce wonder at the service it has done in our Pneumatical Glass.

[\*](https://quod.lib.umich.edu/e/eebo/A29003.0001.001?id=DLPS12;lvl=1;note=inline;rgn=main;view=trgt)WE took a Tallow-Candle of such a size that eight of them make about a pound, and having in a very com∣modious Candlestick let it down into the Receiver, and so suspended it that the Flame burnt almost in the middle of the Vessel, we did in some two minutes ex∣actly close it up: and, upon Pumping ve∣ry nimbly, we found that within little more then half a minute after the Flame went out, though the Snuff had been purposely left of that length we judged the most convenient for the lasting of the Flame.

But the second time having put in the same Candle into the Receiver, (after it had by the blasts of a pair of Bellows been freed from Fumes) the Flame lasted about two minutes from the time the Pumper began to draw out the Air; up∣on the first exsuction whereof, the Flame seem'd to contract it self in all its Dimen∣sions. And these things were further ob∣servable, [Page  75](https://quod.lib.umich.edu/e/eebo/A29003.0001.001/112?vid=56393) that after the two or three first exsuctions of the Air, the Flame (except at the very top) appear'd exceeding blew, and that the Flame still receded more and more from the Tallow, till at length it appear'd to possess onely the very top of the Week, and there it went out.

The same Candle being lighted again was shut into the Receiver, to try how it would last there without drawing forth the Air, and we found that it lasted much longer then formerly; and before it went out receded from the Tallow towards the the top of the Week, but not near so much as in the former Experiment.

And having an intention to observe par∣ticularly what the motion of the smoak would be in these Experiments: We took notice that when the Air was not drawn out, there did upon the extinction of the Flame a considerable part of the Week remain kindled, which (probably by reason of the Circulation of the Air in the Vessel, occasion'd by the heat) e∣mitted a Steam, which ascended swiftly and directly upwards in a slender and unin∣terrupted Cylinder of smoke, till it came to the top, whence it manifestly recoyl'd by the sides to the lower part of the Ves∣sel. [Page  76](https://quod.lib.umich.edu/e/eebo/A29003.0001.001/113?vid=56393) Whereas when the Flame went out upon the exsuction of the Air one time (when the Flame retir'd very leasurely to the top) we perceived it not to be fol∣low'd by any smoke at all. And at an other time the upper part of the Week remaining kindled after the extinction of the Flame, the slender steam of Fumes that did arise ascended but a very little way, and then after some uncertain mo∣tions this and that way, did, for the most part, soon fall downwards.

Being desirous also to try whether there would be any difference as well in our Receiver as there is wont to be else∣where betwixt Candles made of Wax and those made of Tallow, as to their dura∣tion; we took slender Tapers of white Wax, (commonly called Virgins Wax) that being found to burn with much less smoke then common yellow Wax: Six of these of like bigness, and each of them of about the thickness of a Swans Quill, we press'd together into one Candle: And having lighted all the Weeks, we let in the above-mention'd Wax into the Re∣ceiver, and made what haste we could to close it up with Cement. But though in the mean while we left open the Valve [Page  77](https://quod.lib.umich.edu/e/eebo/A29003.0001.001/114?vid=56393) of the Cylinder, the hole of the Stop-cock and that in the Cover of the Re∣ceiver, that some Air might get in to cherish the Flame and the smoke might have a vent; Yet for so great a Flame the Air sufficed not so much as till the Cover could be perfectly luted on: So that before we were quite ready to imploy the Pump, the Candle was extinguished. Wherefore we took but one of the a∣bove mention'd Tapers, and having lighted it, clos'd it up in the Receiver, to try how long a small Flame with a pro∣portionable smoke would continue in such a quantity of Air: But we found upon two several tryals, that from the beginning of pumping, the flame went out in about a minute of an hour. It appear'd indeed to us that the swinging of the Wier to and fro (in the Engine shaken by pumping) hasten'd the vanish∣ing of the Flame, which seem'd by that motion to be cast sometimes on one side of the Week and sometimes on the o∣ther: But though once we purposely refrain'd pumping after a very few ex∣suctions of the Air, that the Flame might not be agitated, yet it lasted not much longer then the newly mention'd time. [Page  78](https://quod.lib.umich.edu/e/eebo/A29003.0001.001/115?vid=56393) And lastly, closing up the same Taper, lighted again, to discover how long it would last without drawing out of the Air, we found that it burn'd for a while vividly enough, but afterwards began to be lessen'd more and more in all its Di∣mensions. And we observ'd that the Flame did not, as before, retire it self by little and little towards the top, but to∣wards the bottom of the Week (from which yet it did a little withdraw upwards just before it went out) so that the upper part of the Week appear'd for a pretty while manifestly above the top of the Flame, which having lasted about five minutes, was succeeded by a directly as∣cending stream of Smoak.

[\*](https://quod.lib.umich.edu/e/eebo/A29003.0001.001?id=DLPS13;lvl=1;note=inline;rgn=main;view=trgt)THere was taken a Wier, which being bent almost in the form of a Screw, constituted such an Instrument to contein Coals and leave them every way accessi∣ble to the Air, as the tenth Figure de∣clares; the breadth of this Vessel was no less then that it might with ease be con∣vey'd into the Receiver: And having filld it to the height of about five Inches with throughly kindled Wood-coals, we let [Page  79](https://quod.lib.umich.edu/e/eebo/A29003.0001.001/116?vid=56393) it down into the Glass; and speedily clo∣sing it, we caus'd the Pumper to ply his work, and observ'd that upon the ve∣ry first exsuction of the Air (though per∣haps not because of that onely) the Fire in the Coals began to grow very dim, and though the agitation of the Vessel did make them swing up and down (which in the free Air would have retarted the ex∣tinction of the Fire) yet when we could no longer discern any redness at all in any of them, casting our eyes upon a Minute-Watch we kept by us on this occasion, we found that from the beginning of the Pumping (which might be about two mi∣nutes after the Coals had been put in glowing) to the total dis-appearing of the Fire, there had passed but three mi∣nutes.

Whereupon, to try the Experiment a little further, we presently took out the Coals, in which it seems there had re∣mained some little parcels of Fire, rather cover'd then totally quench'd: For in the open Air the Coals began to be re-kind∣led in several places, wherefore having by swinging them about in the Wier, throughly lighted them the second time, we let them down again into the Receiver, [Page  80](https://quod.lib.umich.edu/e/eebo/A29003.0001.001/117?vid=56393) and clos'd it speedily as before; and then waiting till the Fire seem'd totally ex∣tinct without medling with the Pump, we found that from the time the Vessel was clos'd till that no Fire at all could be per∣ceiv'd there had passed about four mi∣nutes: Whereby it seem'd to appear that the drawing away of the ambient Air made the Fire go out sooner then other∣wise it would have done; though that part of the Air that we drew out left the more room for the stifling steams of the Coals to be received into.

Lastly, Having taken out the Wier and put other Coals into it, we did, in the same Room where the Engine stood, let it hang quietly by a string in the open Air, to try how long the Fire would last with∣out agitation when no Air was kept from it. And we found that the Fire began to go out first at the top and out-sides of the Coals; but inwards and near the bottom the Fire continu'd visible for above half an hour, a great part of the Coals, espe∣cially those next the bottom, being burnt to ashes before the Fire went out.

We caus'd likewise a piece of Iron to be forg'd, of the bigness of a middle siz'd Char-coal, and having made it red hot [Page  81](https://quod.lib.umich.edu/e/eebo/A29003.0001.001/118?vid=56393) throughout▪ we caus'd it in the lately mention'd Wier, to be speedily convey'd and shut up into the Receiver, being de∣sirous to try what would become of a glowing Body, by reason of its texture more vehemently hot then a burning Coal of the same bigness, & yet unlike to send forth such copious & stifling Fumes: But we could not observe any manifest change upon the exsuction of the Air. The Iron began indeed to lose its Fiery redness at the top, but that seem'd to be because it was at the upper end somewhat more slender then at the lower: The red∣ness, though it were in the day time, con∣tinued visible about four minutes; and then, before it did quite dis-appear, we turn'd the Key of the Stop-cock but could not discern any change of the Iron upon the rushing in of the Air. Yet some little remainders of Wax that stuck to the Wier, and were turn'd into Fumes by the heat of the neighboring Iron, seem'd to afford a more plentiful, or at least a much more free expanded smoke when the Air was suck'd out, then afterwards; though allowance was made for the de∣creasing heat of the Iron. And lastly, notwithstanding a considerable exsuction [Page  82](https://quod.lib.umich.edu/e/eebo/A29003.0001.001/119?vid=56393) of the ambient Air, though not by far so great a one as might have been made by the Engine; and notwithstanding the in∣considerable dissipation of the parts of the Iron, the surrounding sides of the Recei∣ver were sensibly, and almost offensively heated by it; insomuch that a pretty while after the Iron was taken out, the sides of the Glass manifestly retain'd a warmth: which would not be unfit to be consider'd by a Person at more leasure then I am now.

BEing willing to try after this some∣thing that would not cherish much Fire at once,[\*](https://quod.lib.umich.edu/e/eebo/A29003.0001.001?id=DLPS14;lvl=1;note=inline;rgn=main;view=trgt) and would keep Fire much longer then a Coal. We took a piece of Match, such as Souldiers use, of the thick∣ness of a Mans little Finger, or somewhat thicker; and this being well lighted at one end, was by a string suspended with that end downwards in the cavity of the Receiver which was immediately clos'd: And yet by that time it could well be so, the copious Fumes of the Match had neer fill'd and darken'd the Receiver. Where∣fore, lest the Vessel should be endanger'd, the Pump was nimbly ply'd, and a great [Page  83](https://quod.lib.umich.edu/e/eebo/A29003.0001.001/120?vid=56393) deal of Air and Smoke mixt together was drawn out, whereby the Receiver grow∣ing more clear, we could discern the Fire in the Match to burn more and more lan∣guidly: And notwithstanding that by the diligence us'd in Pumping, it seem'd to have room enough allow'd it to throw out Fumes; yet after no long time it ceas'd from being discernable either by its Light or its Smoke. And though by that we were invited to suppose it quite extinguished, yet we continu'd pumping a while, in prosecution of another Expe∣riment we were trying at the same time: And this we did the more willingly be∣cause of a suspicion the Experiment a∣bout the Coals might easily suggest, and which the event declar'd not to have been altogether groundless. For upon the Admission of the external Air, the Fire, that seem'd to have gone out a pretty while before, did presently revive; and being as it were refreshd by the new Air, and blown by the Wind made by that Air in rushing in, it began again to shine and dissipate the neighboring Fuel into Smoke as formerly.

[Page  84](https://quod.lib.umich.edu/e/eebo/A29003.0001.001/121?vid=56393)[\*](https://quod.lib.umich.edu/e/eebo/A29003.0001.001?id=DLPS15;lvl=1;note=inline;rgn=main;view=trgt)A While after we let down into the Receiver together with a ligh∣ted piece of Match, a great Bladder well tyed at the Neck, but very lank, as not containing actually much (if any thing) a∣bove a Pint of Air, but being capable of containing ten or twelve times as much.

Our scope in this Experiment was partly to try whether or no the smoke of the Match, replenishing the Receiver, would be able to hinder the Dilatation of the inward Air, upon the exsuction of the Ambient. And partly to discover whe∣ther the extinction of the Fire in the Match did proceed from want of Air, or barely from the pressure of its own Fumes, which for want of room to ex∣pand themselves in, might be suppos'd to Recoyl upon the Fire, and so to stifle it.

The event of our tryal was, That at the beginning of our Pumping the Match appear'd well lighted, though it had almost fill'd the Receiver with its plentiful Fumes: But by degrees it burnt more and more dimly, notwith∣standing that by the nimble drawing [Page  85](https://quod.lib.umich.edu/e/eebo/A29003.0001.001/122?vid=56393) out the Air and Smoke, the Vessel were made less opacous, and less full of compressing matter; as appeard by this, That the longer we pump'd, the lesser Air and Smoke came out of the Cylin∣der at the opening the Valve, and conse∣quently the less came into it before; yet the Fire in the Match went but slowly out. And when afterwards, to satisfie our selves of its expiration, we had dar∣ken'd the Room, and in vain endeavored to discover any spark of Fire, as we could not for some time before by the help of Candles discern the least rising of Smoke, we yet continued pumping six or seven times; and after all that letting in the Air, the seemingly dead Fire quickly revived, and man•f•sted its recovery by Light and store of Smoke, with the latter of which it quickly began to re∣plenish the Receiver. Then we fell to pumping afresh, and continued that labour so long till the re-kindled Match went out again: and thinking it then fit not to cease from Pum∣ping so soon as before, we found that in less then half a quarter of an hour the Fire was got out for good and all, [Page  86](https://quod.lib.umich.edu/e/eebo/A29003.0001.001/123?vid=56393) and past the possibility of being recover'd by the re-admitted Air.

Some Circumstances, besides those al∣ready mention'd, occurr'd in the making of the Experiment, of which these are the principal.

First, when the Receiver was full of Smoke, if the Cylinder were emptied, immediately upon the turning of the Stop-cock, the Receiver would appear manifestly darken'd to his eye that look'd upon the light through it: and this dark∣ness was much less when the Receiver was much less fill'd with Fumes: It was also instantaneous, and seem'd to proceed from a sudden change of place and scituation in the exhalations, upon the vent sud∣denly afforded them and the Air they were mixt with, out of the Receiver into the Cylinder.

The next thing we observ'd was, a kinde of *Halo* that appear'd a good while about the Fire, and seem'd to be produced by the surrounding Exhalations.

And lastly, it is remarkable, That even when the Fumes seemed most to reple∣nish the Receiver, they did not sensibly hinder the Air included in the Bladder from dilating it self after the same manner [Page  87](https://quod.lib.umich.edu/e/eebo/A29003.0001.001/124?vid=56393) (for ought we could discern) as it would have otherwise done: So that before the Fire or the Match was quite extinct, the Bladder appear'd swell'd at least to six or seven times its former capacity.

Since the writing of these last Lines, we took a small Receiver, capable of containing (by guess) about a pound and a half of Water; and in the midst of it we suspended a lighted Match, but though within one minute of an hour (or there∣abouts) from the putting in of the Match, we had cemented on the Cover, yet we could not make such haste, but that before we began to pump, the Smoke had so fill'd that small Receiver, as for ought we discern'd, to choke the Fire. And having again and again reiterated the Experi∣ment, it seem'd still as at first, that we could not close up the Vessel and pump out all the Fumes time enough to rescue the Fire from Extinction; whereupon we made use of this Expedient. Assoon as we had pump'd once or twice, we sudden∣ly turn'd the Key, and thereby gave access to the excluded Air, which rushing vio∣lently in, as if it had been forced thorow a pair of Bellows, did both drive away the ashes, fill the Glass with fresh Air, and [Page  88](https://quod.lib.umich.edu/e/eebo/A29003.0001.001/125?vid=56393) by blowing the almost extinguish'd Fire, re-kindl'd it, as appear'd by the Matches beginning again to smoke, which before it had ceas'd to do; we having by this means obtain'd a lighted Match in the Receiver, without being reduc'd to spend time to close it up, commanded the Air to be immediatly pump'd out, and found that upon the exsuction of it, the Match quickly left smokeing, as it seem'd, by reason of the absence of the Air; and yet if some urgent occasions had not hin∣der'd us, we would for greater security have try'd, whether or no the Match re∣kindled as formerly, would smoke much longer, in case of no exsuction of the am∣bient Air.

[\*](https://quod.lib.umich.edu/e/eebo/A29003.0001.001?id=DLPS16;lvl=1;note=inline;rgn=main;view=trgt)TO try diverse things at once, and particularly whether Fire, though we found it would not long last, might not yet be produced in our eva∣cuated Receiver: We took a Pistol of about a Foot in length, and having firmly tyed it to a stick almost as long as the Cavity of the Receiver, we very carefully prim'd it with well dry'd Gun-powder, and then cocking it, we ty'd to [Page  89](https://quod.lib.umich.edu/e/eebo/A29003.0001.001/126?vid=56393) the Tricker one end of a string, whose other end was fasten'd to the Key former∣ly mention'd to belong to the Cover of our Receiver. This done, we convey'd the Pistol, together with the annexed Staff, into the Vessel: which being clos'd up, and empty'd after the usual man∣ner, we began to turn the Key in the Cover; and thereby shortning the string that reach'd from it to the Pistol, we pull'd aside the Tricker, and observ'd, that according to our expectation the force of the Spring of the Lock was not sensibly abated by the absence of the Air. (from whose *impetus* yet some Modern Naturalists would derive the cause of the motion of Restitution in solid Bodies) For the Cock falling with its wonted violence upon the Steel, struck out of it as many and as conspi∣cuous parts of Fire, as, for ought we could perceive, it would have done in the open Air. Repeating this Experi∣ment divers times, we also observed whether or no there would appear any considerable Diversity in the Motion of the shining Sparks in a place where the remaining Aire was so much rarified, but could not perceive [Page  100](https://quod.lib.umich.edu/e/eebo/A29003.0001.001/127?vid=56393) but that they moved some of them up∣wards, as well as some of them down∣wards, and some of them side-ways, as they are wont to do, when upon such col∣lisions they fly out in the open Air.

We likewise caus'd a piece of Steel to be made of the form and bigness of the Flint, in whose place we put it, and then the Pistol being cock'd and conveyed in∣to the Receiver, the Trigger was pull'd after the Air was drawn out: And though the place were purposely somewhat dar∣ken'd, yet there appear'd not upon the striking of the two Steels against each o∣ther the least spark of Fire: Nor did we expect any (having before in vain attem∣pted to strike Fire this way in the open Air) though we thought fit to make the Experiment to undeceive those who fan∣cy in rarified Air, I know not what strange disposition, to take Fire upon a much slighter occasion then this Experiment afforded. We have indeed found, that by the dextrous Collision of two har∣den'd pieces of Steel, store of sparks may be struck out: But that was done with such vehement percussion of the edges of the two Steels, as could not well be com∣pass'd in our Receiver.

[Page  101](https://quod.lib.umich.edu/e/eebo/A29003.0001.001/128?vid=56393)But the chief thing we design'd to do with our Pistol, was, To observe whe∣ther Gun-powder would take Fire in our empty'd and closely stop'd Glass? Whe∣ther the expansion of the Flame would be considerably varied by the absence of so much of the ambient Air as was drawn out of the Receiver? and whether the Flame would diffuse it self upward, as it is wont, notwithstanding its not having a∣bout it the usual proportion of Air to force it up? And though most of our at∣tempts to fire the Gun-powder in the Pan of the Pistol succeeded not, because we were fain to let it hang almost perpen∣dicular in the Receiver; whereby the Powder was shaken down before the sparks could reach it; yet once the Ex∣periment succeeded, and the kindled Powder seem'd to make a more expanded Flame then it would have done in the open Air, but mounted upwards accord∣ing to its wont; whether by reason of that little portion of Air, which in spight of our pumping remained in the Receiver, or for any other cause, we have not now the leisure to consider. But we must not for∣get, that upon the extinction of the Flame the Receiver appear'd darken'd with [Page  102](https://quod.lib.umich.edu/e/eebo/A29003.0001.001/129?vid=56393) smoke, which seem'd to move freely up and down, and upon the letting in the Air at the Stop-cock began to circulate much faster then before. We would have made more observations concerning this Flame, but that of two or three attempts we afterwards made to repeat the kindling of Powder, not any one succeeded; and we have not the leasure to dwell long up∣on one kinde of Tryals.

[\*](https://quod.lib.umich.edu/e/eebo/A29003.0001.001?id=DLPS17;lvl=1;note=inline;rgn=main;view=trgt)TO these Experiments concerning Fire we added another, which, though it suc∣ceded not, may perhaps without imper∣tinency be recorded: partly because that (as we have in another Treatise amply de∣clar'd) it is usefull to recite what Experi∣ments miscarry as well as what succeed. And partly also because it is very possible that what we endeavored in vaine, may be performed by Your Lordship, or some other *Virtuoso* that shall have slancker Vessells then we had, and more Sunny dayes then the present Winter allows us.

We convey'd then into one of our small Receivers a piece of matter combustible, dry and black (experience declaring things [Page  103](https://quod.lib.umich.edu/e/eebo/A29003.0001.001/130?vid=56393) of that colour to be most easily kindled) & carefully closing the Vessel we brought it to a Window at which the Sun, not very farre from the Meridian, shone in very free∣ly: then drawing out the Aire with speed united the Sun-beames with a burning Glass upon the combustible matter which began immediatly to send forth a Smoke that quickly darkned the Receiver, but notwithstanding all our care and diligence the externall Aire got in so fast that after diverse tryals we were fayne to leave off the Experiment in that Glasse and induc'd to make tryall of it in our great Re∣ceiver.

Haveing then after some difficulty lodg'd the combustible matter in the ca∣vity of this Vessell in such manner as that it was almost contiguous to that side thereof that was next the Sun, we did en∣deavor with a pretty large burning Glass to kindle it, but found, as we fear'd, That by reason of the thickness of the Glass, (which was also of a less pure and less Diaphanous matter then the o∣ther) the Sun-beams thrown in by the burning Glass, were in their passage so Dislocated and Scattered (not now to mention those many that being reflected, [Page  104](https://quod.lib.umich.edu/e/eebo/A29003.0001.001/131?vid=56393) I could not pierce into the cavity of the Receiver) that we could not possibly u∣nite enough of them to kindle the matter, nor so much as to make it sensibly smoke. Yet we hope that the seeing whether Bo∣dies (other then Gun-powder) may be kindled, and what would happen to them when set on fire, in a place in great mea∣sure devoid of Air, may prove so Lucife∣rous an Experiment, that when the Sea∣son is more favorable we shall, God per∣mitting, make further tryal of it, and ac∣quaint Your Lordship with the Event, if it prove prosperous. In the mean time we shall pass on to other Experiments, assoon as we have advertis'd Your Lord∣ship that we have forborn to make such Reflections upon the several Experiments we have set down concerning Fire, as the matter▪ would have easily enough afford∣ed, and Your Lordship may perhaps have expected. But I made the less scruple to forbear the annexing of Speculations to these Recitals, because *Carneades* & *Eleu∣therius* have in some Dialogues concern∣ing Heat and Flame, which were last year seen by some Friends, and may be, when you please, commanded by You, men∣tion'd [Page  105](https://quod.lib.umich.edu/e/eebo/A29003.0001.001/132?vid=56393) diver's of my Thoughts and Expe∣riments concerning Fire.

WE designed to try whether or no divers Magnetical Experiments would exhibit any unusual *Phaenomena,*[\*](https://quod.lib.umich.edu/e/eebo/A29003.0001.001?id=DLPS18;lvl=1;note=inline;rgn=main;view=trgt) being made in our Evacuated Receiver instead of the open Air: But for want of leisure and conveniency to prosecute such Tryals, we were induced to reserve the rest for an other time, and to content our selves with making that which follows. We convey'd into the Receiver a little Pedestal of Wood, in the midst of which was perpendicularly erected a slender Iron, upon whose sharp point an excited Needle of Steel purposely made, and of about five Inches long, was so placed that hanging in an *Aequilibrium* it could move freely towards either hand. Then the Air being after the usual manner pumped out, we apply'd a Load-stone moderately vigorous to the out-side of of the Glass, and found that it Attracted or Repell'd the ends of the Needle, accor∣ding to the Laws Magnetical, without any remarkable difference from what the same Load-stone would have done had [Page  106](https://quod.lib.umich.edu/e/eebo/A29003.0001.001/133?vid=56393) none of the Air been drawn away from a∣bout the Needle, which when the Load-stone was removed, after some tremu∣lous Vibrations to and fro, rested in a po∣sition wherein it look'd North and South.

[\*](https://quod.lib.umich.edu/e/eebo/A29003.0001.001?id=DLPS19;lvl=1;note=inline;rgn=main;view=trgt)PRoceed we now to the mention of that Experiment, whereof the satis∣factory tryal was the principal Fruit I promis'd my self from our Engine. It being then sufficiently known, that, in the Experiment *De Vacuo,* the Quick-silver in the Tube is wont to remain ele∣vated, above the surface of that whereon it leans, about 27 digits: I considered, that, if the true and onely reason why the Quick-silver falls no lower, be, that at that Altitude, the Mercurial Cylinder in the Tube, is an *Aequilibrium* with the Cylinder of Air, suppos'd to reach from the adjacent Mercury to the top of the Atmosphere: If this Experiment could be try'd out of the Atmosphere, the Quick-silver in the Tube would fall down to a levell with that in the Vessel, since then there would be no pressure up∣on the Subjacent, to resist the weight of [Page  107](https://quod.lib.umich.edu/e/eebo/A29003.0001.001/134?vid=56393) the Incumbent Mercury. Whence I in∣ferr'd (as easily I might) that, if the Ex∣periment could be try'd in our Engine, the Quick-silver would subside below 27 Di∣gits, in proportion to the exsuction of Air, that should be made out of the Re∣ceiver. For, as when the Air is shut in∣to the Receiver, it does (according to what hath above been taught) continue there as strongly compress'd, as it did whil'st all the incumbent Cylinder of the Atmosphere lean'd immediatly upon it; because the Glass, wherein it is pent up, hinders it to deliver it self, by an expansi∣on of its parts, from the pressure where∣with it was shut up. So, if we could per∣fectly draw the Air out of the Receiver▪ it would conduce as well to our purpose, as if we were allow'd to try the Experi∣ment beyond the Atmosphere.

Wherefore (after having surmounted some little difficulties which occurr'd at the beginning) the Experiment was made after this manner. We took a slender and very curiously blown Cylinder of Glass, of near three Foot in length, and whose bore had in Diameter a quarter of an Inch, wanting a hairs breadth: This Pipe being Hermetically seal'd at one end, was, at [Page  108](https://quod.lib.umich.edu/e/eebo/A29003.0001.001/135?vid=56393) the other, fill'd with Quick-silver, care being taken in the filling, that as few bubles as was possible should be left in the Mercury: Then the Tube being stopt with the Finger and inverted, was open'd, according to the manner of the Experi∣ment, into a somewhat long and slender Cylindrical Box (instead of which we now are wont to use a Glass of the same form) half fill'd with Quick-silver: And so, the liquid metal being suffered to subside, and a piece of Paper being pasted on levell with its upper surface, the Box and Tube and all were by strings carefully let down into the Receiver, and then, by means of the hole formerly mention'd to be left in the Cover, the said Cover was slip't along as much of the Tube as reach'd above the top of the Receiver; And the Interval, left betwixt the sides of the Hole and those of the Tube, was very exquisitely fill'd up with melted (but not over hot) Diachylon; and the round chink, betwixt the Cover and the Receiver, was likewise very carefully clos'd up: Upon which clo∣sure there appear'd not any change in the height of the Mercurial Cylinder; no more, then if the interpos'd Glass Recei∣ver did not hinder the immediate pressure [Page  109](https://quod.lib.umich.edu/e/eebo/A29003.0001.001/136?vid=56393) of the ambient Atmosphere upon the inclosed Air; which hereby appears to bear up on the Mercury, rather by virtue of its spring, then of its weight: since its weight cannot be suppos'd to amount to above two or three Ounces, which is in∣considerable in comparison of such a Cy∣linder of Mercury as it would keep from subsiding.

All things being thus in a readiness, the Sucker was drawn down; and, immedi∣ately upon the egress of a Cylinder of Air out of the Receiver; the Quick-silver in the Tube did, according to expectati∣on, subside: and notice being carefully taken (by a mark fasten'd to the outside) of the place where it stopt, we caus'd him that manag'd the Pump to pump again, and mark'd how low the Quick-silver fell at the second exsuction; but continuing this work, we were quickly hindred from accurately marking the Stages made by the Mercury in its descent, because it soon sunk below the top of the Receiver; so that we could thenceforward mark it no other ways then by the eye. And thus, continuing the labor of pumping for a∣bout a quarter of an hour, we found our selves unable to bring the Quick-silver in [Page  110](https://quod.lib.umich.edu/e/eebo/A29003.0001.001/137?vid=56393) the Tube totally to subside; because, when the Receiver was considerably em∣pty'd of its Air, and consequently that little that remain'd grown unable to resist the Irruption of the external, that Air would (in spight of whatever we could do) press in at some little Avenue or other; and though much could not there∣at get in, yet a little was sufficient to coun∣terballance the pressure of so small a Cy∣linder of Quick-silver, as then remain'd in the Tube.

Now (to satisfie our selves further, that the falling of the Quick-silver in the Tube to a determinate height, proceeds from the *Aequilibrium,* wherein it is at that height with the external Air, the one gravitating, the other pressing with equal force upon the subjacent Mercury) we Re∣turned the Key and let in some new Air; upon which the Mercury immediatly be∣gan to ascend (or rather to be impell'd up∣wards) in the Tube, and continu'd ascend∣ing, till having Return'd the Key it im∣mediatly rested at the height which it had then attain'd: And so, by Turning and Returning the Key, we did several times at pleasure impel it upwards, and check its ascent. And lastly, having given a free [Page  111](https://quod.lib.umich.edu/e/eebo/A29003.0001.001/138?vid=56393) egress at the Stop-cock to as much of the external Air as would come in, the Quick-silver was impell'd up almost to its first height: I say almost, because it stopt near a quarter of an Inch beneath the Pa∣per mark formerly mention'd; which we ascrib'd to this, That there was (as is u∣sual in this Experiment) some little Parti∣cles of Air engag'd among those of the Quick-silver; which Particles, upon the descent of the Quick silver, did manifest∣ly rise up in Bubbles towards the top of the Tube, and by their pressure, as well as by lessening the Cylinder by as much room as they formerly took up in it, hin∣der'd the Quick-silver from regaining its first height.

This Experiment was a few days after repeated in the presence of those excellent and deservedly Famous Mathematick Professors, Dr. *Wallis,* Dr. *Ward,* and Mr. *Wren,* who were pleased to Honor it with their Presence: And whom I name, both as justly counting it an Honor to be known to them, and as being glad of such Judicious and illustrious Witnesses of our Experiment; and 'twas by their guess that the top of the Quick-silver in the Tube was defin'd to be brought within an Inch [Page  112](https://quod.lib.umich.edu/e/eebo/A29003.0001.001/139?vid=56393) of the surface of that in the Vessel.

And here, for the Illustration of the foregoing Experiment, it will not be a∣miss to mention some other particulars relating to it.

First then, When we endeavor'd to make the Experiment with the Tube clos'd at one end with *Diachylon* instead of an Hermetical Seal; we perceiv'd, that upon the drawing of some of the Air out of the Receiver, the Mercury did indeed begin to fall, but continu'd afterwards to subside, though we did not continue pum∣ping. Whence it appear'd, that though the *Diachylon* that stopt the end of the Tube were so thick and strong, that the external Air could not press it in (as expe∣rience taught us that it would have done, if there had been but little of it) yet the subt'ler parts of it were able (though slowly) to insinuate themselves through the very body of the Plaister, which it seems was of so close a Texture, as that which we mention'd our selves to have successfully made use of in the Experi∣ment *De Vacuo* some years ago. So that now we begin to suspect, that perhaps one Reason, why we cannot perfectly pump out the Air, may be, that when the Vessel [Page  113](https://quod.lib.umich.edu/e/eebo/A29003.0001.001/140?vid=56393) is almost empty, some of the subtler parts of the external Air may, by the pressure of the Atmosphere, be strain'd through the very body of the *Diachylon* into the Receiver. But this is onely con∣jecture.

Another Circumstance of our Expe∣riment was this, That, if (when the Quick-silver in the Tube was fallen low) too much ingress were, at the hole of the Stop-cock, suddenly permitted to the ex∣ternal Air; it would rush in with that vio∣lence, and bear so forcibly▪ upon the sur∣face of the subjacent Quick-silver, that it would impel it up into the Tube rudely enough to endanger the breaking of the Glass.

We formerly mention'd, that the Quick-silver did not in its descent fall as much at a time after the two or three first exsuctions of the Air, as at the beginning: For, having mark'd its several Stages up∣on the Tube, we found, that at the first suck it descended an Inch and •/8, and at the second an Inch and ⅛; and when the Ves∣sel was almost empty'd, it would scarce at one exsuction be drawn down above the breadth of a Barly-corn. And indeed we found it very difficult to measure in what [Page  114](https://quod.lib.umich.edu/e/eebo/A29003.0001.001/141?vid=56393) proportion these decrements of the Mer∣curial Cylinder did proceed: partly be∣cause (as we have already int•mated) the Quick-silver was soon drawn below the top of the Receiver; and partly because, upon its descent at each ex•uction, it would immediatly reascend a little up∣wards; either by reason of the leak•ng of the Vessel at some imperceptible hole or other, or by reason of the motion of Restitution in the Air, which, being some∣what comprest by the fall as well as we we•ght of the Quick-silver, would repell it a lit∣tle upwards, and make it vibrate a little up and down, before they could reduce each other to such an *Aequilibrium* as both might rest in. But though we could not hitherto make observations accurate e∣nough concerning the measures of the Quick-silver's descent, to reduce them in∣to any *Hypothesis,* yet would we not dis∣courage any from attempting it; since, if it could be reduc'd to a certainty, 'tis proba∣ble that the discovery would not be un∣useful.

And, to illustrate this matter a little more, we will adde, That we made a shift to try the Experiment in one of our above mention'd small Receivers, not containing [Page  115](https://quod.lib.umich.edu/e/eebo/A29003.0001.001/142?vid=56393) a Quart; but that (agreeably to what we formerly observed) we found it as difficult to bring this to be quite empty as to eva∣cuate the greater; the least external Air that could get in (and we could not possi∣bly keep it all perfectly out) sufficing in so small a Vessel to display a considerable pressure upon the surface of the Mercury, and thereby hinder that in the Tube from falling to a level with it. But this is remark∣able, that having two or three times try'd the Experiment in that small Vessel, upon the very first Cylinder of Air that was drawn out of the Receiver, the Mercury fell in the Tube 18 Inches and a half, and at another 19 Inches and a half.

But, on this occasion, I hold it not un∣fit to give Your Lordship notice that I hop'd, from the descent of the Quick-silver in the Tube upon the first suck, to derive this advantage: that I should thence be enabled to give a near guess at the pro∣portion of force betwixt the pressure of the Air (according to its various states, as to Density and Rarefaction) and the gra∣vity of Quick-silver, then hitherto has been done. For in our Experiment there are diverse things given, that may be made use of towards such a discovery. [Page  116](https://quod.lib.umich.edu/e/eebo/A29003.0001.001/143?vid=56393) For first we may know the capacity of the Receiver wherein the Experiment is made, since, by filling it with water, we may easily compute how many Quarts, or Measures of any other denomination, it contains of Air; which Air, when shut up in the Vessel, may be suppos'd to have a pressure equal to that of the Atmo∣sphere; since it is able to keep the Quick-silver in the Tube from falling any lower then it did in the free and open Air. Next here is given us the capacity of the brass Cylinder empty'd by the drawing down of the Sucker (its bore and height being mention'd in the description of our Pump) whereby we may come to know how much of the Air contain'd in the Recei∣ver is drawn out at the first suck. And we may also easily define, either in weight or cubick measures the Cylinder of Quick-silver that answers to the Cy∣linder of Air lately mention'd (that Mercuriall Cylinder being in our En∣gine computable by deducting from the entire altitude of that Cylinder of Quick-silver, the altitude at which it rests upon the first exsuction.) But though, if this Experiment were very watchfully try'd in Vessels of several sizes, and the [Page  117](https://quod.lib.umich.edu/e/eebo/A29003.0001.001/144?vid=56393) various descents of the Quick-silver com∣par'd among themselves, 'tis not impro∣bable that some such thing as we hop'd for may thereby be discover'd. Yet because not onely the solid contents of as much of the Glass-tube as remains within the concave surface of the Receiver, and (which is more difficult) the varying con∣tents of the Vessel containing the Mer∣cury, and of as much of the Mercury it self as is not in the Tube, must be dedu∣cted out of the capacity of the Receiver; but there must also an allowance be made for this, that the Cylinder that is empty'd by the drawing down of the Sucker, and comes to be fill'd upon the letting of the Air out of the Receiver into it, is not so replenish'd with Air as the Receiver it self at first was: because there passes no more Air out of the Receiver into the Cylin∣der, then is requisite to reduce the Air in the cavity of the Cylinder, and in that of the Receiver to the same measure of dila∣tation: Because of these (I say) and some other difficulties that require more skill in Mathematicks then I pretend to, and much more leasure then my present occasions would allow me, I was willing to refer the nicer consideration of this matter to some [Page  118](https://quod.lib.umich.edu/e/eebo/A29003.0001.001/145?vid=56393) of our Learned and Acurate Mathema∣ticians, thinking it enough for me to have given the Hint already suggested.

For further confirmation of what hath been delivered, we likewise tryed the Ex∣periment in a Tube of less then two foot long: and, when there was so much Air drawn out of the Vessel, that the remain∣ing Air was not able to counterballance the Mercurial Cylinder, the Quick-silver in the Tube subsided so visibly, that (the Experiment being try'd in the little Ves∣sel lately mention'd) at the first suck it fell above a span, and was afterwards drawn lower and lower for a little while; and the external Air being let in upon it, impell'd it up again almost to the top of the Tube: So little matters it how heavy or light the Cylinder of Quick silver to subside is, provided its gravity over-power the pressure of as much external Air as bears upon the surface of that Mer∣cury into which it is to fall.

Lastly we also observ'd, That if (when the Mercury in the Tube had been drawn down, and by an Ingress permitted to the external Air, impell'd up again to its for∣mer height) there were some more Air thrust up by the help of the Pump into [Page  119](https://quod.lib.umich.edu/e/eebo/A29003.0001.001/146?vid=56393) the Receiver, the Quick-silver in the Tube would ascend much above the wonted height of 27 digits, and immediatly up∣on the letting out of that Air would fall a∣gain to the height it rested at before.

Your Lordship will here perhaps expect, that as those who have treated of the *Tor∣ricellian* Experiment, have for the most part maintaind the Affirmative, or the Ne∣gative of that famous Question, Whether or no that Noble Experiment infer a *Va∣cuum?* so I should on this occasion inter∣pose my Opinion touching that Contro∣versie, or at least declare whether or no, in our Engine, the exsuction of the Air do prove the place deserted by the Air suck'd out, to be truly empty, that is, devoid of all Corporeal Substance. But besides that, I have neither the leisure, nor the ability, to enter into a solemn Debate of so nice a Question; Your Lordship may, if you think it worth the trouble, in the Dia∣logues not long since referr'd to, finde the Difficulties on both sides represented; which then made me yield but a very wa∣vering assent to either of the parties con∣tending about the Question: Nor dare I yet take upon me to determine so difficult a Controversie.

[Page  120](https://quod.lib.umich.edu/e/eebo/A29003.0001.001/147?vid=56393)For on the one side it appears, that not∣withstanding the exsuction of the Air, our Receiver may not be destitute of all Bo∣dies, since any thing placed in it, may be seen there; which would not be, if it were not pervious to those Beams of Light which rebounding from the seen Object to our eyes, affect us with the sense of it: And that either these Beams are Corporeal Emanations from some lucid body, or else at least the light they convey doth result from the brisk Motion of some subtle Matter, I could, if I mistake not, sufficiently manifest out of the Dialogues above-mention'd, if I thought your Lord∣ship could seriously imagine that Light could be convey'd without, at least, having (if I may so speak) a Body for its Ve∣hicle.

By the sixteenth Experiment, it also appears that the closeness of our Receiver hinders it not from admitting the Efflu∣via of the Load-stone; which makes it very probable that it also freely admits the Magnetical steams of the Earth; con∣cerning which, we have in another Trea∣tise endeavour'd to manifest that numbers of them do always permeate our Air.

But on the other side it may be said, [Page  121](https://quod.lib.umich.edu/e/eebo/A29003.0001.001/148?vid=56393) That as for the subtle Matter which makes the Objects enclosed in our evacuated Re∣ceiver, visible, and the Magnetical Efflu∣via of the Earth that may be presum'd to pass thorow it, though we should grant our Vessel not to be quite devoyd of them, yet we cannot so reasonably affirm it to be replenish'd with them, as we may suppose, that if they were gather'd toge∣ther into one place without Intervals be∣tween them, they would fill but a small part of the whole Receiver. As in the thirteenth Experiment, a piece of Match was inconsiderable for its bulk, whilest its parts lay close together, that afterwards (when the Fire had scatter'd them into smoke) seem'd to replenish all the Vessel. For (as elsewhere our Experiments have demonstrated) both Light and the Efflu∣via of the Load-stone, may be readily ad∣mitted into a Glass, Hermetically seal'd, though before their Admission, as full of Air as hollow Bodies here below are wont to be, so that upon the exsuction of the Air, the large space deserted by it, may remain empty, notwithstanding the pre∣tence of those subtle Corpuscles, by which Lucid and Magnetical Bodies pro∣duce their effects.

[Page  122](https://quod.lib.umich.edu/e/eebo/A29003.0001.001/149?vid=56393)And as for the Allegations above mention'd, they seem to prove but that the Receiver devoy'd of Air, *May* be re∣plenish'd with some such Etherial Matter, as some Modern Naturalists write of; but not that it really *is* so. And indeed to me it yet seems, that as to those spaces which the *Vacuists* would have to be empty, be∣cause they are manifestly devoid of Air; and all grosser Bodies, the *Plenists* (if I may so call them) do not prove that such spaces are replenish'd with such a subtle Matter as they speak of, by any sensible effects, or operations of it (of which di∣vers new Tryals purposely made, have not yet shown me any) but onely conclude that there must be such a Body, because there cannot be a Void. And the reason why there cannot be a Void, being by them taken, not from any Experiments, or *Phaenomena* of Nature, that clearly and particularly prove their *Hypothesis,* but from their notion of a Body, whose Na∣ture, according to them, consisting one∣ly in extension (which indeed seems the property most essential to, because insepa∣rable from a Body) to say a space devoid of Body, is to speak in the School-mens Phrase, a Contradiction *in Adjecto*: This [Page  123](https://quod.lib.umich.edu/e/eebo/A29003.0001.001/150?vid=56393) reason, I say, being thus desum'd, seems to make the Controversie about a *Vacu∣um,* rather a Metaphysical, then a Physio∣logical Question; which therefore we shall here no longer debate, finding it very dif∣ficult either to satisfie Naturalists with this Cartesian Notion of a Body, or to manifest wherein it is erroneous, and sub∣stitute a better in its stead.

But though we are unwilling to exa∣mine any further the Inferences wont to be made from the *Torricellian* Experi∣ment, yet we think it not impertinent to present Your Lordship with a couple of Advertisements concerning it.

First, then if in trying the Experiment here or elsewhere, you make use of the English measures that Mathematicians and Tradesmen are here wont to imploy, You will, unless you be forewarn'd of it, be apt to suspect that those that have writ∣ten of the Experiment have been mista∣ken. For whereas men are wont gene∣rally to talk of the Quick-silver's remain∣ing suspended at the heighth of between six or seven and twenty Inches; we com∣monly observ'd, when divers years. since we first were sollicitous about this Expe∣riment, that the Quick-silver in the Tube [Page  124](https://quod.lib.umich.edu/e/eebo/A29003.0001.001/151?vid=56393) rested at about 29 Inches & an half above the surface of the Restagnant Quick-silver in the Vessel, which did at first both amaze and perplex us, because though we held it not improbable that the difference of the grosser English Air, and that of *Italy* and *France,* might keep the Quick-silver from falling quite as low in this colder, as in those warmer Climates; yet we could not believe that that difference in the Air should alone be able to make so great a one in the heights of the Mercurial Cylinders; and accordingly upon enquiry we found, that though the various density of the Air be not to be over-look'd in this Ex∣periment, yet the main Reason why we found the Cylinder of Mercury to consist of so many Inches, was this, That our English Inches are somewhat inferior in length to the digits made use of in Fo∣rein Parts, by the Writers of the Expe∣riment.

The next thing I desire Your Lordship to take notice of, is, That the heigth of the Mercurial Cylinder is not wont to be foūd altogether so great as really it might prove, by reason of the negligence or in∣cogitancy of most that make the Experi∣ment. For of••n times upon the opening [Page  125](https://quod.lib.umich.edu/e/eebo/A29003.0001.001/152?vid=56393) of the inverted Tube into the Vessell'd Mercury, you may observe a bubble of Air to ascend from the bottom of the Tube through the subsiding Quick-silver to the top; and almost always you may, if you look narrowly, take notice of a multitude of small bubbles all along the inside of the Tube betwixt the Quick-silver & the glass: (not now to mention the Particles of Air that lye conceal'd in the very Body of the Mercury) Many of which, upon the Quick-silvers forsaking the upper part of the Tube, do break in∣to that deserted space where they finde little or no resistance to their expanding of themselves. Whether this be the rea∣son that upon the Application of warm Bodies to the emptyed part of the Tube, the subjacent Mercury would be depress'd somewhat lower, we shall not determine; though it seem very probable, especially since we found that upon the application of Linnen cloaths dipped in Water, to the same part of the Tube, the Quick-silver would somewhat ascend, as if the cold had condens'd the Imprison'd Air, that press'd upon it, into a lesser room. But that the deserted space is not wont to be totally devoid of Air, we were induc'd [Page  126](https://quod.lib.umich.edu/e/eebo/A29003.0001.001/153?vid=56393) to think by several Circumstances. For when an eminent Mathematician, and ex∣cellent Experimenter, had taken great pains and spent much time in accuratly fil∣ling up a Tube of Mercury, we found that yet there remain'd store of inconspi∣cuous bubbles, by inverting the Tube, letting the Quick-silver fall to its wonted heighth; and by approaching (by de∣grees) a red hot Iron to the out-side of the Tube, over against the upper part of the Mercurial Cylinder, for hereby the little unheeded bubbles, being mightily expan∣ded, ascended in such numbers, and so fast to the deserted space, that the upper part of the Quick-silver seem'd, to our wonder, to boyl. We further observ'd, That in the tryals of the *Torricellian*Experiment we have seen made by others, and (one excepted) all our own, we never found that upon the inclining of the Tube the Quick-silver would fully reach to the very top of the seal'd end: which argued, that there was some Air retreated thither that kept the Mercury out of the unreplenish'd space.

If Your Lordship should now demand what are the best expedients to hinder the intrusion of the Air in this Experiment; [Page  127](https://quod.lib.umich.edu/e/eebo/A29003.0001.001/154?vid=56393) we must answer, That of those which are easily intelligible without ocular demon∣stration, we can at present suggest upon our own tryals no better then these. First, at the open end of the Tube the Glass must not onely be made as even at the ed∣ges as you can, but it is very conveni∣ent (especially if the Tube be large) that the bottom be every way bent inwards, that so the Orifice, not much exceeding a quarter of an Inch in Diameter, may be the more easily and exactly stopp'd by the Experimenter's finger; between which and the Quick-silver, that there may be no Air intercepted (as very often it hap∣pens that there is) it is requisite that the Tube be fill'd as full as possibly it can be, that the finger which is to stop it, pressing upon the accumulated and protuberant Mercury, may rather throw down some, then not finde enough exactly to keep out the Air. It is also an useful and compen∣dious way not to fill the Tube at first quite ful of Mercury, but to leave near the top about a quarter of an Inch empty; for if you then stop the open end with your finger, and invert the Tube that quarter of an Inch of Air will ascend in a great bubble to the top, and in its passage thi∣ther, [Page  128](https://quod.lib.umich.edu/e/eebo/A29003.0001.001/155?vid=56393) will gather up all the little bubbles, and unite them with it self into one great one, so that if by reinverting the Tube you let that bubble return to the open end of it, you will have a much closer Mer∣curial Cylinder then before, and need but to adde a very little Quick-silver more to fill up the Tube exactly. And lastly, as for those lesser and inconspicuous parcels of Air which cannot this way be gleaned up, You may endeavor before you invert the Tube, to free the Quick-silver from them by shaking the Tube, and gently knock∣ing on the out-side of it, after every little parcel of Quick-silver which you pour in; and afterwards, by forcing the small la∣titant bubbles of Air to disclose them∣selves and break, by imploying a hot Iron in such manner as we lately mention'd. I remember that by carefully filling the Tube, though yet it were not quite free from Air, we have made the Mercurial Cylinder reach to 30 Inches and above an eighth, and this in a very short Tube: which we therefore mention, because we have found, by experience, that in short Tubes a little Air is more prejudicial to the Experiment then in long ones, where the Air having more room to expand it [Page  129](https://quod.lib.umich.edu/e/eebo/A29003.0001.001/156?vid=56393) self, does less potently press upon the sub∣jacent Mercury.

And since we are fallen upon the consi∣deration of the Altitude of the Mercurial Cylinder, I must not conceal from Your Lordship an Experiment relating thereun∣to, which perhaps will set both You and many of your Friends the *Virtuosi* a think∣ing; and, by disclosing some things a∣bout the Air or Atmosphere that have scarce hitherto been taken notice of, may afford you some hints conducive to a fur∣ther discovery of the subject of this E∣pistle.

WE took a Glass Tube,[\*](https://quod.lib.umich.edu/e/eebo/A29003.0001.001?id=DLPS20;lvl=1;note=inline;rgn=main;view=trgt) which, though it were not much above three Foot long, we made choice of be∣cause it was of a more then ordinarily even thickness. This we fill'd with Mer∣cury, though not with as much care as we could, yet with somewhat more then is wont to be used in making the *Torricellian* Experiment. Then, having according to the manner inverted the Tube, and open'd the mouth of it beneath the surface of some other Quick-silver, that in the Tube fell down to the wonted heigth, leaving, [Page  130](https://quod.lib.umich.edu/e/eebo/A29003.0001.001/157?vid=56393) as is usual, some little Particles of Air in the space it deserted, as we ghest by ob∣serving, that upon the Application of hot Bodies to the upper part of the Tube, the Quick-silver would be a little depress'd. Lastly, having put both the Tube and the Vessel it lean'd on into a convenient Wooden Frame, to keep them from mis∣chances: we plac'd that Frame in a Win∣dow within my Bed-chamber, that I might both keep the Mercury from being stirr'd, and have opportunity to watch from time to time the *Phaenomena* it was to exhibit. For the better discovery of which, when the Quick-silver both in the Tube and subjacent Vessel was perfectly at rest, we took notice, by a mark made on the out∣side of the Glass, how high the included Liquor then reach'd.

During several Weeks that the Tube was kept in that Window (which was very rarely open'd) I had the opportunity to observe, that the Quick-silver did some∣times faintly imitate the Liquor of a Weather-glass, subsiding a little in warm, and rising a little in cold Weather, which we ascribed to the greater or lesser pressure of that little Air that remain'd at the top of the Tube, expanded or condens'd by [Page  131](https://quod.lib.umich.edu/e/eebo/A29003.0001.001/158?vid=56393) the heat or cold that affected the ambient Air. But that which I was chiefly careful to observe, was this, That oftentimes the Quick-silver did rise and fall in the Tube, and that very notably, without conforming it self to what is usual in Weather-glasses, whose Air is at the top, nay quite contrary thereunto: for sometimes I observ'd it in very cold weather (such as this Winter has already afforded us good store of) to fall down much lower then at other times, when by reason of the absence of both Frost, Snow, and sharp Winds, the Air was comparatively much warmer. And I fur∣ther observ'd, That sometimes the Quick-silver would for some days together rest almost at the same height; and at other times again it would in the compass of the same day considerably vary its altitude, though there appear'd no change either in the Air abroad, or in the temper of the Air within the Room (wherein was constantly kept a good Fire) nor in any thing else, to which either I, or some eminently Learned Men whom I then acquainted with the Experiment, could reasonably impute such a change: Especially considering that the space wherein the Mercury wandred up and down, within about five Weeks, a∣mounted to full two Inches, of which we [Page  132](https://quod.lib.umich.edu/e/eebo/A29003.0001.001/159?vid=56393) found by our several marks whereby we had taken notice of its several removes, that it had descēded about •/16 of an Inch from the place where it first setled, & the other Inch and •/16 it had ascended. And it seems pro∣bable that the height of the Mercurial Cy∣linder would have varied yet more, if the Experiment had been made in the open Air and in a long Tube, where the Parti∣cles of the Imprison'd Air, by having more room to display themselves in, might not have had so strong a Spring to work upon the Quick-silver with. But for want both of time and of a competent quantity of Mercury (which was not to be procur'd where we then happen'd to be) we were unable to make any further try∣als: which therefore chiefly troubled us, because we would gladly have try'd an in∣genious Experiment which was suggested unto us by that excellent Mathematician Mr. *Wren,* who being invited to name any thing he would have us try touching the pressure of the Air, desired us to observe whether or no the Quick-silver in a long Tube would not a little vary its height ac∣cording to the Tides, especially about the New and Full Moon, about which times Mariners observe those great Flowings and Ebbs of the Sea, that they call the [Page  133](https://quod.lib.umich.edu/e/eebo/A29003.0001.001/160?vid=56393) Spring-Tides. For he sagaciously and plausibly conjectur'd that such observati∣ons accurately made, would discover the truth or erroneousness of the *Cartesian Hypothesis*concerning the Ebbing and Flowing of the Sea: which *Des Cartes* ascribes to the greater pressure made upon the Air by the Moon, and the Intercur∣rent Ethereal Substance at certain times (of the Day, and of the Lunary Moneth) then at others. But in regard we found the Quick-silver in the Tube to move up and down so uncertainly, by reason, as it seems, of accidental mutation in the Air; I somewhat doubt whether we shall finde the Altitude of the Quick-silver to vary as regularly as the Experiment is ingeni∣ously propos'd. The success we shall (God permitting us to make tryal of it) acquaint Your Lordship with; and in the mean time take notice, that when we had occa∣sion to take the Tube out of the Frame (after it had staid there part of *November* and part of *December*) a good Fire being then in the room, because it was a Snowy day, we found the Quick-silver in the Tube to be above the upper surface of the subjacent Mercury 29 Inches three quarters.

[Page  134](https://quod.lib.umich.edu/e/eebo/A29003.0001.001/161?vid=56393)If Your Lordship should now ask me what are the true causes of this varying al∣titude of the Mercurial Cylinder; I should not undertake to answer so difficult a que∣stion, and should venter to say no more, then that among divers possible causes to which it may be ascribed, it would not be, perhaps, absurd to reckon these that fol∣low.

First then we may consider, that the Air in the upper part of the Tube is much more rarified, and therefore more weak then the external Air, as may appear by this among other things, That upon the in∣clining of the Tube the Quick-silver will readily ascend almost to the very top of it, and so take up eight or nine tenth parts, and perhaps more of that space which it deserted before: which would not happen if that whole space had been full of unra∣rified Air, since that (as tryal may easily satisfie you) would not have suffer'd it self to be thrust into so narrow a room by so weak a pressure. So that although in our Tube when the included Air was heated, the Quick-silver was somewhat depress'd: Yet there is this difference be∣twixt such a Tube and common Weather-Glasses, that in these the included and the [Page  135](https://quod.lib.umich.edu/e/eebo/A29003.0001.001/162?vid=56393) ambient Air are in an *Aequilibrium* as to pressure, and the weight of the Water that keeps them separate is scarce consi∣derable. Whereas in such a Tube as we are speaking of, the Air within is very much more dilated then that without▪ and 'tis not so much the spring or resistance of the included Air, as the weight of the Mercurial Cylinder it self that hinders the Quick-silver from ascending higher; for if we should suppose that deserted part of the Tube perfectly devoid of Air, yet would the Quick-silver rise but a little higher in it, and be far from filling it, in regard the outward Air would not be able to impel up such a weight much higher: whereas it may, by our former Experiments appear, that if all the Air in the upper part of a Weather-Glass were away, the Water would be impell'd up to the very top of it, though the Pipe were above thirty Foot long.

We may next consider, that this ra∣rified Air at the upper part of our Tube being exactly shut up betwixt the Glass and the Quick-silver, it was scarce subject to any discernable alterations, save those it receiv'd from heat and cold.

[Page  136](https://quod.lib.umich.edu/e/eebo/A29003.0001.001/163?vid=56393)And we may further consider that yet the external Air or Atmosphere is subject to many alterations, besides them that proceed from either of those Quali∣ties.

For the Experiment that occasion'd this Discourse, seems to make it proba∣ble enough that there may be strange Ebbings and Flowings, as it were, in the Atmosphere; or at least, that it may ad∣mit great and sudden Mutations, either as to its Altitude or its Density, from causes, as well unknown to us, as the effects are unheeded by us. And that You may not think that there is nothing in Nature but our Experiment that agrees with this our conjecture, we might put Your Lordship in minde of the Pains and Aches that are often complain'd of by those that have had great Wounds or Bruises, and that doe presage great Mutations in the Air oftentimes, whilst to strong and healthy Persons no sign of any such thing appears. And that is also very memorable to this purpose, which I remember I have some∣where read in a Book of the Ingenious *Kircherus,* who giving a pertinent admoni∣tion concerning the various refractions that may happen in the Air, relates, That [Page  137](https://quod.lib.umich.edu/e/eebo/A29003.0001.001/164?vid=56393) during his stay in *Malta,* he often saw Mount *Aetna,* though the next day, not∣withstanding its being extreamly clear, he could not see it; adding, that *Vintemillius,* a very Learned Person, did oftentimes, from a Hill he names, behold the whole Island he calls *Luprica* protuberant above the Sea, though at other times, notwith∣standing a clear Sky, he could not see it. And though perhaps this may be in part a∣scribed to the various light & position of the sun, or to the various disposition of the Spectators eye, or peradventure to some other cause; yet the most probable cause seems to be the differing Density of the Air, occasion'd by Exhalations capable to increase the refraction, and consequently bring Beams to the Eye, which otherwise would not fall on it. We have likewise in another Treatise mention'd our having often observ'd with Telescopes a plenty of Steams in the Air, which without such a help would not be taken notice of; and which as they were not at all times to be seen even through a Telescope, so they did sometimes, especially after a shower of Rain, hastily disappear: and when we have visited those places that abound with Mines, we have several times been told [Page  138](https://quod.lib.umich.edu/e/eebo/A29003.0001.001/165?vid=56393) by the Diggers, that even when the Sky seem'd clear, there would not seldom sud∣denly arise, and sometimes long continue, a certain Steam (which they usually call a damp) so gross and thick, that it would oftentimes put out their very Candles, if they did not seasonably prevent it. And I think it will easily be granted, that the ascension of such Steams into this or that part of the Air, and their mixing with it, are very like to thicken it; as on the o∣ther side either heat or the sudden conden∣sation of the Air in another part of the At∣mosphere (to mention now no other cau∣ses) are capable of rarifying it.

Nor will it very much import the main scope of our Discourse, whether it be suppos'd that the copious Steams the earth sends into the air, thicken that part of the Atmosphere that receives them, and make it more heavy: Or that some∣times the Fumes may ascend with such ce∣lerity, that though the Air be thicken'd yet they rather diminish then encrease its gravitation, in regard that the quickness of their ascent, not onely keeps them from gravitating themselves, but may hinder the pressing downwards of many Aërial Corpuscles that they meet with in [Page  139](https://quod.lib.umich.edu/e/eebo/A29003.0001.001/166?vid=56393) their way upwards. This, I say, is of no great importance to our present Dis∣course, since either way the Terrestrial Steam may here and there considerably alter the gravity or pressure of the At∣mosphere.

Your Lordship may also be pleased to remember, That by our seventeenth Ex∣periment it appear'd that as when the Air in the Receiver was expanded more then ordinarily, the Quick-silver in the Tube did proportionably subside; so when the Air in the same Receiver was a little more then ordinarily compress'd, it did impell up the Quick-silver in the Tube above the wonted height of betwixt six and se∣ven and twenty digits.

And if to these things we annex, that for ought we can finde by tryals purpose∣ly made, the degree of rarity or density of the Air, shut up into our Receiver, does not sensibly alter its temperature as to cold or heat. It will not, I hope, appear absurd to conceive, That since the Air, included in the Tube, could but very faint∣ly hinder the ascent of the Quick-silver, or press it downwards, since too that inclu∣ded Air could scarce immediately receive any sensible alteration, save either by heat [Page  140](https://quod.lib.umich.edu/e/eebo/A29003.0001.001/167?vid=56393) or cold. And since also that according to the bare density or rarity of the Air in∣cumbent on the subjacent Quick-silver in the Vessel, that in the Tube was impell'd more or less high; such changes happen∣ing in the neighboring part of the out∣ward Air, either by the ascension of gross or copious exhalations, or by any other cause (of which there may be divers) as were capable to make considerable altera∣tions in the consistence of the Air, as to rarity and density, *may* be able propor∣tionably to alter the heighth of the Quick-silver: I rather say, that such alte∣rations *may* be, then that they *are* the causes of our *Phaenomenon,* because I think it sufficient, if I have propos'd conje∣ctures not altogether irrational about a new Mystery of Nature, touching which, the chief thing I pretend to, is to give oc∣casion to the Curious to inquire further into it then I have been yet able to do.

[\*](https://quod.lib.umich.edu/e/eebo/A29003.0001.001?id=DLPS21;lvl=1;note=inline;rgn=main;view=trgt)THe same Reason that mov'd us to conclude, that by the drawing of the Air out of the Receiver, the Mercury would descend in a Tube shorter then six and twenty digits, induc'd us also to ex∣pect, [Page  141](https://quod.lib.umich.edu/e/eebo/A29003.0001.001/168?vid=56393) that by the same means Water might be brought to subside in Glass Tubes of a moderate length, though by the noble Experiment, said to have been accurately made in *France* by *Monsieur Paschal,* we are informed that a Tube of no less then about two and thirty Foot, was found requisite to make the Experi∣ment *De Vacuo* succeed with Water in∣stead of Quick-silver: so tall a Cylinder of that lighter Liquor, being, it seems, requisite to equal the weight of a Mercu∣rial Cylinder of six or seven and twenty digits, and surmount the pressure of the Atmosphere.

We took then a Tube of Glass, Her∣metically seal'd at one end, of about four foot in length, and not very slender: This at the open end we fill'd with common Water, and then stopt that end till we had inverted the Tube, and open'd it be∣neath the surface of a quantity of the like Water, contain'd in a somewhat deep and slender Vessel. This Vessel, with the Tube in it, was let down into the Recei∣ver, and the Receiver being clos'd up af∣ter the accustom'd manner, the Pump was set awork.

[Page  142](https://quod.lib.umich.edu/e/eebo/A29003.0001.001/169?vid=56393)As much of the event as concerns our present purpose, was this, That till a con∣siderable part of the Air was drawn out of the Receiver, the Tube continu'd top-full of Water as when it was put in, it be∣ing requisite that a great part of the Air formerly contain'd in the Receiver, should be drawn out, to bring the remaining Air to an *Aequilibrium* with so short and light a Cylinder of Water. But when once the Water began to fall in the Tube, then each exsuction of Air made it de∣scend a little lower, though nothing near so much as the Quick-silver at the begin∣ning did in the Experiment formerly men∣tion'd. Nor did there appear so much inequality in the spaces transmitted by the Water in its descent, as there did in those observ'd in the •all of the Quick-silver, of which the cause will scarce seem abstruse to him that shall duly reflect up∣on what has been already deliver'd. And whereas we drew down the Quick-silver in the Tube so far as to bring it within an Inch of the surface of the other Quick-silver into which it was to fall; the lowest we were able to draw down the Water was, by our conjecture, to about a Foot [Page  143](https://quod.lib.umich.edu/e/eebo/A29003.0001.001/170?vid=56393) or more above the surface of that in the Vessel; of which I know not whether it will be needful to assign so obvious a cause as that, though the little Air remaining in the Receiver could not hinder a Cylin∣der of above an Inch high of Quick-silver from subsiding; yet it might very well be able, by its pressure, to countervail the weight of a Cylinder of a Foot long or more, of a Liquor so much less ponderous then Quick-silver, as Water is. And in fine, to conclude our Experiment, when the Water was drawn down thus low, we found, that by letting in the outward Air, it might be immediately impell'd up a∣gain to the higher parts of the Tube.

We will adde no more concerning this Experiment, save that having try'd it in one of our small Receivers, we observ'd, That upon the first exsuction of the Air the Water did usually subside dive•s In∣ches, and at the second (exsuction) fall down much lower, subsiding sometimes near two Foot; as also that upon the let∣ting in of the Air from without, the Wa∣ter was impell'd up with very great ce∣lerity.

[Page  144](https://quod.lib.umich.edu/e/eebo/A29003.0001.001/171?vid=56393)THat the Air has a notable Elastical power (whencesoever that proceeds) we have,[\*](https://quod.lib.umich.edu/e/eebo/A29003.0001.001?id=DLPS22;lvl=1;note=inline;rgn=main;view=trgt) I suppose, abundantly evinc'd, and it begins to be acknowledg'd by the eminentest Modern Naturalists. But whe∣ther or no there be in Water so much as a languid one, seems hitherto to have been scarce consider'd, nor has been yet, for ought I know, determin'd either way by any Writer, which invited us to make the following Experiment.

There was taken a great Glass-bubble, with a long neck; (such as Chymists are wont to call a Philosophical Egg) which being fill'd with common Water till the Liquor reach'd about a span above the bubble, and a piece of Paper being there pasted on, was put unstop'd into the Re∣ceiver, and then the Air was suck'd out after the wonted manner. The event was this, That a considerable part of the Air, pent up in the Receiver, was drawn out before we discern'd any expansion of the Water; but, continuing the labor of pumping, the Water manifestly began to ascend in the stem of the Glass, and di∣vers bubbles loosening themselves from [Page  145](https://quod.lib.umich.edu/e/eebo/A29003.0001.001/172?vid=56393) the lower parts of the Vessel, made their way through the Body of the Water, to the top of it, and there brake into the Receiver: And after the Water once ap∣pear'd to swell, then at each time the Stop-cock was turn'd to let out the air from the Receiver into the Pump, the Water in the Neck of the Glass did suddenly rise a∣bout the breadth of a Barly-corn in the Neck of the Glass, and so attain'd, by degrees, to a considerable height above the mark formerly mention'd. And at length (to make the expansion of the Wa∣ter more evident) the outward Air was suddenly let in, and the Water immedi∣ately subsided and deserted all the space it had newly gain'd in the Glass.

And, on this occasion, it will not per∣haps be amiss to acquaint Your Lordship here (though we have already mention'd it in another Paper, to another purpose) with another Expedient that we made use of two or three years ago, to try whether or no Water had a Spring in it. About that time then, That Great and Learned Promoter of Experimental Philosophy Dr. *Wilkins,* doing me the Honor to come himself, and bring some of his in∣quisitive Friends to my Lodging, we [Page  146](https://quod.lib.umich.edu/e/eebo/A29003.0001.001/173?vid=56393) there had in readiness a round and hollow Vessel of Pewter, great enough to con∣tain two pounds of Water, and exactly close every where, but at one little hole where it was to be fill'd; then partly by sucking out the Air, and partly by inject∣ing Water with a Syringe, it was (not without some difficulty) fill'd up to the top; and that hole being plac'd directly upwards, there was a little more Water leisurely forc'd in by the Syringe. Upon which, though the Vessel were permitted to rest, and the hole kept in its former po∣sture, yet the compress'd Water leisurely swell'd above the Orifice of the hole, and divers drops ran over along the sides of the Vessel. After this, we caus'd a skilful Pew∣terer (who had made the Globe) to close it up in our presence with Soder so exqui∣sitely, that none suspected there was any thing left in it besides Water. And last∣ly, the Vessel thus soder'd up, was wari∣ly and often struck in divers places with a Wooden Mallet, and thereby was mani∣festly compress'd, whereby the inclosed Water was crouded into less room then it had before: And thereupon when we took a Needle, and with it and the Mallet per∣forated the Vessel, and drew out the [Page  147](https://quod.lib.umich.edu/e/eebo/A29003.0001.001/174?vid=56393) Needle again; the Water (but in a very slender Stream) was suddenly thrown af∣ter it into the Air, to the height of two or three Feet. As for the other *Phaenome∣na* of this Experiment, since they belong not to our present purpose, and are partly mention'd in another of our Papers, we shall, instead of recording them here, give this Advertisement: That as evidently as this Experiment, and that made in our Receiver, seem to prove a power in the Water to expand and restore it self after compression; yet for a reason to be met with ere long, I judged it not safe to in∣fer that Conclusion from these Premises, till I had made some of the following try∣als, to the mention of which I will there∣fore hasten.

TO discover whether the Expansion of the Water really proceeded from an Elastical power in the parts of the Water it self,[\*](https://quod.lib.umich.edu/e/eebo/A29003.0001.001?id=DLPS23;lvl=1;note=inline;rgn=main;view=trgt) we thought it requisite to try two things: The one, Whether or no the Atmosphere gravitates upon Bodies under Water; and the other, Whether in case it do gravitate, the Intumescence of the Water may not be ascribed to some [Page  148](https://quod.lib.umich.edu/e/eebo/A29003.0001.001/175?vid=56393) substance subtler then it self, residing in it. In order to the satisfying my self about the first of these, I intended to let down into the Receiver a Vessel of Water, wherein should be immers'd a very small oyl'd Bladder, almost devoid of Air, but strongly ty'd up at the Neck with a string, and detain'd a little under Water by such a weight fasten'd to that string, as should just be able to keep the Bladder from swimming, and no more. For I suppos'd, that if when all things were thus order'd, the Receiver were empty'd, in case there were any such pressure of the Atmosphere upon Water, as I was inclin'd to believe, the Air within the Bladder, being upon the exsuction of the Air within the Receiver, freed from that pressure, and being press'd onely by the small weight of the in∣cumbent Water, would considerably ex∣pand it self; but whil'st we were prepa∣ring Bladders for this Experiment, there occurd an easie way for the making at once both the Discoveries I desir'd.

We took then a Glass Viol, containing by ghess a pound and some ounces of Water, this we fill'd top full, and then we put into the Neck of it a Glass Pipe a pretty deal bigger then a Goose Quill, [Page  149](https://quod.lib.umich.edu/e/eebo/A29003.0001.001/176?vid=56393) open at both ends, and of divers Inches in length: One end of this Pipe was so put into the Neck of the Viol, as to reach a little below it, and then was carefully cemented thereto that no Air might get into the Viol, nor no Water get out of it, otherwise then through the Pipe; and then the Pipe being warily fill'd, about half way up to the top, with more Wa∣ter, and a mark being pasted over against the upper surface of the Liquor; the Viol thus fitted with the Pipe, was, by strings let down into the Receiver, and according to the wonted manner exquisitely clos'd up in it.

This done, we began to Pump out the Air, and when a pretty quantity of it had been drawn away, the Water in the Pipe began to rise higher in the Pipe, at the sides of which some little bubbles disco∣ver'd themselves. After a little while longer, the Water still swelling, there appear'd at the bottom of the Pipe a bub∣ble about the bigness of a small Pea, which ascending through the Pipe to the top of the Water, staid there awhile and then broke; but the Pump being nimbly ply'd, the expansion of the Water so en∣creas'd, that quickly, getting up to the [Page  150](https://quod.lib.umich.edu/e/eebo/A29003.0001.001/177?vid=56393) top of the Pipe some drops of it be∣gan to run down along the out-side of it, which oblig'd us to forbear pumping a∣while, and give the Water leave to sub∣side within less then two Inches of the bottom of the Pipe. After this the Pump being again set at work, the bub∣bles began to ascend from the bottom of the Pipe, being not all of a size, but yet so big, that estimating one with another, they appear'd to be of the size of the smal∣ler sort of Peas; and of these we reckon'd about sixty which came up one after ano∣ther, besides store of smaller ones, of which we made no reckoning: And at length, growing weary of reckoning and pumping too (because we found, that in spight of all our pains and industry, some un∣discern'd Leak or other in the Recei∣ver hinder'd us from being able to empty it altogether) we thought fit to desist for that time. After tryal made of what o∣peration the external Air, being let in upon the expanded Water, would have; and accordingly turning the Key to let in the Air, we saw, as we expected, that the Water in the Pipe in a moment fell down almost to the bottom of it.

[Page  151](https://quod.lib.umich.edu/e/eebo/A29003.0001.001/178?vid=56393)Now of this Experiment there are two or three Circumstances yet to be men∣tion'd, which are no less then those alrea∣dy recited, pertinent to our present pur∣pose.

In the first place then, when the great∣er part of the Air had been pump'd out of the Receiver, the rising bubbles ascend∣ed so very slowly in the Pipe, that their Progress was scarce discernable; which seem'd to proceed from this, That their bigness was such, That they could not sufficiently extend themselves in the cavity of the Glass, without pressing on both hands against the sides of it, whereby they became of more difficult extrusion to the Water. And though it may seem strange these bubbles should be of any considerable bulk, since 'tis like they consisted of lesser parcels of the Air lurking in the Water, then those that were vigorous enough to make their way through long before them: yet they were commonly much larger then before, some of them being equal in quantity to four or five Peas: Whether this their in∣crease of bulk proceeded from the greater decrement of the pressure of the Air, [Page  152](https://quod.lib.umich.edu/e/eebo/A29003.0001.001/179?vid=56393) or from the Union of two or three of those numerous bubbles which were then generated below the bottom of the Pipe, where we could not see what was done a∣mong them.

Another thing we noted in our bubbles was, That whereas in ordinary ones the Air, together with the thin film of Water that invests and detains, is wont to swell above the surface of the Water it swims on, and commonly to constitute Hemis∣pherical Bodies with it, the little parcels of Air that came up after the Receiver was pretty well empty'd, did not make protuberant bubbles, but such whose up∣per surface was either level with or be∣neath that of the Water, so that the up∣per surface being usually somewhat con∣vex, the less protuberant parts of it had a pretty quantity of Water remaining a∣bove them.

We also further observ'd, That where∣as in the bubbles that first appear'd in the Pipe, the ascending Air did, as in o∣ther common bubbles, make its way up∣wards, by dividing the Water through which it pass'd, in those bubbles that ap∣pear'd at the latter end of our Experi∣ment, when the pressure of the little ex∣ternal [Page  153](https://quod.lib.umich.edu/e/eebo/A29003.0001.001/180?vid=56393) Air, remaining in the Receiver, was grown inconsiderable, the ascending parcels of Air having now little more then the weight of the incumbent Water to surmount, were able both so to expand themselves as to fill up that part of the Pipe which they pervaded, & by pressing every way against the sides of it, to lift upwards with them what Water they found above them, without letting any considerable quantity glide down along the sides of the Glass: So that sometimes we could see a bubble thrust on before it a whole Cylinder of Water of perhaps an Inch high, and carry it up to the top of the Pipe; though as we formerly no∣ted, upon the letting in the external Air, these tumid bubbles suddenly relaps'd to their former inconspicuousness.

All these things laid together seem'd sufficiently to confirm that, which the consideration of the thing it self would easily enough perswade, namely, That the Air, and such like Bodies being under Water, may be press'd upon as well by the Atmosphere, as by the weight of the incumbent Water it self.

Hence likewise we may verifie what we observ'd at the close of the foregoing [Page  154](https://quod.lib.umich.edu/e/eebo/A29003.0001.001/181?vid=56393) Experiment, namely, That from the sole swelling of Water there recorded, it can∣not be so safely concluded that Water, when freed from compression, is endow•d with an Elastical power of expanding it self, since thereby it appears that the In∣tumescence produc'd by that Experiment, may (at least in great part) be ascrib'd to the numerous little bubbles which are wont to be produc'd in Water, from which the pressure of the Atmosphere is in great measure taken off. So apt are we to be mis-led, even by Experiments them∣selves, into Mistakes, when either we con∣sider not that most Effects may proceed from various Causes, or minde onely those Circumstances of our Experiment, which seem to comply with our preconceiv'd *Hypothesis* or Conjectures.

And hence it seems also probable, that in the Pores or invisible little recesses of Water it self there lie commonly inter∣spers'd many parcels of either Air, or at least something Analogous thereunto, al∣though so very small that they have not been hitherto so much as suspected to lurk there. But if it be demanded how it appears that there is interspers'd through the Body of Water any substance thinner [Page  155](https://quod.lib.umich.edu/e/eebo/A29003.0001.001/182?vid=56393) then it self, and why that which produc'd the bubbles above mention'd should not be resolutely said to be nothing else then a more active and spirituous part of the Water, we shall, in order to the Elucida∣tion of this matter, subjoyn to what was formerly deliver'd the following Ex∣periment.

WE recited in our nineteenth Ex∣periment,[\*](https://quod.lib.umich.edu/e/eebo/A29003.0001.001?id=DLPS24;lvl=1;note=inline;rgn=main;view=trgt) how by drawing most of the Air out of the Receiver, we made the Water subside by degrees in a Glass not four Foot long: We shall now adde, that in the like Experiment made in such a Tube, or a greater, it may be observ'd, That when the Water begins to fall, there will appear store of bubbles fasten'd all a∣long to the sides of the Glass; of which bubbles, by the agitation of the Vessel consequent upon pumping, there will arise good numbers to the top of the Water, and there break; and as the Cylinder of Water is brought to be lower and lower, so the bubbles will appear more numerous in that part of the Tube which the Water yet fills; and the nearer the surface of the Water, in its descent, approaches to these [Page  156](https://quod.lib.umich.edu/e/eebo/A29003.0001.001/183?vid=56393) bubbles, the greater they will grow, be∣cause having the less weight and pressure upon them, the Expan∣sion of that Air which makes them, can be the less resisted by the pressure of the incumbent Water and Air; as seems probable from hence, that upon the letting in a little external Air, those bubbles immediately shrink.

It may indeed, as we lately intimated, be conjectur'd, that these bubbles pro∣ceed not so much from any Air pre-exi∣stent in the Water, and lurking in the Pores of it, as from the more subtle parts of the Water it self; which by the expansion allow'd them upon the diminish'd pressure of the ambient Bodies may gene∣rate such bubbles. And indeed, I am not yet so well satisfied that bubbles may not (at least sometimes) have such an Origina∣tion: but that which makes me suspect that those in our tryals contain'd real Air formerly latitant in the Pores of the Wa∣ter, is this, That upon the inletting of the external Air, the Water was not again impell'd to the very top of the Tube whence it began to fall, but was stopt in its ascent near an Inch beneath the top. And since, if the upper part of the Tube had been devoyd of any other [Page  157](https://quod.lib.umich.edu/e/eebo/A29003.0001.001/184?vid=56393) then such Ethereal matter as was subtle enough freely to penetrate the pores of the Glass, the external Air would have been able to impel the Water to the top of a Tube seven or eight times as long as ours was; The *Phaenomenon* under consi∣deration seem'd manifestly to argue that the many bubbles that broke at the top of the Water did contain a real Air, which, being collected into one place and hinder'd by the top of the Glass from re∣ceding, was able to withstand the pressure of the outward Air. As we see that if never so little Air remain in the Tube up∣on the making the Experiment *De Vacuo* with Quick-silver, no inclining of the Tube, though a long one, will enable a Man to impel the Mercury up to the very top, by reason (as we formerly noted) of the resistance of the included Air, which will not be compress'd beyond a certain degree.

But in order to a further Discovery what our bubbles were, we will, on this occa∣sion, inform Your Lordship that we try'd the XIXth *Experiment* in one of our small Receivers, and found, that upon the draw∣ing down of the Water, so many bubbles disclos'd themselves and broke into the [Page  158](https://quod.lib.umich.edu/e/eebo/A29003.0001.001/185?vid=56393) upper part of the Tube, that having after∣wards let in the external Air, the Water was not thereby impell'd to the top of the Tube (three Foot in length) within a lit∣tle more then half an Inch. And whe∣ther or no it were Air that possess'd that space at the top of the Tube which was not fill'd with Water, we took this course to examine. We drew the second time the Air out of the Receiver, and found, that by reason of the body that possess'd the top of the Tube, we were able not onely to make the Water in the Tube fall to a level with the surface of the Water in the Vessel: But also (by plying the Pump a little longer) a great way beneath it: which since it could not well be ascrib'd to the bare subsiding of the Water by rea∣son of its own weight, argued that the Wa∣ter was depress'd by the Air: which was confirm'd by the Figure of the surface of the Water in the Tube, which was much more concave then that of Water in Tubes of that bigness uses to be. And this further tryal (to adde that upon the by) we made at the same time, That when the Water in the Pipe was drawn down almost as low as the Water without it, we observ'd, that (though we desisted [Page  159](https://quod.lib.umich.edu/e/eebo/A29003.0001.001/186?vid=56393) from pumping) by the bare application of a hand moderately warm to the desert∣ed part of the Tube, the remaining Wa∣ter would be speedily and notably de∣press'd. And having for a while held a kindled Coal to the outside of the Tube, (the Pump being still unimploy'd, because the Vessel chanced to hold extraordinarily well) the Air was by the heat so far ex∣panded, that it quickly drave the Water to the bottom of the Tube, which was divers Inches beneath the surface of the ambient Water. Whereby it appears (by the same way by which we formerly mea∣sur'd the dilatation of the Air) that the Air, even when it is expanded to between 90 and 100 times, its extent will yet rea∣dily admit of a much further rarifaction by heat.

I consider'd also that in case the Bub∣bles we have been speaking of, were pro∣duc'd by the parcels of Air latitant in the Water, that Air being now got together to the top of the Tube, though the Air were again drawn out of the Receiver, the taking off its pressure would not dis∣close bubbles as before; and accordingly, the Air being again pump'd out, the Wa∣ter in the Tube descended as formerly: [Page  160](https://quod.lib.umich.edu/e/eebo/A29003.0001.001/187?vid=56393) but for a great while we scarce saw one bubble appear, onely when the Receiver had been very much exhausted, and the Water was fallen very low, there appear'd near the bottom of the Tube, certain little bubbles, which seem'd to consist of such parcels of Air as had not, by reason of their smalness, got up to the top of the Water, with the more bulkie and vi∣gorous ones. And that which is not in∣considerable, is, That having, by letting in the Air, forc'd up the Water into the Tube, we could not perceive that it as∣cended nearer the top, though we per∣mitted the Engine to remain unimploy'd for two or three Nights together, and watch'd whether the Water would swell up and fill the Tube. And on this occa∣sion I remember, that having try'd such an Experiment as this with Quick-silver in∣stead of Water, in a Tube of about a Foot and a half long, wherein it might seem more hopeful to escape bubbles; yet up∣on the drawing down the Quick-silver as low as we could, and letting in the exter∣nal Air upon it, we found that some lurk∣ing particles of Air were got up to the top of the Tube, and hinder'd the Quick-silver from being forc'd up again so high. [Page  161](https://quod.lib.umich.edu/e/eebo/A29003.0001.001/188?vid=56393) And though the Quick-silver were by this means brought to appear a very close and lovely Metalline Cylinder, not inter∣rupted by interspers'd bubbles as before; yet having caus'd the Air to be again drawn out of the Receiver, I could per∣ceive several little bubbles to disclose themselves, fasten'd to the inside of the Tube, near the bottom of it; and having purposely watch'd one or two of the chief∣est, I had the pleasure to observe, that though they grew bigger and bigger as the surface of the Mercurial Cylinder fell nearer and nearer to them, so as that at length they swell'd into a conspicuous bulk; yet upon the wary letting in the Air upon them, they did not break, but presently shrunk up into a littleness that render'd them inconspicuous.

Whence it seems very probable, if not certain, that even in the closest and most ponderous Liquors, and therefore much more in Water, there may lurk undiscern∣able parcels of Air, capable, upon the removal of the pressure of the ambient Air (though but in part) and that of the Liquor wherein it lurks, to produce con∣spicuous bubbles. And consequently, if it seem inconvenient to admit an Elastical [Page  162](https://quod.lib.umich.edu/e/eebo/A29003.0001.001/189?vid=56393) power in the Water, it may be said that the swelling of the compress'd Water in the Pewter Vessel lately mention•d, and the springing up of the Water at the hole made by the Needle, were not the effects of any internal *Elater* of the Water, but of the spring of the many little particles of Air dispers'd through that Water, and acting upon it in their sudden recovering themselves to a greater extent, then that to which a violent compression had re∣duc'd them.

But though, from all these particulars, it seems manifest that the bubbles we have been all this while treating of, were pro∣duc'd by such a substance as may be pro∣perly enough call'd Air; yet till we shall have had the opportunity of making some further tryals concerning the nature of the Air, we shall not resolutely deter∣mine whether or no Air be a Primogenial Body (if I may so speak) that cannot now be generated or turn'd either into Water or any other Body. Yet in the mean while (because it is an important Question, and if rightly determin'd, may much conduce to the knowledge of the [Page  163](https://quod.lib.umich.edu/e/eebo/A29003.0001.001/190?vid=56393) nature of the Air) We think it not unfit to make a brief mention of some of the particulars which at present occur to our thoughts in favor of either part of the Question.

First then, divers Naturalists esteem the Air (as well as other Elements) to be in∣generable and incorruptible. And reasons plausible enough may be drawn to coun∣tenance this Opinion from the considera∣tion of that permanency that ought to belong to the corporeal Principles of o∣ther Bodies.

Next, Experience may be pleaded to the same purpose, for I have read of some who have in vain attempted to turn Air into Water, or VVater into Air.

The diligent *Schottus* tells us,[\*](https://quod.lib.umich.edu/e/eebo/A29003.0001.001?id=DLPS25;lvl=1;note=inline;rgn=main;view=trgt) That a∣mongst the other rarities to be met with in that great Repository of them, the *Musaeum Kercherianum,* there is a round Glass with a tapering Neck near half full (as one may guess by the Scheme he an∣nexes) of ordinary Spring-water, which having been Hermetically shut up there by *Clavius* the famous Geometrician, The included water is to this day pre∣serv'd, not onely clear and pure, as if it were but newly put in: But (as it seems) [Page  164](https://quod.lib.umich.edu/e/eebo/A29003.0001.001/191?vid=56393) without (in the least) turning into Air, notwithstanding its having been kept there these fifty years: For he tells us, That the Water hath continued there all this while without any diminution.

Nor does it appear in those Glasses, which for Chymical Experiments we usu∣ally close with *Hermes* his Seal (as they call it) that the included Air does, during its long Imprisonment, notwithstanding the alteration it receives from various de∣grees of heat, discernably alter its nature. Whereas we plainly perceive in our Dige∣stions and Distillations, that though it may be rarified into invisible Vapors, yet it is not really chang'd into Air, but onely divided by heat, and scatter'd into very minute parts, which meeting together in the Alembick or in the Receiver, do pre∣sently return into such Water as they con∣stituted before. And we also see, that ev'n Spirit of Wine, and other subtle and fugitive Spirits, though they easily fly in∣to the Air, and mingle with it, do yet in the Glasses of Chymists easily lay aside the disguise of Air, and resume the deve∣sted form of Liquors. And so volatile Salts, as of Urine, Harts-horn, *&c.* though they will readily disperse themselves [Page  165](https://quod.lib.umich.edu/e/eebo/A29003.0001.001/192?vid=56393) through the Air, and play up and down in the capacity of an Alembick or a Recei∣ver: yet will they, after a while, fasten themselves to the insides of such Glasses in the form of Salts.

Besides, since Air is confessedly en∣dow'd with an Elastical power that proba∣bly proceeds from its Texture, it appears not what it is that in such light alterations of Water, as are by many presum'd ca∣pable of turning it into Air, can be rea∣sonably suppos'd so to contrive the Parti∣cles of Water, as to give them, and that permanently, the structure requisite to a Spring. I adde the word, Permanently, because the newly mention'd observations seem to argue the Corpuscles of Air to be irreducible into Water, whereas the Aqueous Particles may perhaps for a while be so vehemently agitated, as to press almost like Springs upon other Bo∣dies; yet upon the ceasing of the agitati∣on, they quickly, by relapsing into Wa∣ter, disclose themselves to have been no∣thing else whil'st they counterfeited the Air.

Lastly, The Experiment formerly made in our Engine with a piece of Match, seems to evince, that even those light and [Page  166](https://quod.lib.umich.edu/e/eebo/A29003.0001.001/193?vid=56393) subtle Fumes (for the most part not aque∣ous neither) into which the Fire it self shatters dry Bodies, have no such Spring in them as the Air, since they were unable to hinder or repress the expansion of the Air included in the Bladder they surroun∣ded.

[\*](https://quod.lib.umich.edu/e/eebo/A29003.0001.001?id=DLPS26;lvl=1;note=inline;rgn=main;view=trgt)I remember indeed that the Learned *Iosephus Acosta,* in his History of the *West Indies,* tells us, That he saw in those parts some Grates of Iron so rusted and consum'd by the Air, that the Metal be∣ing press'd between the Fingers, dissolv'd (to use his words) to powder, as if it had been Hay or parched Straw. And I re∣member too,[\*](https://quod.lib.umich.edu/e/eebo/A29003.0001.001?id=DLPS27;lvl=1;note=inline;rgn=main;view=trgt) that the accurate *Varenius*tells us, That in the Islands commonly called *Azores,* the Air (and Wind) is so sharp, that in a short time it frets not only Iron Plates, but the very Tiles upon the Roofs of Houses, and reduces them to dust. And I have elsewhere mention'd some recent Observations of this kinde. But it may be said, That the above-men∣tion'd Authors ascribe the recited effects chiefly to the Winds, and that however the corrosion of the Iron and the Tiles may proceed not from the Air it self, or any of its genuine parts, but from some [Page  167](https://quod.lib.umich.edu/e/eebo/A29003.0001.001/194?vid=56393)•aline Corpuscles dispers'd through the Air, and driven by the Winds against the Bodies it is presum'd to fret. And that such volatile Salts may copiously ascend into the Air, and yet retain their Nature, as doth the more fixt Salt in the Sea Wa∣ter, the sublimations of *Sal-Armoniack* may sufficiently evince. Not to mention that I have shown some Friends a secret kinde of saline Substance incomparably subtler then *Sal-Armoniack,* which did not onely easily enough ascend it self, but carried up with it (and that in a very great proportion) the solid and ponderous Bo∣dy ev'n of uncalcin'd Gold in the form of subtle exhalations, which did afterwards fasten themselves to the upper parts of the Vessels, and yet manifest themselves to continue Gold. We remember also, that to try whether Water could be turn'd into Air, we once took an *Aeolipile,* into which we had before convey'd some Wa∣ter, and placing it upon kindled Coals when the heat forc'd out a vehement stream of aqueous Vapors; we ty'd about the neck of it, that of a Bladder, which we had before empty'd of Air; and find∣ing the *Aeolipile* after a while to blow up the Bladder, we carefully ty'd it again [Page  168](https://quod.lib.umich.edu/e/eebo/A29003.0001.001/195?vid=56393) that the included substance might not get away. Then slipping it off from the *Ae•∣lipile* we convey'd it into our Receiver, to try whether or no that which in part di∣stended the Bladder would appear by its Spring to be true Air: whereby we found that upon the exsuction of the ambient Air, the included substance expanded it self and the Bladder to a very much great∣er bulk then it was of before. And for further satisfaction, having again taken out the Bladder, we suffer'd it to remain ty'd up till next morning, to try whether time, and the coldness of the night, would make the contain'd substance relapse in∣to Water: But the next Morning we found it little less tumid then before. I remember, I say, that I once made this Experiment; but I might say in answer to it, that the chief reason of my men∣tioning it, is, To let Your Lordship see how requisite it is to be circumspect and considerate, when we are to make and to build upon nice Experiments. For though I may seem to have used sufficient cauti∣on, yet afterward considering with my self that the *Aeolipile* I had imploy'd was a very large one, and that it required much more care then one that has not try'd it [Page  169](https://quod.lib.umich.edu/e/eebo/A29003.0001.001/196?vid=56393) would imagine, to drive out all the Air from a large *Aeolipile,* I easily suspected that the distension of the Bladder in our pneumatical Vessel, might proceed not from the Watery steams that came out at the narrow mouth of the *Aeolipile,* and had very much wetted the Bladder, but from the rarified Air which in that sort of Vessels is wont for a good while together to come out with the rarified Water: and accordingly having reiterated the Experi∣ment I found it very difficult (by rea∣son of the shrinking of the Bladders (up∣on their being heated) and of other impe∣diments) to make it so accurately as to de∣duce from it, that Water may be rarified into true Air.

Against the four other above-mention'd Considerations, we cannot spend time to frame Objections, but must forth with proceed to the mention of those things that seem to argue that Air (at least such as produc'd our bubbles) maybe gene∣rated of Water and other Bodies.

First then we have found by Experi∣ence that a vapid Air, or Water rarified into vapor, may at least for a while emu∣late the elastical power of that which is generally acknowledg'd to be true Air. [Page  170](https://quod.lib.umich.edu/e/eebo/A29003.0001.001/197?vid=56393) For if you take a good *Aeolipile,* with a moderately strong and slender Neck, and filling it with Water, lay it upon quick Coals, you may after a while observe so great a pressure by some of the parts con∣tain'd in the *Aeolipile* upon others, that the Water will sometimes be thrown up into the Air above three or four Foot high; and if you then take the *Aeolipile*almost red hot from off the Fire, you may perceive that the Water will for a longer time then one would easily imagine con∣tinue to be spouted out in a violent Stream. And if there remains but little Water in the *Aeolipile* when tis taken ve∣ry hot from the Fire, immersing the Neck of it into cold Water, you will finde, that after it begins to suck in some Water, there will be made from time to time store of large bubbles in that Water whereinto the neck was plunged. Which bubbles seem manifestly to proceed from hence, that for a while the heat in the *Ae∣olipile* continues strong enough to rarifie part of the Water that is suck'd in, and expel it in the form of Vapors through the Water incumbent on the Pipe. If al∣so when the *Aeolipile* is almost full of wa∣ter, and therefore can contain but little [Page  171](https://quod.lib.umich.edu/e/eebo/A29003.0001.001/198?vid=56393) Air; you hold a Coal or Brand in that stream of Vapors that issues out of the narrow mouth of it, you will finde this vapid or rorid Air, (if I may so call it) to blow the Fire very strongly and with a roaring noise. And that it be not said that 'tis by the external Air which the a∣queous steams drive before them, and not by the Steams themselves, that the Blast is made and the Flame excited; it has been observ'd, that by approaching the Coal or Brand almost to the mouth of the *Aeolipile,* the winde appear'd more vehement then if the Body to be kindled were held some Inches off.

But in regard the elastical power of the Stream, issuing out of an *Aeolipile,* seems manifestly due to the heat that expands and agitates the aqueous Particles where∣of that Stream consists, and that such rapid winds seem to be but water scatter'd into little parts and set a moving; since we finde, that holding a Knife, or any solid, smooth and close Body against the stream that issues out of the Aeolipile, the vapors condensing upon it, will presently cover it with water: It will be very per∣tinent to subjoyn a notable Experiment that I remember I have met with in the [Page  172](https://quod.lib.umich.edu/e/eebo/A29003.0001.001/199?vid=56393) description given us by the Industrious *Kircher,* of several Musical Engines. And (though it may seem somewhat prolix) we will recite what he delivers in his own words, which are these.

[\*](https://quod.lib.umich.edu/e/eebo/A29003.0001.001?id=DLPS28;lvl=1;note=inline;rgn=main;view=trgt)*Cum eodem tempore quo haec scripsi summi Pont: Innocentii* Xmi *mandato or∣gani hydraulici in horto Quirinali consti∣tuendi cur a mihi commendata esset; Aeoliam cameram insigni sane successu construi jussi∣mus, eâ quae sequitur ratione.*

*Erat longitudo sive altitudo camerae* AH 5 *Pedum, Latitudine* 3 *fere ex lateribus constructa;*[\*](https://quod.lib.umich.edu/e/eebo/A29003.0001.001?id=DLPS29;lvl=1;note=inline;rgn=main;view=trgt)*in medio duo tenebat Diaphrag∣mata* CD *&* EJ *in modum cribri pluri∣bus for aminibus pertusa. Paulo infra ca∣nalis* G *aquam advehens inserebatur in* H *eidem epistomium parabat exitum. Aqua itáque per canalem* G *maximo impetu ruen• vehementissimum ventum mox intus exci∣tabat; qui ventus nimia humiditate imbu∣tus, ut purior exiret siccior{que}, Diaphrag∣mata illa in cribri modum pertusa, ordinata sunt. Intra haec enim aquae vehemens agi∣tatio rupta fracta{que} aerem puriorem per* A *canalem subtilioremque emittebat: Verum cum postea inventū sit acrē plus aequo humi∣dū interioribus Organi meatibus maximū detrimentum inferre: Hinc ut aer aquosus* [*Page  173*](https://quod.lib.umich.edu/e/eebo/A29003.0001.001/200?vid=56393) *siccissimam cōsistentiam acquireret, ordina∣vimus canalem plumbeum* QR *in helicem contortum vasi* S *aliquantulum capaciori in modum Urnae efformato, inser•um. Intra urnam enim plumbeam & canalem tortuo∣sum illisus aer humidus, ita ab omni aquosi∣tate defaecabatur, ut ex furno in Organum derivatus dici potuerit. Urna* S *canalis tortuosus* QR *ultimum orificium* Q *inse∣ritur anemothecae organi. Et hunc modum organis hydraulicis omniū aptissimū reperi.*

*Debet autem camera illa situari in loco quantum fieri potest sicciori ita ut longo ca∣nali aqua intra eam derivetur ne locus hu∣miditate sua Organis officiat.*

Thus far the Ingenious *Kircherus,* whom I the rather cite, because although I have been informed of divers Ventiducts (as they call them) by very knowing Tra∣vellers that have observ'd them: Yet this relation of our Author being very pun∣ctual, and deliver'd upon his own particu∣lar Experience, has, I confess, made me wish I had had the good fortune when I was at *Rome,* to take notice of these Or∣gans; or that I had now the opportunity of examining of such an Experiment. For if upon a strict inquiry I should find that the breath that blows the Organs [Page  174](https://quod.lib.umich.edu/e/eebo/A29003.0001.001/201?vid=56393) does not really upon the ceasing of its un∣usual agitation by little and little relapse into water, I should strongly suspect that 'tis possible for Water to be easily turn'd into Air. I remember indeed, that we have formerly taught that there lurks an interspersed Air in the pores of ordinary Water, which may possibly be struck out by the breaking of the Water in its fall into the Aeolian Chamber, (as he calls it.) But in regard the Scheme seems to repre∣sent that Chamber as closely shut, and thereby forbids us to suppose that any Air is carried into it. but what is latitant in the Water, it will scarce seem probable to him who remembers how small a propor∣tion of Air, that appear'd to be when its rarification seased, which was conceal'd in the Water we freed from bubbles in our Receiver, that so little Air as is common∣ly dispers'd through Water, should be a∣ble, in so little Water as was requisite for so small a room, to make so vehement a Wind as our Author here tells us of. I have sometime therefore suspected, that in this case the Wind may be produc'd by small particles of the water it self, forci∣bly expell'd out of the Chamber into the Organs. And to the Objection to which [Page  175](https://quod.lib.umich.edu/e/eebo/A29003.0001.001/202?vid=56393) I foresaw this ghess to be liable, namely, That, no heat intervening, there appear'd nothing that should raise the Water into exhalations and give them an impulse. I thought it might be said that motion a∣lone, if vehement enough, may, with∣out sensible heat, suffice to break Water into very minute parts, and make them as∣cend upwards, if they can no where else more easily continue their agitation. For I remember, that Travelling betwixt *Ly∣ons* and *Geneva,* I saw, not very far out of the Way, a place where the River of *Rhone* coming suddenly to be streighten'd betwixt two Rocks, so near each other, that a Man may (if my Memory fail me not) stand astride upon both at once: that rapid Stream dashing with great impetuo∣sity against its Rocky Boundaries, does break part of its Water into such minute Corpuscles, and put them into such a mo∣tion, that Passengers observe at a good di∣stance off, as it were a Mist arising from that place, and ascending a good way up into the Air. Such, I say, was my sus∣picion touching the Wind we have been considering, but it seems something odde that aqueous Vapors should, like a dry Wind, pass through so long and tortu∣ous [Page  176](https://quod.lib.umich.edu/e/eebo/A29003.0001.001/203?vid=56393) a Pipe of Lead, as that describ'd by our Author, since we see in the Heads of Stills, and the Necks of *Aeolipiles,* how quickly such vapors are even by a very lit∣tle cold recondensed into Water. But to this also something may be speciously reply'd; wherefore contenting my self to have mention'd our Authors Experiment as a plausible, though not demonstrative proof, that Water may be transmuted in∣to Air. We will pass on to mention in the third place another Experiment, which we try'd in order to the same enquiry.

We took a clear Glass bubble (capable of containing by ghess about three Oun∣ces of Water) with a Neck somewhat long and wide, of a Cylindrical form; this we fill'd with Oyl of Vitriol and fair water, of each almost a like quantity, and casting in half a dozen small Iron Nails, we stopt the mouth of the Glass (which was top-full of Liquor) with a flat piece of *Diapalma* provided for the purpose, that accommodating it self to the surface of the water, the Air might be exqui∣sitely excluded: and speedily inverting the Viol, we put the Neck of it into a small wide-mouth'd Glass that stood rea∣dy with more of the same Liquor in it, to [Page  177](https://quod.lib.umich.edu/e/eebo/A29003.0001.001/204?vid=56393) receive it. As soon as the neck had reach'd the bottom of the Liquor it was dipp'd into, there appear'd at the upper part (which was before the bottom) of the Viol a bubble, of about the bigness of a Pea, which seem'd rather to consist of small and recent bubbles, produc'd by the action of the dissolving Liquor upon the Iron, then any parcel of the external Air that might be suspected to have got in upon the inversion of the Glass, especi∣ally since we gave time to those little Particles of Air which were carried down with the Nails into the Liquor to fly up again. But whence this first bubble was produced, is not so material to our Expe∣riment, in regard it was so small: For soon after we perceiv'd the bubbles produced by the action of the *Men∣struum,* upon the Metal ascending co∣piously to the bubble already named, and breaking into it, did soon exceedingly in∣crease it, and by degrees depress the wa∣ter lower and lower, till at length the sub∣stance contain'd in these bubbles possessed the whole cavity of the Glass Viol, and almost of its Neck too, reaching much lower in the Neck then the surface of the ambient Liquor, wherewith the open-mouth'd Glass was by this means almost [Page  178](https://quod.lib.umich.edu/e/eebo/A29003.0001.001/205?vid=56393) replenished. And because it might be suspected that the depression of the Li∣quor might proceed from the agitation whereinto the exhaling and imprison'd steams were put, by that heat which is wont to result from that action of corro∣sive salts upon Metals, we suffered both the Viol and the open-mouthed Glass to remain as they were, in a Window, for three or four days and nights together; but looking upon them several times during that while, as well as at the expiration of it, the whole cavity of the Glass bubble, and most of its Neck, seem'd to be pos∣sess'd by Air, since by its spring it was a∣ble for so long to hinder the expell'd and ambient Liquor from regaining its former place. And it was remarkable, that just before we took the Glass bubble out of the other Glass, upon the application of a warm hand to the convex part of the bubble; the Imprison'd substance readily dilated it self like Air, and broke through the Liquor in divers bubbles, succeeding one another.

Having also another time try'd the like Experiment with a small Viol, and with Nails dissolv'd in *Aquafortis,* we found nothing incongruous to what we have now deliver'd. And this Circumstance [Page  179](https://quod.lib.umich.edu/e/eebo/A29003.0001.001/206?vid=56393) we observ'd, that the newly generated steams did not onely possess almost all the whole cavity of the Glass, but divers times without the assistance of the heat of my hand, broke away in large bubbles through the ambient Liquor into the o∣pen Air: So that these Experiments with corrosive Liquors, seem'd manifest∣ly enough to prove, though not that Air may be generated out of the Water, yet that in general air may be generated anew.

Lastly, to the foregoing Arguments from Experience we might easily subjoyn the Authority of *Aristotle,* and of (his followers) the Schools who are known to have taught, that Air and Water being Symbolizing Elements (in the quality of moisture) are easily transmutable into one another. But we shall rather to the fore∣going Argument adde this, drawn from Reason, That if, as *Leucippus, Democri∣tus, Epicurus* and others, follow'd by divers modern Naturalists, have taught, the difference of Bodies proceeds but from the various Magnitudes, Figures, Motions, and Textures of the small parts they consist of, (all the quali∣ties that make them differ, being de∣ducible from thence) there appeares [Page  180](https://quod.lib.umich.edu/e/eebo/A29003.0001.001/207?vid=56393) no reason why the minute parts of Wa∣ter, and other Bodies, may not be so agi∣tated or connected as to deserve the name of Air. For if we allow the *Cartesian Hypothesis,* according to which, as we no∣ted at the beginning of this Letter, the Air may consist of any terrene or aqueous Corpuscles, provided they be kept swim∣ming in the interfluent Celestial Matter; it is obvious that Air may be as often ge∣nerated, as Terrestrial Particles minute enough to be carried up and down, by the Celestial Matter ascend into the Atmo∣sphere. And if we will have the Air to be a *congeries* of little slender Springs, it seems not impossible, though it be diffi∣cult, that the small parts of divers Bo∣dies may by a lucky concourse of causes be so connected as to constitute such little Springs, since (as we note in another Treatise) Water in the Plants it nourishes is usually contriv'd into Springy Bodies, and even the bare alter'd position and con∣nexion of the parts of a Body may suf∣fice to give it a Spring that it had not be∣fore, as may be seen in a thin and flexible Plate of Silver; unto which, by some stroaks of a Hammer, you may give a Spring, and by onely heating it red hot [Page  181](https://quod.lib.umich.edu/e/eebo/A29003.0001.001/208?vid=56393) you may make it again flexible as be∣fore.

These, My Lord, are some of the Considerations at present occurring to my thoughts, by which it may be made probable that Air may be generated a∣new. And though it be not impossible to propose Objections against these, as well as against what has been represented in favor of the contrary Doctrine; yet having already almost tyr'd my self, and I fear more then almost tyr'd Your Lord∣ship with so troublesome an Enquiry af∣ter the Nature of bubbles, I shall wil∣lingly leave Your Lordship to judge of the Arguments alledged on either side, and I should scarce have ventur'd to enter∣tain You so long concerning such empty things as the Bubbles, which have occa∣sion'd all this Discourse, but that I am willing to invite You to take notice with me of the obscurity of things, or the dim∣ness of our created Intellects (which yet of late too many so far presume upon, as either to Deny or Censure the Almighty and Omniscient Creator himself) and to learn hence this Lesson, That there are very many Things in Nature that we dis∣dainfully over-look as obvious or despi∣cable, [Page  182](https://quod.lib.umich.edu/e/eebo/A29003.0001.001/209?vid=56393) each of which would exercise our Understandings▪ if not pose them too, if we would but attentively enough consider it, and not superficially contemplate, but attempt satisfactorily to explicate the na∣ture of it.

[\*](https://quod.lib.umich.edu/e/eebo/A29003.0001.001?id=DLPS30;lvl=1;note=inline;rgn=main;view=trgt)SInce the writing of the twenty one and twenty second Experiments (and not∣withstanding all that hath been on their occasion deliver'd concerning bubbles) we made some further tryals in prosecution of the same inquiry whereto they were designed.

We chose then, amongst those Glasses which Chymists are wont to call Philoso∣phical Eggs, one that containing about nine Ounces of Water, had a Neck of half an Inch in Diameter at the top, and as we ghest, almost an Inch at the bot∣tom; which breadth we pitch'd upon for a reason that will by and by appear: then filling it with common Water to the height of about a Foot and a half, so that the upper part remain'd empty, we shut it into the Receiver, and watch'd what would follow upon pumping, which pro∣ved [Page  183](https://quod.lib.umich.edu/e/eebo/A29003.0001.001/210?vid=56393) that a great part of the Air being drawn out, the bubbles began to discover themselves at the bottom and sides of the Glass▪ and increasing, as the Air was more and more drawn away, they did from time to time ascend copiously e∣nough to the top of the Water, and there quickly break: but by reason that the wideness of the Glass allow'd them free passage through the Water, they did not appear as in the former Experiments to make it swell: The Water scarce ever ri∣sing at all above the mark affixt to its up∣per surface when it was put in, and upon the return permitted to the outward Air, and consequently the shrinking in of the remaining bubbles, the Water seem'd to have lost of its first extent, by the avo∣lation of the formerly interspers'd Air.

Being willing likewise to try whether distilled Water were by having been di∣vided into minute parts, and then re-uni∣ted, more or less dispos'd to expand it self then Water not distill'd: We took out of our Laboratory some careful∣ly distill'd Rain-water, and put about two Ounces of it into a round Glass [Page  184](https://quod.lib.umich.edu/e/eebo/A29003.0001.001/211?vid=56393) bubble with a very small Neck (not ex∣ceeding the sixth part of an Inch in Dia∣meter) which we fill'd half way to the top, and then convey'd it into the Recei∣ver; the issue was, That though we drew out more then ordinary, yet there ap∣pear'd not the least intumescence of the Water, nor any ascending bubbles.

But suspecting that either the small quantity of the water or the Figure of the Vessel might have an interest in this odde *Phaenomenon,* we took the lately mention'd Philosophical Egge, and another not much differing from it; the former we fill'd up with distill'd Rain-water to the old mark, and into the latter we put a long Cylinder or Rod of solid Glass to streighten the cavity of the Neck by al∣most filling it up; and then pouring some distilled Water into that also, till it reach'd within some Fingers breadth of the top, the Eggs were let down into the Receiver. In this Experiment the Air was so far drawn forth before there ap∣pear'd any bubble in either of the Glasses, that the disparity betwixt this and com∣mon water was manifest enough. But at length, when the Air was almost quite pump'd out, the bubbles began to dis∣close [Page  185](https://quod.lib.umich.edu/e/eebo/A29003.0001.001/212?vid=56393) themselves, and to increase as the pressure of the Air in the Receiver de∣creas'd. But whereas in the first men∣tion'd Philosophical Egge the bubbles were very small, and never able to swell the Water, that we took notice of, at all above the mark: In the other, whose Neck, as we lately said, was straightned, and their passage obstructed, great num∣bers of them, and bigger, fastned them∣selves to the lower end of the Glass ram∣mer (if we may so call it) and gather'd in such numbers between that and the sides of the Neck, that the Water swell'd a∣bout a Fingers breadth above the mark, though upon the admitting of the exter∣nal Air it relaps'd to the former mark, or rather fell somewhat below it. And al∣though thereupon in the first nam'd Ves∣sel all the bubbles presently dis-appear'd, yet in the other we observ'd, that divers remained fastned to the lower part of the Glass rammer, and continued there some∣what to our wonder, for above an hour after, but contracted in their Dimen∣sions.

Moreover, having suffered the Glasses to remain above twenty four hours in the [Page  186](https://quod.lib.umich.edu/e/eebo/A29003.0001.001/213?vid=56393) Receiver, we afterwards repeated the Ex∣periment, to try what change the exsucti∣on of the external Air would produce in the Water, after the internal and latitant Air had (as is above recited) in great mea∣sure got away in bubbles, and whether or no the Water would by standing re-admit any new particles of Air in the room of those that had forsaken it. But though we exhausted the Receiver very diligent∣ly, yet we scarce saw a bubble in either of the Glasses; notwithstanding which, we perceiv'd the Water to rise about the breadth of a Barly-corn, or more, in the Neck of that Glass wherein the solid Cy∣linder had been put; The Liquor in the other Glass not sensibly swelling.

And lastly, upon the letting in of the Air, the Water in the straightned Neck soon subsided to the mark above which it had swollen, which whether it ought to be ascrib'd to the same small expansion of the parts of the Water it self, or to the rarifaction of some yet latitant Air broken into such small particles, as to e∣scape our observation, seems not easily determinable, without such further tryals, as would perhaps prove tedious to be re∣cited as well as to be made, though I was [Page  187](https://quod.lib.umich.edu/e/eebo/A29003.0001.001/214?vid=56393) content to set down those already men∣tion'd, that it might appear how requi∣site it is in nice Experiments to consider variety of Circumstances.

AFter having thus discover'd what ope∣ration the exsuction of the ambient Air had upon Water,[\*](https://quod.lib.umich.edu/e/eebo/A29003.0001.001?id=DLPS31;lvl=1;note=inline;rgn=main;view=trgt) we thought good to try also what changes would happen in other Liquors upon the like taking off the pressure of the external Air. We took ••en a Glass Egge, somewhat bigger then a Turkey Egge, which had a long Neck or Stem of about a ⅓ part of an Inch in Diameter; and filling it up with Sallet Oyl until it reach'd above half way to the top of the Neck, we inclos'd it in the Re∣ceiver together with common Water in a resembling Vessel, that we might the better compare together the operation of the exsuction of the Air upon those two Liquors. The Pump being set awork there began to appear bubbles in the Oyl much sooner then in the Water, and afterwards they also ascended much more copiously in the former Liquor then the latter: Nay, and when by having quite tired the Pum∣per, and almost our own patience, we [Page  188](https://quod.lib.umich.edu/e/eebo/A29003.0001.001/215?vid=56393) gave over, the bubbles rise almost (if not altogether) in as great numbers as ever, insomuch as none of the various Liquors we tryed either before or since, seem'd to abound more with Aerial Parti∣cles then did this Oyl. In which it was further remarkable, that between the time it was set into the Receiver, and that at which we could get ready to Pump, it sub∣sided notably (by ghess about half an Inch) below the mark it reach'd before it was put in.

After this express'd Oyl, we made try•• of a distill'd one, and for that purpose made choice of the common Oyl or Spi∣rit (for in the Shops where it is sold, the same Liquor is promiscuously call'd by ei∣ther name) of Turpentine; because 'twas onely of that Chymical Oyl, we had a sufficient quantity: which, being put in∣to a small Glass bubble with a slender Neck, so as to fill it to about two Inches from the top, did, upon the evacuating of the Receiver, present us with great store of bubbles; most of which rising from the bottom, expanded themselves exceedingly in their ascent, and made the Liquor in the Neck to swell so much by degrees, that at length it divers times ran [Page  189](https://quod.lib.umich.edu/e/eebo/A29003.0001.001/216?vid=56393) over at the top: by which means, we were hindred from being able to discern upon the letting in of the Air, how much the subsidence of the Oyl below the first mark was due to the recess of the bub∣bles.

Having likewise a minde to try whe∣ther as strong a solution of Salt of Tartar in fair Water as could be made (we ha∣ving then no Oyl of Tartar *per deliqui∣um* at hand) though it be accounted, Quick-silver excepted, the heaviest of Liquors would afford us any bubbles; we put in a Glass Egge full of it at the same time, with other Liquors, and found that they did long yield store of bubbles be∣fore any discovered themselves in the Liquor of Tartar; and having pursued the Experiment, it appear'd, That of all the Liquors we made tryal of, this afford∣ed the fewest and the smallest Bubbles.

Spirit of Vinager being try'd after the same manner, exhibited a moderate num∣ber of bubbles, but scarce any thing else worth the mentioning.

Nor could we in red Wine, try'd in a Glass Egge, take notice of any thing ve∣ry observable. For though upon the ex∣suction of the Air the bubbles ascended [Page  190](https://quod.lib.umich.edu/e/eebo/A29003.0001.001/217?vid=56393) in this Liquor, as it were in sholes, and shifted places among themselves in their ascent; yet the Intumescence of the whole bulk of the Liquor was scarce at all sensible, the bubbles most commonly breaking very soon after their arrival at the top, where during their stay, they compos'd a kinde of shallow froth, which alone appear'd higher in the Neck of the Glass, then was the Wine when it was first let down. Neither yet did Milk, con∣vey'd into our Pneumatical Vessel, pre∣sent us with any thing memorable, save that (as it seem'd by reason of some un∣ctuousness of the Liquor) the bubbles not easily breaking at the top, and thrust∣ing up one another made the intumescence appear much greater then that of common Water.

We likewise convey'd Hens Eggs into the Receiver, but, after the exsuction of the Air, took them out whole again. That which invited us to put them in, was, That (as perhaps we mention in other Papers) we had among other Experiments of cold, made Eggs burst, by freezing them within doors with Snow and Salt: The Ice, into which the aqueous parts of the Egge were turned by the cold, so distend∣ing [Page  191](https://quod.lib.umich.edu/e/eebo/A29003.0001.001/218?vid=56393) (probably by reason of the numerous bubbles wont to be observable in Ice) the outward parts of the Egge, that it usually crack'd the shell, though the inner Mem∣brane that involv'd the several Liquors of the Egge, because it would stretch and yield, remain'd unbroken. And here∣upon we imagin'd that in our Engine it might appear whether or no there were any considerable Spring, either in any of the Liquors, or in any other more spiri∣tuous substance included in the Egge.

We took also some Spirit of Urine, carelesly enough deflegmed, and put it in∣to the same Glass (first carefully scowr'd and cleans'd) wherein we had put the Oyl-olive above mention'd: We took also an∣other Glass, differing from a Glass Egge, onely in that its bottom was flat, and fill'd it up to about 2/5 of the Neck (which was wider then that of the Egge) with rectifi∣ed Spirit of Wine.

We took also another Glass Egge, and having fill'd it with common Water till it reach'd to the middle of the Neck, we pour'd to it of the same Spirit of Wine, till it reach'd about an Inch higher.

These three Glasses having marks set on them, over against the edges of the [Page  192](https://quod.lib.umich.edu/e/eebo/A29003.0001.001/219?vid=56393) contain'd Liquors were put into the Re∣ceiver, and that beginning to be evacua∣ted, the bubbles in all the three Liquors began to appear. The mixture of the Spirit of Wine and Water disclos'd a great store of bubbles, especially towards the top; but scarce afforded us any thing worth remembring. The Spirit of Urine appear'd to swell near an Inch and an half above the mark; and besides that, sent forth store of bubbles, which made a kinde of froth at the upper part of it. And above that spume there appear'd eight or ten great bubbles one above another, in a very decent order, each of them constitu∣ting, as it were, a Cylinder of about half an Inch high, and as broad as the internal cavity of the Neck: So that all the upper part of the Neck (for these bubbles reach'd to the top) seem'd to be divided into al∣most equal parts, by certain Diaphrag∣mes, consisting of the coats of the bub∣bles, whose edges appear'd like so many Rings suspended one above another.

In the Spirit of Wine there did arise a great multitude of bubbles, even till weariness did make us give over the Ex∣periment. And in these bubbles two or three things were remarkable; as first, [Page  193](https://quod.lib.umich.edu/e/eebo/A29003.0001.001/220?vid=56393) That they ascended with a very notable celerity: Next, That being arriv'd at the top, they made no stay there, and yet, notwithstanding the great thinness and spirituousness of the Liquor, did, before they broke, lift up the upper surface of it, and for a moment or two form thereof a thin film or skin which appear'd protu∣berant above the rest of the superficies like a small Hemisphere. Thirdly, That they ascended straight up, whereas those produc'd at the lower part of the Vessel, containing the mixture of the Water and Spirit of Wine, ascended with a waver∣ing or wrigling motion, whereby they describ'd an indented Line. Lastly, It was observable in the Spirit of Wine (and we took notice of the like in the Oyl of Turpentine lately mention'd) that not onely the bubbles seem'd to rise from cer∣tain determinate places at the bottom of the Glass, but that in their ascension they kept an almost equal distance from each other, and follow'd one another in a cer∣tain order, whereby they seem'd part of small Bracelets, consisting of equally lit∣tle incontiguous Beads: the lower end of each Bracelet, being as it were, fasten'd to a certain po•nt at the bottom of the Glass.

[Page  194](https://quod.lib.umich.edu/e/eebo/A29003.0001.001/221?vid=56393)The Air being sparingly let into the Receiver, the great bubbles formerly mention'd as incumbent upon one ano∣ther, in that Glass that contain'd the Spi∣rit of Urine, were by orderly degrees lessen'd, till at length they wholly subsi∣ded, notwithstanding the recess of so ma∣ny bubbles as broke on the top of the Spirit of Urine, during all the time of the Experiment; yet it scarcely appear'd at all to be sunk below the mark: Nor did the mixture of Spirit of Wine and Water considerably subside. But that is no∣thing to what we observ'd in the Spirit of Wine, for not onely it conspicuously expanded it self in the Neck of the Vessel that contain'd it, notwithstand∣ing the largeness of it; and that the bubbles were about to break at the top of it almost assoon as they arriv'd there: but upon the re-admission of the external Air, the Spirit of Wine retain'd its newly acquired expansion. And though we let it alone for near an hour together, in expectation that it might subside; yet when we took it out, we found it still swell'd between a quarter and half an Inch above the mark; and although it was not easily [Page  195](https://quod.lib.umich.edu/e/eebo/A29003.0001.001/222?vid=56393) imaginable how this *Phaenomenon* could proceed from any mistake in trying the Experiment, yet the strangenesse of it invited me to repeat it with fresh Spirit of Wine; which, swelling in the Neck as formerly, I left all Night in the Receiver, allowing free access to the external Air at the Stop-cock, and the next day found it still expanded as be∣fore, save that it seem'd a little lower: which decrement perhaps proceeded from the avolation of some of the fugitive parts of so volatile a Liquor. And for better satisfaction having taken out the Glass, and consider'd it in the open Air, and at a Window, I could not finde that there was any remaining Bubbles that could occasion the persevering and ad∣mir'd expansion.

BEing desirous to discover what diffe∣rence there might be as to gravity and levity,[\*](https://quod.lib.umich.edu/e/eebo/A29003.0001.001?id=DLPS32;lvl=1;note=inline;rgn=main;view=trgt) between Air expanded under Wa∣ter, and it selfe before such expansion; we took two very small Viols, such as Chy∣mical Essences (as they call them) are wont to be kept in, and of the size and shape ex∣pressed by the 8th Figure: into one of these [Page  196](https://quod.lib.umich.edu/e/eebo/A29003.0001.001/223?vid=56393) we put so much of a certain ponderous Mercurial mixture (hapning to be then at hand) that the mouth being stopt with a little soft Wax, the Glass would just sink in Water and no more; this we let fall to the bottom of a wide-mouth'd Crystal Jar, fill'd with about half a pint of com∣mon Water, and into the same Vessel we sunk the other Essence Glass unstopp'd, with as much Water in it as was more then sufficient to make it subside. Both these sunk with their mouthes downward, the former being about three quarters full of Air, the latter containing in it a bub∣ble of Air that was ghess'd to be of the bigness of half a Pea: This done, the wide-mouth'd Glass was let down into the Receiver, and the way of imploy∣ing the Engine was carefully made use of.

The success was, That having drawn out a pretty quantity of Air, the bubbles began to disclose themselves in the Wa∣ter, as in the former Experiments; and though for a good while after the bubbles ascended in swarms from the lower parts of the Water, and hastily broke at the top; yet we prosecuted the Experiment so long without seeing any effect wrought [Page  197](https://quod.lib.umich.edu/e/eebo/A29003.0001.001/224?vid=56393) upon the Essence Bottles, that we began to dispair of seeing either of them rise, but continuing to ply the Pump, that little Glass, whose mouth was open'd, came to the top of the Water, being, as it were, boy'd up thither by a great number of bubbles that had fastned themselves to the sides of it; swimming thus with the mouth downward, we could easily per∣ceive that the internal Air above men∣tion'd had much delated it self, and there∣by seem'd to have contributed to the e∣merging of the Glass, which remain'd floating, notwithstanding the breaking and vanishing of most of the contiguous bubbles: being hereby incouraged to per∣sist in pumping, we observed with some pleasure, that at each time we turn'd the Key, the Air in the little Glass did mani∣festly expand it self and thrust out the wa∣ter, generally retaining a very protuberant surface where it was contiguous to the re∣maining Water. And when after divers exsuctions of the Air in the Receiver, that in the little Viol so dilated it self as to expel almost all the Water, it turn'd up its mouth towards the surface of the Water in the Jar, and there deliver'd a large bubble, and then relapsed into its [Page  198](https://quod.lib.umich.edu/e/eebo/A29003.0001.001/225?vid=56393) former floating posture: And this Expe∣riment taught us, among other things, that it was a work of more time and la∣bor then we imagin'd, to exhaust our En∣gine as much as it may be exhausted: for although before the emerging of the small Viol, we did (as has been▪ touch'd alrea∣dy) think we had very considerably em∣ptyed the Receiver, because there seem'd to come out but very little or almost no sensible Air at each exsuction into and out of the Cylinder; yet after∣wards, at each drawing down the Suc∣ker, the Air included in the Viol did manifestly dilate it self, so long, that it did no less then nine times turn its mouth upwards, and discharge a bub∣ble by conjecture about the bigness of a Pea, after the manner newly recited. But as for that Violl which had the weight in it, it rose not at all. So that being not able by quick pumping to gain another bubble from the Air in the swimming Glass, which proceed∣ed from some small leak in the Vessel, though it held in this Experiment more stanch then was usual, we thought fit to let in leasurely the Air from with∣out, upon whose admission that with∣in [Page  199](https://quod.lib.umich.edu/e/eebo/A29003.0001.001/226?vid=56393) the Viol shrinking into a very nar∣row compass, the Glass did, as we expe∣cted, fall down to the bottom of the Jar.

But being desirous before we proceed∣ed to any new Experiment, to try once more whether the little Glass that had the weight in it might not also be rais'd. After we had suffer'd the Engine to re∣main clos'd as it was, for five or six hours, the Pump was again ply'd with so much obstinacy, that not onely a∣bout the upper part of the Jar there ap∣pear'd a good number of bubbles (but very much smaller then those we saw the first time) but afterwards there came from the bottom of the Jar, bub∣bles about the bigness of smal Peas: which the Pump being still kept going, fol∣low'd one another, to the number of forty, coming from the stopp'd Violl; whose mouth, it seems, had not been shut so strongly and closely, but that the included Air, dilating it self by its own spring, made it self some little passage betwixt the Wall and the Glass, and got away in these bub∣bles; after which, the unstopp'd Glass be∣gan to float again, the Air shut up in it [Page  200](https://quod.lib.umich.edu/e/eebo/A29003.0001.001/227?vid=56393) being manifestly so dilated as to expel a good part of the Water, but not so much as to break quite thorow. And at length, when our expectation of it was almost ti∣red out, the heavier of the two Viols be∣gan to come aloft, and immediately to subside again, which appear'd to be oc∣casion'd by the Air within it, whose bulk and spring being weaken'd by the recess of the forty bubbles before-mention'd, it was no longer able, as formerly, to break forcibly through the incumbent Water; but forming a bubble at the mouth of the Glass, boyed it up towards the top, and there getting away, left it to sink again till the pressure of the Air in the Recei∣ver being further taken off, the Air in the Viol was permitted to expand it self fur∣ther, and to create another bubble, by which it was again for a while carried up. And it was remarkable, that though after having emptyed the Receiver as far as well we could, we ceas'd from pumping; yet the Vessel continuing more stanch then it was wont, this ascent and fall of the Viol was repeated to the ninth time; the included Air, by reason of the smal∣ness of the vent at which it must pass out, being not able to get away otherwise then [Page  201](https://quod.lib.umich.edu/e/eebo/A29003.0001.001/228?vid=56393) little by little; and consequently, in divers such parcels as were able to constitute bubbles, each of them big enough to raise the Viol and keep it aloft until the avolation of that bubble. Whereby it may appear, that the grand rule in *Hy∣drostaticks,* That a Body will swim in the Water, in case it be lighter then as much of that Water that equals it in bulk, will hold likewise when the pressure of the At∣mosphere is in very great measure, if not when it is totally taken off from the Li∣quor and the Body: though it were worth inquiring what it is that so plentifully concurs to fill the bubbles made in our Experiment by the so much expanded Air, for to say with the old Peripatetick Schools, That the Air, in Rarefaction, may acquire a new extent, without the admission of any new substance, would be an account of the *Phaenomenon* very much out of date, and which, I suppose, our Modern Naturalists would neither give, nor acquiess in.

I know not whether it may be requisite to adde, that in this Experiment, as in the former, the outward Air being let in did soon precipitate the floating Viol. But I think it will not be amiss to note, that [Page  202](https://quod.lib.umich.edu/e/eebo/A29003.0001.001/229?vid=56393) (congruously to what hath been above recorded of the vast expansion of the Air) the Water which in the heavier Viol suc∣ceeded in the room of those forty odde, if not fifty great bubbles of Air, which at several times got out of it, amounted but to a very inconsiderable bigness.

[\*](https://quod.lib.umich.edu/e/eebo/A29003.0001.001?id=DLPS33;lvl=1;note=inline;rgn=main;view=trgt)IT having been observ'd by those that have consider'd what belongs to *Pendu∣lums* (a Speculation that may, in my poor judgement, be highly useful to the Naturalists) that their Vibrations are more slowly made, and that their moti∣on lasts less in a thicker, then in a thinner Medium: We thought it not amiss to try if a *Pendulum* would swing faster, or continue swinging longer in our Receiver, in case of the exsuction of the Air, then otherwise. Wherefore we took a couple of round and polish'd *Pendulums* of Iron or Steel, of equal bigness, as near as we could get the Artificer to make them, and weighing each of them twenty Dragmes, wanting as many Grains. One of these we suspended in the cavity of the Recei∣ver by a very slender silken string, of a∣bout seven Inches and a half in length [Page  203](https://quod.lib.umich.edu/e/eebo/A29003.0001.001/230?vid=56393) from the cover of the Receiver to which it was fasten'd. Then (by inclining the Engine) we made the *Pendulum* swing too and •ro in it, and describ'd as long Arches as in the capacity of so brittle a Vessel we thought safe and convenient. And one of the Assistants telling the recursions of the other *Pendulum* hanging in the free Air, by a string of about the same length, we shorten'd and lengthen'd this other *Pen∣dulum,* till it appear'd to keep the same pace in its Vibrations, with that shut up in the Receiver. Then having carefully drawn away the Air, we did again set the *Pendulum* in the Receiver a vibrating; and giving the other *Pendulum* such a mo∣tion as made it describe an Arch, accord∣ing to ones ghess, equal to that of the in∣cluded *Pendulum*; we reckon'd, one of us, the Recursions of that *Pendulum* which was swinging within the Receiver; and another of us that which was moving in (that which one would think a much more resisting *medium*) the Air. But once, one of us reckon'd near two and twenty Re∣cursions of the included *Pendulum,* whilst the other reckon'd but twenty of the *Pen∣dulum* that vibrated without. And an∣other time also, the former of these *Pen∣dula*[Page  204](https://quod.lib.umich.edu/e/eebo/A29003.0001.001/231?vid=56393) was reckon'd to have made one and twenty Recursions, wherein the other made but twenty: Yet this Experiment seem'd to teach us little, save that the dif∣ference betwixt the motion of such a *Pen∣dulum* in the common Air, and in one ex∣ceedingly rarified, is scarce sensible in Vessels no bigger then our Receiver; e∣specially since though during this Expe∣riment it held very well, yet we could not suppose it to be altogether devoid of Air. We observ'd also, that when the Receiver was full of Air, the included *Pendulum* continu'd its Recursions about fifteen minutes (or a quarter of an hour) before it left off swinging; and that after the exsuction of the Air, the Vibration of the same *Pendulum* (being fresh put in∣to motion) appear'd not (by a minutes Watch) to last sensibly longer. So that the event of this Experiment being other then we expected, scarce afforded us any other satisfaction, then that of our not having omitted to try it. And whether in case the tryal be made with a *Pendulum* much less disproportionate to the Air then Steel is, the event will much better an∣swer expectation, experience may be con∣sulted.

[Page  205](https://quod.lib.umich.edu/e/eebo/A29003.0001.001/232?vid=56393)THat the Air is the medium whereby sounds are convey'd to the Ear,[\*](https://quod.lib.umich.edu/e/eebo/A29003.0001.001?id=DLPS34;lvl=1;note=inline;rgn=main;view=trgt) has been for many Ages, and is yet the com∣mon Doctrine of the Schools. But this Received Opinion has been of late op∣pos'd by some Philosophers upon the ac∣count of an Experiment made by the Industrious *Kircher,* and other Learned Men, who have (as they assure us) ob∣serv'd, That if a Bell, with a Steel Clap∣per, be so fasten'd to the inside of a Tube, that upon the making the Experiment *De Vacuo* with that Tube, the Bell remain'd suspended in the deserted space at the up∣per end of the Tube: And if also a vi∣gorous Load-stone be apply'd on the out∣side of the Tube to the Bell, it will at∣tract the Clapper, which upon the Remo∣val of the Load-stone falling back, will strike against the opposite side of the Bell, and thereby produce a very audible sound, whence divers have concluded, That 'tis not the Air, but some more sub∣tle Body that is the medium of sounds. But because we conceiv'd that, to invali∣date such a consequence from this ingeni∣ous Experiment (though the most lucife∣rous, [Page  206](https://quod.lib.umich.edu/e/eebo/A29003.0001.001/233?vid=56393) that could well be made without some such Engine as ours) some things might be speciously enough alleadg'd; we thought fit to make a tryal or two, in or∣der to the Discovery of what the Air does in conveying of sounds, reserving divers other Experiments tryable in our Engine concerning sounds, till we can obtain more leasure to prosecute them. Conceiving it then the best way to make our tryal with such a noise as might not be loud enough to make it difficult to discern slighter va∣riations in it, but rather might be, both lasting, that we might take notice by what degrees it decreas'd; and so small, that it could not grow much weaker with∣out becoming imperceptible. We took a Watch, whose Case we open'd, that the contain'd Air might have free egress into that of the Receiver. And this Watch was suspended in the cavity of the Vessel onely by a Pack-thred, as the unlikeliest thing to convey a sound to the top of the Receiver: And then closing up the Ves∣sel with melted Plaister, we listen▪d near the sides of it, and plainly enough heard the noise made by the ballance. Those al∣so of us, that watch'd for that Circum∣stance, observ'd, that the noise seem'd to [Page  207](https://quod.lib.umich.edu/e/eebo/A29003.0001.001/234?vid=56393) come directly in a straight Line from the Watch unto the Ear. And it was observa∣ble to this purpose, that we found a mani∣fest disparity of noise, by holding our Ears near the sides of the Receiver, and near the Cover of it: which difference seem'd to proceed from that of the Texture of the Glass, from the structure of the cover (and of the Cement) through which the sound was propagated from the Watch to the Ear. But let us prosecute our Experiment. The Pump after this being imployd, it seemd that from time to time the sound grew fainter and fainter; so that when the Rec•iver was empty'd as much as it us'd to be for the foregoing Experiments, nei∣ther we, nor some strangers that chanc'd to be then in the room, could, by applying our Ears to the very sides, hear any noise from within; though we could easily per∣ceive that by the moving of the hand which mark'd the second minutes, and by that of the ballance, that the Watch nei∣ther stood stil, nor remarkably varied from its wonted motion. And to satisfie our selvs further that it was indeed the absence of the Air about the Watch that hinder'd us from hearing it, we let the external Air at the Stop-cock, and then though we [Page  208](https://quod.lib.umich.edu/e/eebo/A29003.0001.001/235?vid=56393)〈1 page duplicate〉[Page  209](https://quod.lib.umich.edu/e/eebo/A29003.0001.001/236?vid=56393)〈1 page duplicate〉[Page  208](https://quod.lib.umich.edu/e/eebo/A29003.0001.001/237?vid=56393) turn'd the Key and stopt the Valve, yet we could plainly hear the noise made by the ballance, though we held our Ears some∣times at two Foot distance from the out∣side of the Receiver. And this Experi∣ment being reiterated in another place, succeded after the like manner. Which seems to prove, that whether or no the Air be the onely, it is at least, the princi∣pal medium of Sounds. And by the way it is very well worth noting, that in a Ves∣sel so well clos'd as our Receiver, so weak a pulse as that of the ballance of a Watch should propagate a motion to the Ear in a Phisically straight Line, notwithstanding the interposition of so close a Body as Glass, especially Glass of such thickness as that of our Receiver; since by this it seems that the air imprison'd in the Glass, must, by the motion of the ballance, be made to beat against the concave part of the Receiver, strongly enough to make its convex part beat upon the contiguous Air, and so propagate the motion to the Listners ears. I know this cannot but seem strange to those, who, with an emi∣nent Modern Philosopher, will not allow that a Sound, made in the cavity of a Room, or other place so clos'd, that there [Page  209](https://quod.lib.umich.edu/e/eebo/A29003.0001.001/238?vid=56393) is no intercourse betwixt the external and internal Air, can be heard by those with∣out, unless the sounding Body do imme∣diately strike against some part of the in∣closing Body. But not having now time to handle Controversies, we shall onely annex, That after the foregoing Experi∣ment, we took a Bell of about two Inches in Diameter at the bottom, which was supported in the midst of the cavity of the Receiver by a bent stick, which by reason of its Spring press'd with its two ends against the opposite parts of the in∣side of the Vessel: in which, when it was clos'd up, we observ'd that the Bell seem'd to sound more dead then it did when just before it sounded in the open Air. And yet, when afterwards we had as formerly emptyed the Receiver, we could not dis∣cern any considerable change (for some said they observ▪d a small one) in the loud∣ness of the sound, whereby it seem'd that though the Air be the principal medium of sound, yet either a more subtle mat∣ter may be also a medium of it, or else an ambient Body that contains but very few particles of Air, in comparison of those it is easily capable of, is sufficient for that purpose. And this, among o∣ther [Page  210](https://quod.lib.umich.edu/e/eebo/A29003.0001.001/239?vid=56393) things, invited us to consider, whether in the above-mention'd Experiment made with the Bell and the Load-stone, there might not in the deserted part of the Tube remain Air enough to produce a sound: since the Tubes for the Experiment *De Vacuo* (not to mention the usual thin∣ness of the Glass) being seldom made greater then is requisite, a little Air might bear a not inconsiderable proportion to the deserted space. And that also, in the Experiment *De Vacuo,* as it is wont to be made, there is generally some little Air that gets in from without, or at least store of bubbles that arise from the Body of the Quick-silver, or other Liquor it self, Observations heedfully made have fre∣quently informed us: And it may also appear, by what has been formerly deli∣vered concerning the *Torricellian* Experi∣ment.

On the occasion of this Experiment concerning sounds, we may adde in this place, That when we try'd the Experiment formerly mention'd, of firing Gun pow∣der with a Pistol in our evacuated Recei∣ver, the noise made by the striking of the Flint against the Steel, was exceeding languid in comparison of what it would [Page  211](https://quod.lib.umich.edu/e/eebo/A29003.0001.001/240?vid=56393) have been in the open Air. And on di∣vers other occasions it appear'd that the sounds created within our exhausted Glass, if they were not lost before they reach'd the Ear, seem'd at least to arrive there very much weaken'd. We intended to try whether or no the Wire-string of an Instrument shut up into our Receiver, would, when the ambient Air was suck'd out, at all tremble, if in another Instrument held close to it, but without the Receiver a string tun'd (as Musicians speak, how properly I now examine not) to an Unison with it, were briskly toucht, and set a Vi∣brating. This, I say, we purpos'd to try to see how the motion made in the Air without, would be propagated through the cavity of our evacuated Receiver. But when the Instrument wherewith the tryal was to be made came to be imploy'd, it prov'd too big to go into the Pneumatical Vessel, and we have not now the conveni∣ency to have a fitter made.

We thought likewise to convey into the Receiver a long and slender pair of Bellows, made after the fashion of those usually employ'd to blow Organs, and fur∣nish'd with a small Musical instead of an [Page  212](https://quod.lib.umich.edu/e/eebo/A29003.0001.001/241?vid=56393) ordinary Pipe. For we hop'd, that by means of a string fastned to the upper part of the Bellows, and to the moveable stopple that makes a part of the Cover of our Receiver, we should, by frequent∣ly turning round that stopple, and the an∣nexed string, after the manner already often recited, be able to lift up and distend the Bellows; and by the help of a com∣petent weight fasten'd to the same upper part of the Bellows, we should likewise be able, at pleasure, to compress them: and by consequence, try whether that subtler matter then Air (which, accord∣ing to those that deny a *Vacuum,* must be suppos'd to fill the exhausted Receiver) would be able to produce a sound in the Musical Pipe; or in a Pipe like that of or∣dinary Bellows, to beget a Wind capable to turn or set a moving some very light matter, either shap'd like the Sails of a Wind-Mill, or of some other conveni∣ent form, and expos'd to its Orifice. This Experiment, I say, we thought to make, but have not yet actually made it for want of an Artificer to make us such a pair of Bellows as it requires.

We had thoughts also of trying whe∣ther or no, as Sounds made by Bodies in [Page  213](https://quod.lib.umich.edu/e/eebo/A29003.0001.001/242?vid=56393) our Receiver become much more languid then ordinary, by reason of the want of Air, so they would grow stronger, in case there were an unusual quantity of Air crouded and shut up in the same Vessel, which may be done (though not without some difficulty) by the help of the Pump, provided the Cover and Stopple be so firmly fasten'd (by binding and Cement, or otherwise) to the Glass; and to each other, that there be no danger of the condens'd Airs blowing of either of them away, or its breaking through the jun∣ctures. These thoughts, My Lord, as I was saying, we entertain'd; but for want of leasure, as, of as good Receivers as ours, to substitute in its place, in case we should break it before we learn'd the skill of condencing the Air in it, we durst not put them in practice: Yet, on this occa∣sion, give me leave to advertise Your Lordship once for all, That though for the reasons newly intimated, we have, Onely in the seventeenth Experiment, taken notice, that by the help of our En∣gine the Air may be condens'd as well as rarified; yet there are divers other of our Experiments, whose *Phaenomena* it were [Page  214](https://quod.lib.umich.edu/e/eebo/A29003.0001.001/243?vid=56393) worth while to try to vary, by means of the compression of the Air.

[\*](https://quod.lib.umich.edu/e/eebo/A29003.0001.001?id=DLPS35;lvl=1;note=inline;rgn=main;view=trgt)WE taught, among divers other things, when we discours'd of our first Experiment, That the Air shut up in our Receiver, presseth as strongly upon the Bodies shut up with it, as if they were expos'd to the pressure of the whole Atmosphere. That this was not incon∣siderately propounded, we hope Your Lordship has gather'd from divers of the things already recited: But yet perhaps it will not be amiss to subjoyn, by way of further confirmation of the same truth, the following Experiment, which should have accompanied the 20th, but the Paper where in the one was written chanc▪d not to be at hand, when the other was sent away.

We convey'd into the Receiver a new Glass Viol, capable of holding about 6 or 7 ounces of Water, into which we had before put 2 or 3 Spoon-fulls of that Li∣quor, and stopt it close with a fit Cork. The Pneumatical Vessel being empty'd, there appear'd not any change in the in∣clos'd Water, the Air imprison'd with it, not having the force to blow out the stop∣ple, [Page  215](https://quod.lib.umich.edu/e/eebo/A29003.0001.001/244?vid=56393) which event, though it were no other then we expected, was differing from what we desir'd. For we would gladly have seen what change would have appear'd in the Water upon the Bottles being suddenly unstopp'd, in a place where the ambient Body was so differing from our common Air. Wherefore we did again put in the Viol, but less strongly clos'd then for∣merly, though as strongly stopt as seem'd requisite on ordinary occasions: But when the Air was pump'd out of the Receiver, that within the Viol did quickly, as we expected, find or make it self little passa∣ges to get out at: as we argu'd, from this, That whereas when the Viol was put in the time before, the Water remain'd all the while perfectly free from bubbles; at this time the bottom of the Glass ap∣pear'd all cover'd with them, and they, upon the regress of the excluded Air into the Receiver, did presently flag and shrink up.

From these tryals it seem'd deducible enough, that whil'st the Viol continu'd to be well stopt, the included Water did, from the Air, shut up with it, sustain a pressure equal to that of the Atmosphere; since till the Air could get [Page  216](https://quod.lib.umich.edu/e/eebo/A29003.0001.001/245?vid=56393) out of the Glass, there appear'd no bub∣bles in the Water, notwithstanding the want of pressure in the ambient Body.

But to be sure to reach the chief end of our Experiment, we made use of this o∣ther expedient: We caus'd a convenient quantity of Water to be put, and Her∣metically shut up into a Glass Egge, to whose long Neck (which was purposely made of an unequal thickness) was fa∣sten'd to one end of a string, whose o∣ther end was ty'd to the Cover of our Receiver, after the manner elsewhere men∣tion'd already: Then the Egge being convey'd into the Pneumatical Vessel, and that being evacuated, we did, by turning the brass Stopple formerly de∣scrib'd amongst the parts of our En∣gine, so shorten the string as to break the Glass; whereby liberty being given to the Air imprison'd in the Egge, to pass into the capacity of the Receiver, the sud∣den recess of the Air made the bubbles in a trice appear so numerous, and ascend so swiftly in the Water, that their motion look'd like that of a violent shower of Rain; save that the bubbles did not, like the drops of Rain, tend downwards, but upwards, which made me resemble this [Page  217](https://quod.lib.umich.edu/e/eebo/A29003.0001.001/246?vid=56393)*Phaenomenon* to what I have seen happen in the dissolution of Seed-Pearl in some acid *Menstruum,* in which, if a good quan∣tity of the little Pearls be cast whole, they will at first, if the *Menstruum* be sharp e∣nough, be carryed in swarms from the bottom to the top of the Liquor. We will adde, that without sealing up the Glass, this Experiment may be try'd in one of our smallest Receivers, for there the exsuction of the ambient Air may be perform'd so nimbly, that immediately the bubbles lurking in the Water are al∣low'd to display themselves, and ascend in throngs; insomuch, as having in such a Receiver try'd the Experiment with Wine (as a more spirituous Liquor) in∣stead of Water, the Red-Wine appear'd all cover'd, with a copious, but vanishing white Froth, almost as if a Vessel full of bottl'd drink had been unwarily open'd.

IT may not a little conduce to the clear∣er explication of divers Points in the Doctrine of Meteors,[\*](https://quod.lib.umich.edu/e/eebo/A29003.0001.001?id=DLPS36;lvl=1;note=inline;rgn=main;view=trgt) and perhaps of some other Physiological difficulties, to discover what the Air does to the motion of those Steams or Exhalations that as∣cend [Page  218](https://quod.lib.umich.edu/e/eebo/A29003.0001.001/247?vid=56393) into it, namely, Whether they mount upwards by vertue of any such *positive le∣vity* (as some Peripateticks speak) ac∣quir'd together with their Aërial nature, as inables them to pierce through part of the Atmosphere, and over-come its re∣sistance. Or else, whether these steams being once rais'd above the Earth by their agitation, have their ascent and sustenta∣tion aloft, rather promoted then hindred by the Air: as the inferior parts of that, being thicker and heavier then the supe∣rior, the steams can more easily continue for a while their agitation upwards then downwards; And afterwards are by the same fluidity and thickness of the Air, carried to and fro in it, and kept from re∣lapsing to the Earth, as in the Sea water the saline parts are kept from subsiding by those aqueous ones wherewith they are associated.

We hop'd to illustrate this matter, by observing the motion of the smoke, pro∣ceeding from kindled or flaming Bodies in our exhausted Receiver. But as we for∣merly noted, upon the exsuction of the Air, the smoking of those Bodies pre∣sently ceas'd. We had thoughts also of conveying into our Pneumatical Glass a [Page  219](https://quod.lib.umich.edu/e/eebo/A29003.0001.001/248?vid=56393)•ot Iron, with some Body easie to be dissipated into smoke set upon it, but con∣sider'd, that neither was that way free from inconveniencies; especially this, that the hot Body would make the Imprison'd Air circulate within the Receiver, and consequently make it questionable whe∣ther the ascent of the steams would not be due to the new and acquired motion of the Air.

Wherefore I bethought my self of an∣other way to satisfie in some measure my curiosity, to wit, by means of a certain Liquor, which I call'd to minde that some years ago I had (for a design that belongs not to our present purpose) prepar'd; which, I suppose, I shew'd Your Lord∣ship, and which had the luck to be ta∣ken notice of by divers very Ingenious and Famous Men. For this Liquor, though most of its Ingredients be Metals, and all of them ponderous enough, is yet of that nature, that whilst the Viol where∣in it is kept is stopt (how slight a Cover soever) both the Liquor and the Glass are transparent; and so is that upper half of the Glass to which the Liquor reaches not. But assoon as ever the stopple is ta∣ken out, and full access is given to the ex∣ternal [Page  220](https://quod.lib.umich.edu/e/eebo/A29003.0001.001/249?vid=56393) Air, both the inward part of the Cork, and the Liquor it self, do present∣ly send upwards, and scatter abroad a fume as thick and white, as if there were a quantity of Alablaster-dust thrown up into the Air: And this smoking of the Liquor lasts till my unwillingness to waste it, invites me stop it again, and then the ascension of the fumes suddenly ceases, till the Viol be again unstop'd.

This fuming Liquor then I thought would much conduce to the discovery I desir'd to make, since it sav'd me the need of conveying any hot Body with it into the Receiver, and would not darken it with fumes before the time. Wherefore having ty'd to the Viol a great weight o• Lead, to keep it from being lifted up by the drawing out of the Cork; and having ty'd to the stopple one end of a string, of which the other end was made fast to the Cover of the Pneumatical Glass, the Li∣quor was carefully clos'd up after the wonted manner, then the Air being dili∣gently pump'd out, the Viol was unstopt in the empty'd Receiver: and though immediately, upon the drawing out of the Cork, there appear'd to be as it were thrown up some white fumes, which [Page  221](https://quod.lib.umich.edu/e/eebo/A29003.0001.001/250?vid=56393) seem'd to proceed from the Air before imprison'd in the Viol, and diffusing it self suddenly into the capicity of the Receiver. Yet we afterward observ'd, as we expected, That the fumes did not mount and disperse themselves as they use to do in the open Air, but that, when by reason of the agitation of the Cor∣puscles of the Liquor, which could not continue their motion in so narrow a space as the Viol afforded them, and were therefore reduc'd to thrust one another out of it; when, I say, by these assi∣stances the fumes were ascended to the lip of the Viol, they mounted no higher, but ran down along the out-side of the Viol to the bottom of it; and thence along, a long and inclining piece of Lead, on which the Viol rested, like a little Stream (not very much bigger then a Swans Quill) whose nature it seemd to e∣mulate so well, that it quitted not the Viol till it was come to the bottom of it, and then forsook it in such a manner as a stream of Water of the same bigness would have done. And this stream lasted a pretty while, and would probably have lasted longer, but that being loath to waste my Liquor, I let in at the Stop-cock a [Page  222](https://quod.lib.umich.edu/e/eebo/A29003.0001.001/251?vid=56393) pretty deal of the external Air; notwith∣standing which, finding after a while the stream did run afresh, though, as it seem'd, not altogether so copious as before: I let as much more Air, as would, come in, and found (somewhat to my wonder) that though the stream formerly mention'd dis-appear'd, yet there appear'd not any white fumes to arise, either from the Cork, or out of the Viol it self, no not when the Cover was remov'd from the Recei∣ver; though not onely after a while there ascended white Fumes from the Receiver: but having forthwith taken out the Viol into the open Air, it emitted white ex∣halations as before; and having presently after unstop'd it in an open Window, we found both it and the Cork immediatly to send forth a yet much more plentiful smoak. Though it be now divers years since this Numerical Liquor was prepa∣red, after the manner mention'd either by *Carneiades* or *Eleutherius* (for I do not well remember which) in those Dialogues concerning Heat and Flame that have a∣bove been mention'd.

More Circumstances concerning these Fumes we might have observ'd, had we not been deterr'd by an Indisposition in [Page  223](https://quod.lib.umich.edu/e/eebo/A29003.0001.001/252?vid=56393) point of health, from having much to do with steams of so dangerous a nature, as by that of the Ingredients of this Liquor these seem likely to be of.

The Reflections that may be made up∣on this Experiment, we have not now the leasure to prosecute, and therefore shall content our selves to recommend the se∣veral Circumstances of it to Your Lord∣ships serious consideration; and to take notice *(en passant)* that steams in an am∣bient Body, or a medium thinner then themselves, may both tend downwards, and otherwise emulate the nature of a Liquor; which I therefore point at, that it may appear the less strange, if we some∣times speak of the Atmosphere as of a kinde of Liquor, in comparison of that more thin and subtle Celestial Matter that surrounds it.

And though it might perchance suf∣fice to have on this occasion intima∣ted thus much; yet, lest this way of speaking of the Atmosphere should be thought too bold and extra∣vagant, I am content to borrow an Experiment of the Discourse former∣ly [Page  224](https://quod.lib.umich.edu/e/eebo/A29003.0001.001/253?vid=56393) mention'd (touching fluidity and firm∣ness) and subjoyn it here with alterations suitable to the contrivance of our Engine; and this the rather, because I hope it may conduce to the discovery of the nature of the Atmosphere: for which reason it might have been annext to what has been noted either upon the first, or eighteenth Experiment, but that when they were written and sent away, it came not into my minde. The Experiment then as we try'd in our Engine, was as follows.

[\*](https://quod.lib.umich.edu/e/eebo/A29003.0001.001?id=DLPS37;lvl=1;note=inline;rgn=main;view=trgt)WE took one of the small Receivers, often mention'd already, and into it we convey'd a piece of well lighted Match; and letting it remain there till it had fill'd the Receiver with smoak, we took it out and hastily clos'd again the Receiver, that the smoak might not get away. Then staying awhile to let these fumes leisurely subside, we found, as we expected, that after some time they setled themselves in the lower half of the Receiver, in a dark∣ish Body, leaving the upper half of the Receiver transparent, and as to sight, full of nought but clear Air. Now to mani∣fest that this smoak thus setled emulated [Page  225](https://quod.lib.umich.edu/e/eebo/A29003.0001.001/254?vid=56393) a Liquor, we inclin'd the Engine that con∣tain'd it, sometimes to one side, and some∣times to the other; and observ'd the smoak to keep its surface almost Hori∣zontal, notwithstanding the stooping of the Vessel that held it, as Water or an∣other Liquor would in the like case have done. And if by a quicker rocking of the Engine the smoke were more swiftly sha∣ken, it would, like Water, either Vibrate to and fro from one side to the other of the Glass, or else have its surface manifest∣ly curll'd with Waves, but preserve its self in an intire and distinct Body from the incumbent Air; and being permitted to rest awhile, would soon recover its for∣mer smooth and level *superficies*: If also the Key were turn'd and the Valve un∣stopp'd, so that there was a free, though but a narrow passage open'd betwixt the external Air and the cavity of the Recei∣ver, then would some of this smoak fall down, as it were, in a stream into the sub∣jacent Cylinder, and a proportionate quantity of the outward Air, would ma∣nifestly ascend through it into the incum∣bent Air, much after the same manner as if you invert a Viol with a long Neck, and well fill'd with Red-Wine, into a Glass [Page  226](https://quod.lib.umich.edu/e/eebo/A29003.0001.001/255?vid=56393) full of fair water, you shall see the Water and Wine by degrees mingle with one an∣other; the one falling downe as it were in little colour'd streames, and the other as∣cending into its room in the like curled streames, sometimes preceded by round parcels of water, which, by reason of their transparency, looke almost like bubbles. The other circumstances of this Experi∣ment, belonging not all of them to our present purpose, we shall content our selves with taking notice of one which seemes the most important, and may illu∣strate and confirme some things former∣ly delivered. And it was, That if, when the *superficies* of our Smoke lay smooth and horizontal, a hot iron were held near the outside of the Receiver, the Neigh∣bouring part of the included fumes (for the rest did not very much alter their for∣mer *superficies*) being rarified by the heat, would readily ascend in a large Pillar of smoke to the very top of the Receiver, yet without seeming to loose a distinct *superficies,* or to be confounded with Air; below which, upon the recess of the ad∣ventitious heat that by agitating it im∣pell'd it upward, it would againe sub∣side.

[Page  227](https://quod.lib.umich.edu/e/eebo/A29003.0001.001/256?vid=56393)All which being added to the late Ex∣periment of the smoking Liquor, and to what may be from that which has been elsewhere sayd, gather'd to the same pur∣pose, will, I hope, keep it at least from ap∣pearing absur'd: If since we see that there is so great an inequality in the density and weight of Liquors, that water is neere 14 times thinner or lighter than Quick-silver of the same bulk, and well dephlegm'd; Spirit of Wine yet much lighter than wa∣ter; we venter to speak sometimes of the Atmosphere, as if it were a peculiar kind of thin and halituous Liquor (if I may so call it) much lighter than Spirit of Wine.

To these things I know not whether it will be requisite to add, that as we late∣ly took notice of conspicuous waves that appear'd upon the *superficies* of our agi∣tated smoke. So some such thing may not absurdly be conjectur'd to happen on the *superficies* of the Atmosphere, by those strange ruggednesses that ap∣peare (especially in the Spring and Fall, when exhalations and vapours are wont to ascend most plentifully) upon the Limb or Edge of the Rising and Setting Sun. I speake thus diffidently upon this occasion because I know that by the Fluctuation or [Page  228](https://quod.lib.umich.edu/e/eebo/A29003.0001.001/257?vid=56393) Boyling of the Sun's own *superficies* di∣verse eminent Mathematicians have plau∣sibly enough (but how truly I leave your Lordship to Judge) endeavour'd to give an Account of it. But if we will joine with those that have ascrib'd of late this *Phaenomenon* to the Refraction the Sun-Beames suffer in our vapid Air; we may, as hath been intimated, promote their Do∣ctrin by deducing from it, that probably the surface Atmosphere is oftentimes (if not alwayes) exceedingly curl'd or wav'd. And certainly it is somewhat wonderfull as well as very pleasant to behold, how, to him that looks upon the setting Sun through a long & excellent Telescope, there will not only appeare strange ine∣qualities in the edge of it (insomuch that I have often seen it more indented than a Saw) but those inequalities will vanish in one place and presently appeare in ano∣ther, and seem perfectly to move like waves succeeding and destroying one an∣other; save that their Motion oftentimes seemes to be quickest as if in that vast sea they were carried on by a current, or at least by a tide. And this (as we else where note) appear's to the eye not on∣ly when it looks directly through the •e∣lescope [Page  229](https://quod.lib.umich.edu/e/eebo/A29003.0001.001/258?vid=56393) upon the sunne; but also when a large and well defin'd image of the sunne is by the same telescope brought into a roome and cast upon a sheet of white pa∣per. But to insist on this were to digress: and therefore I will proceed to experi∣ments of another kind.

IT has been admir'd by very ingenious Men,[\*](https://quod.lib.umich.edu/e/eebo/A29003.0001.001?id=DLPS38;lvl=1;note=inline;rgn=main;view=trgt) that if the exquisitly polish'd surfaces of two flat peeces of marble be so congruous to each other that from their mutuall application there will result an immediate contact, they will stick so fast together, that he that lifts up the upper∣most, shall, if the undermost be not ex∣ceeding heavy, lift up that too, and sus∣taine it aloft in the free aire. A proba∣ble cause of this so close adhesion we have elsewhere endeavour'd to deduce from the unequall pressure of the Air upon the un∣dermost stone; For the lower *superficies* of that stone being freely expos'd to the Air is press'd upon by it, whereas the up∣permost surface, being contiguous to the superiour stone, is thereby defended from the pressure of the Air which consequent∣ly pressing the lower stone against the up∣per, [Page  230](https://quod.lib.umich.edu/e/eebo/A29003.0001.001/259?vid=56393) hinders it from falling, as we have elsewhere more fully declar'd. Upon these grounds we conjectur'd that in case we could procure two marbles exactly ground to one another; and in case we could also sufficiently evacuate our Re∣ceiver, the lower stone would, for want of the wonted and sustaining pressure of the Air, fall from the upper. But the further tryal of this Experiment we must, unless your Lordship think it worth Your making at *Paris,* put off till a fitter opportunity. For where we now are, we cannot procure marbles so exactly ground, that they will sustaine one another in the Air, above a minute or two, which is a •uch shorter time than the emptying of our Receiver requires. We did indeed try to make our marbles stick close to∣gether by moistening their pollished sur∣faces with rectifi'd spirit of Wine, in re∣gard that Liquor by its sudden avolation from marble, if powr'd thereon, without leaving it moist or less smooth, seem'd unable to sustaine them together after the manner of a glutinous body, and yet seem'd sufficient to exclude and keep out the Air. But this we try'd to little pur∣pose, for having convey'd into the Recei∣ver [Page  231](https://quod.lib.umich.edu/e/eebo/A29003.0001.001/260?vid=56393) two black square marbles (the one of two inches and a third in length or breadth, and somewhat more than halfe an inch in thickness: The other of the same extent, but not much above halfe so thick) fasten'd together by the interven∣tion of pure Spirit of Wine; and having suspended the thicker by a string from the cover, we found not that the exsuction of the ambient Air would separate them, though a weight amounting to four oun∣ces were fasten'd to the lowermost mar∣ble to facilitate it's falling off.

I would gladly have the Experiment try'd with marble so well pollish't as to need no Liquor whatsoever to make them cohere, and in a Vessel out of which the Air may be more perfectly drawn than it was out of ours. But in the mean time though we will not determin whether the Spirit of wine did contribute to the strong cohesion of these stones, otherwise than by keeping ev'n the subtl'st parts of the Air from getting in between them, yet it seemed that the not falling downe of the lowermost marble might without impro∣bability be ascrib'd to the pressure of the Air remaining in the Receiver; which as we formerly noted having been able [Page  232](https://quod.lib.umich.edu/e/eebo/A29003.0001.001/261?vid=56393) to keep a Cylinder of water of above a Foot in height from falling to the bot∣tom of the Tube, may well enough be suppos'd capable of keeping so broad a flat Marble from descending. And though this may seem a strange proof of the strength of the spring of Air, ev'n when rarified, yet it will scarce seem incredible to him that has observ'd how exceeding strong a cohesion may be made betwixt broad Bodies, one∣ly by their immediate touching one ano∣ther. A notable instance of which, I have met with in this short Narrative of the Learned *Zucchius.*[\*](https://quod.lib.umich.edu/e/eebo/A29003.0001.001?id=DLPS39;lvl=1;note=inline;rgn=main;view=trgt)*Iuveni* (says: he) *lacertorum suorum robur: jactanti propo∣sita semel est lamina aerea, per ansam in medio extantem apprehensam elevanda è tabula marmorea, cui optime congruebat: qui primo tanquam rem ludicram puero committendam contempsit: tum instanti∣bus amicis manum utrámque admovens, cum luctatus diu haerentem non removisset, excusavit impotentiam, objecta perigrini & potentissimi glutinis interpositione, quo fortissime copulante nequiret divelli; do∣nec vidit ab alio per tabulam facilimè lami∣nam deduci, & ad extrema productam, & actam in transversum inde deportari.* But that we may learn from our own Engine, [Page  233](https://quod.lib.umich.edu/e/eebo/A29003.0001.001/262?vid=56393)•hat two Bodies, though they touch each other but in a small part of their surfaces, may be made to cohere very strongly, o•ely by this, That the Air presses much more forcibly upon the inferior superfi∣cies of the lowermost Body, then upon the upper surface of the same: We will hereunto annex the following Experi∣ment, though out of the order wherein they were made.

I remember I have,[\*](https://quod.lib.umich.edu/e/eebo/A29003.0001.001?id=DLPS40;lvl=1;note=inline;rgn=main;view=trgt) in a Discourse con∣cerning Fluidity and Firmness, made mention of my having, by the exsuction of the Air out of a Glass Vessel, made that Vessel take up, or suck up (to speak in the common Language) a Body weighing divers Ou•ces▪ but our Engine affording us the opportunity of making consider∣abler Experiments of that kinde, We thought fit to make a further tryal of the force of the Atmosphere's pressure up∣wards, a••er the following manner.

The Receiver having been exquisitely clos'd, as we have often taught already, and the Air being in a good measure drawn out of it, it was remov'd from off the Pump: and to the lower Branch of the [Page  234](https://quod.lib.umich.edu/e/eebo/A29003.0001.001/263?vid=56393) Stop-cock, there was speedily apply'd a tapering Valve of brass, such as is describ'd in the 9th fig: made fit to go with its nar∣rower end into the cavity of the branch, and to fill the orifice of that cavity with its broader part. And that the Air might not get in at the litle intervals, left here and there between the convex surface of the stopple and the internall edge of the branch, those intervals were stop't with a little Diachylon. And to the doore, or, (if you please) that part of the Valve which was to move to and fro, and in this Experiment hung perpendicular to the Horizon, there was, at a button of brass belonging to the Valve fasten'd a broad scale wherein weights were to be put. This done the key of the Stop-cock was turn'd, and the externall Air beating like a forcible streame upon the Valve to get in there, it did suddenly both shut the Valve and keep it shut so strongly, that we had time to cast in diverse weights one after another into the Scale; till at length the weight overpowering the pres∣sure of the Atmosphere, drew downe the Valve by the stringes that ty'd the Scale to it, and gave liberty to the outward Air to rush into the Receiver. Though a∣•other [Page  235](https://quod.lib.umich.edu/e/eebo/A29003.0001.001/264?vid=56393) time, when the Valve had but lit∣•le weight hanging at it, being, by I know not what accident, drawn down beneath its former place, it was by the impetuous current of the outward Air suddenly im∣pell'd up into it again, and kept there. But in the former Experiment it is re∣markable, That though the Receiver were not well exhausted, and though it leak'd whil'st the rest of the Experiment was in prosecution, and though the Valve whereon the Cylinder of the Atmosphere could press, were not above an Inch and • half in Diameter, yet the weight kept up by suction, or rather supported by the Air, namely the Valve, the Seal and what was cast into it, being sent to be weigh'd, amounted to about ten of our common Pounds, consisting of sixteen Ounces apiece: So that we doubted not but that, had the Experiment been made with favorable Circumstances, the Air endeavoring to press in at the Orifice of the Stop-cock, would have kept a very much greater weight from falling out of it; I say the Air, because we found, by tryal purposely made, that neither the imperfect contact of the Valve and the Stop-cock, nor the Diachylon that was [Page  236](https://quod.lib.umich.edu/e/eebo/A29003.0001.001/265?vid=56393) employ'd to fill up the little Crannies left betwixt them, were considerable in this Experiment; by which may among other things appear, that I did not without cause in the above-nam'd Discourse touch∣ing Fluidity and Firmness, ascribe a great force, ev'n to such Pillars of Air as may be suppos'd to begin at the top of the Atmosphere, and recoyling from the ground to terminate on the Bodies on which they press: since in the present Ex∣periment such a weight was supported by so slender a Cylinder of Air, rebounding from the Earth to the Valve whereon •t did bear.

[\*](https://quod.lib.umich.edu/e/eebo/A29003.0001.001?id=DLPS41;lvl=1;note=inline;rgn=main;view=trgt)BUt in regard we have not yet been able to empty so great a Vessel as our Receiver, so well as we can the Cylinder it self; our Pump alone may afford us a nobler instance of the force of the Air we live in, insomuch, that by help of this part of our Engine, we may give a pretty near ghess at the strength of the Atmo∣sphere, computed as a weight. And the way may be this; First, the Sucker be∣ing brought to move easily up and down the Cylinder, is to be impell'd to the top [Page  237](https://quod.lib.umich.edu/e/eebo/A29003.0001.001/266?vid=56393) of it: Then the Receiver must be taken off from the Pump, that the upper Ori∣fice of the Cylinder remaining open, the Air may freely succeed the Sucker, and therefore readily yield to its motion downward. This done, there must be fasten'd to one of the Iron Teeth of the Sucker, such a weight as may just suffice to draw it to the bottom of the Cylinder. And having thus examin'd what weight is necess•ry to draw down the Sucker, when the Atmosphere makes no other then the ordinary resistance of the Air against its descent; the Sucker must be again forc'd to the top of the Cylinder, whose upper Orifice must now be exactly closed; and then (the first weight remaining) we easi∣ly may, by hanging a Scale to the above-metion'd Iron (that makes part of the Sucker) cast in known weights so long, till in spight of the reluctancy of the At∣mostphere the Sucker be drawn down. For to these weights in the Scale, that of the Scale it self being added, the sum will give us the weight of a Column of Air, equal in Diameter to the Sucker, or to the ca∣vity of the Cylinder; and in length to the heighth of the Atmosphere.

According to this method we did, since [Page  238](https://quod.lib.umich.edu/e/eebo/A29003.0001.001/267?vid=56393) the writing of the last Experiment, at∣tempt to measure the pressure of the At∣mosphere, but found it more difficult then we expected, to perform it with any ac∣curateness; for though by the help of the *Manubrium* the Sucker moved up and down with so much ease, that one would have thought that both its convex surface, and the concave one of the Cylinder were exquisitely smooth, & as it were slippery; yet when the Sucker came to be moved onely with a dead weight or pressure (that was not (like the force of him that pump'd) intended as occasion required) we found that the little rufnesses, or other inequalities, and perhaps too, the unequal pressure of the Leather against the cavity of the Cylinder, were able now and then to put a stop to the descent or ascent of the Sucker, though a very little external help would easily surmount that impedi•ment; and then the Sucker would, for a while, continue its formerly interrupted motion, though that assistance were with∣drawn. But this discouragement did not deterre us from prosecuting our Experi∣ment, and endeavoring, by a careful trial, to make it as instructive as we could. We found then that a Leaden Weight, [Page  239](https://quod.lib.umich.edu/e/eebo/A29003.0001.001/268?vid=56393) of 28 pounds (each consisting of sixteen Ounces) being fastned to one of the teeth of the Sucker, drew it down slowly e∣nough; when the upper Orifice of the Cylinder was left open, though by the help of Oyl and Water, and by the fre∣quent moving the Sucker up and down with the *Manubrium,* its motion in the Cylinder had been before purposely faci∣litated. This done, the upper Orifice of the Cylinder was very carefully and close∣ly stopp'd, the Valve being likewise shut with its wonted Stopple well oyl'd, af∣ter the Sucker had been again impell'd up to the top of the Cylinder. Then to the precedent twenty eight pound, we added a hundred and twelve pounds more; which forcing down the Sucker, though but leisurely, we took off the twenty eight pound weight; and being unable to procure just such weights as we would have had, we hung on, instead of it, one of fourteen pound, but found that, with the rest, unable to carry down the Sucker. And to satisfie our selves, and the Spe∣ctators, that it was the resistance of the ambient Air that hinder'd the descent of so great a weight, after that we had try'd that upon unstopping the Valve, and [Page  240](https://quod.lib.umich.edu/e/eebo/A29003.0001.001/269?vid=56393) thereby opening an access to the external Air, the Sucker would be immediately drawn down: After this, I say, we made this further Experiment, That having by a Man's strength forcibly depress'd the Sucker to the bottom of the Cylinder, and then fastned weights to the above-named Iron that makes part of that Suc∣ker, the pressure of the external Air find∣ing little or nothing in the cavity of the evacuated Cylinder to resist it, did pre∣sently begin to impell the Sucker, with the weights that clogg'd it, towards the upper part of the Cylinder, till some such accidental Impediment as we former∣ly mention'd, check'd its course; and when that rub, which easily might be, was taken out of the way, it would continue its ascent to the top, to the no small won∣der of those By-standers, that could not comprehend how such a weight could as∣cend, as it were, of it self; that is, with∣out any visible force, or so much as Su∣ction to lift it up. And indeed it is very considerable, that though possibly there might remain some particles of Air in the Cylinder, after the drawing down of the Sucker; yet the pressure of a Cylinder of the Atmosphere, somewhat less then [Page  241](https://quod.lib.umich.edu/e/eebo/A29003.0001.001/270?vid=56393) three Inches in Diameter (for, as it was said in the description of our Engine, the cavity of the Cylinder was no broader) was able, uncompress'd, not only to sustain, but even to drive up a weight of an hun∣dred and odde pounds: for besides the weight of the whole Sucker it self, which amounts to some pounds, the weights an∣nexed to it made up a hundred and three pounds, besides an Iron Bar, that by con∣jecture weighed two pounds more; and yet all these together fall somewhat short of the weight which we lately mention'd, the resistance of the Air to have held su∣spended in the cavity of the Cylinder.

And though (as hath been already ac∣knowledg'd) we cannot, peradventure, obtain by the recited means so exact an account as were to be wish'd, of what we would discover: Yet, if it serve us to ground Conjectures more approaching to the Truth, then we have hitherto met with, I hope it will be consider'd (which a famous Poet judiciously says)

Est quodd•m prodire tenus, si non da∣tur ultra.

Peradventure it will not be imperti∣nent [Page  242](https://quod.lib.umich.edu/e/eebo/A29003.0001.001/271?vid=56393) to annex to the other Circumstances that have been already set down concern∣ing this Experiment, That it was made in Winter, in Weather neither Frosty nor Rainy, about the change of the Moon, and at a place whose latitude is near about 51d and a half: For perhaps the force or pressure of the Air may vary, according to the Seasons of the Year, the tempera∣ture of the Weather, the elevation of •he Pole, or the phases of the Moon; 〈◊〉, or even any of them seeming capable to al∣ter either the heighth or consistence of the incumbent Atmosphere: And therefore it would not be amiss if this Experiment were carefully tryd at several times and places, with variety of Circumstances. It might also be try'd with Cylin•ers of se∣veral Diameters, exquisitely fitted with Suckers, that we might know what pro∣portion several Pillars of the Atmosphere bear, to the Weights they are able to su∣stain or lift up; and consequently, whe∣ther the increase or decrement of the re∣sistance of the ambient Air, can be re∣duc'd to any regular proportion to the Diameters of the Suckers: These, and divers other such things which may be try'd with this Cylinder, might most of [Page  243](https://quod.lib.umich.edu/e/eebo/A29003.0001.001/272?vid=56393) them be more exactly try'd by the Torri∣cellian Experiment, if we could get Tubes so accurately blown and drawn, that the Cavity were perfectly Cylindrical.

To dwell upon all the several Refle∣ctions, that a speculative Wit might make upon this and the foregoing Expe∣riment, (I mean the thirty third and thir∣ty second) would require almost a Vo∣lume; whereas our occasions will scarce allow us time to touch upon three or four of the chief Inferences that seem de∣ducible from them, and therefore we shall content our selves to point at those few.

And first, as many other *Phaenomena* of our Engine, so especially, the two lately mention'd Experiments, seem ve∣ry much to call in question the receiv'd Opinion of the Nature or Cause of Su∣ction. For 'tis true indeed, that when men suck, they commonly use some manifest endeavour by a peculiar motion of their Mouthes, Chests, and some other conspi∣ring parts, to convey to them the body to be suckt in. And hence perhaps they have taken occasion, to think that in all [Page  244](https://quod.lib.umich.edu/e/eebo/A29003.0001.001/273?vid=56393) Suction there must be some Endeavour or motion in the sucking to attract the sucked Body. But in our last Experi∣ment it appeares not at 〈◊〉how the up∣per part of the empty'd Cylin•er that re∣maines moveless all the 〈◊〉, or any part of it, does at all en•eavour to draw to it the depressed Sucker and the an∣nex'd weights. And yet those that be∣hold the ascention of the Sucker, without seriously considering the cause of it, doe readily conclude it to be rays'd by some∣thing that powerfully Sucks or attracts it, though they see not what that may be or where it lurks. So that it seemes not absolutely necessary to Suction, that there 〈◊〉Body, which is said to suck, an 〈◊〉or motion in order thereun∣to, but rather that Suction may be at least for the most part reduc'd to Pulsion, and its effects ascrib'd to such a pressure of the neighboring air upon those Bodies (whther aërial, or of other Natures) that are contiguous to the Body that is sayd to attract them, as is stronger than that Sub∣stance which possesses the cavity of that sucking Body is able to resist. To ob∣ject here, that it was some particles of Air remaining in the empty'd Cylin∣der [Page  245](https://quod.lib.umich.edu/e/eebo/A29003.0001.001/274?vid=56393) that attracted this weight to obviate a *Vacuum,* will scarce be satisfactory; un∣less it can be cleerly made out by what li∣tle hooks, or other grappling Instruments, the internal Air could take hold of the Sucker; how so litle of it obtain'd the force to lift up so great a weight; and why also, upon the letting in of a litle more Air into one of our evacuated Ves∣sels, the attraction is, instead of being strengthen'd, much weaken'd, though, if there were danger of a *Vacuum* be∣fore, it would remain, notwithstanding this ingress of a little Air. For that still there remain'd in the capacity of the ex∣hausted Cylinder store of little rooms, or spaces empty or devoid of Air, may appear by the great violence wherewith the air rushes in, if any way be open'd to it. And that 'tis not so much the decrement of the *Vacuum* within the cavity of the vessel that debilitates the attraction, as the spring of the included air (whose presence makes the decrement) that does it by resisting the pressure of the external Air, seems probable, partly from the Disabi∣lity of vacuities, whether greater or lesser, to resist the pressure of the Air; and part∣ly by some of the *Phaenomena* of our Ex∣periments, [Page  246](https://quod.lib.umich.edu/e/eebo/A29003.0001.001/275?vid=56393) and particularly by this Cir∣cumstance of the three and Thirtieth, that the Sucker was by the pressure of the Ambient Air impell•d upwards, with its weight hanging at it, not only when it was at the bottome of the Cylinder, and consequently left a great *Vacuum* in the cavity of it; but when the Sucker had been already impel'd almost to the top of the Cylinder, and consequently, when the *Vacuum* that remain'd was become very litle in comparison of that which preceded the beginning of the Sucker's ascention.

In the next place, these Experiments may teach us, what to judge of the vul∣gar Axiom receiv'd for so many Ages as an undoubted Truth in the Peripate∣tick Schools; That Nature abhorres and flys a *Vacuum,* and that to such a de∣gree, that no humane power (to go no higher) is able to make one in the Uni∣verse; wherein Heaven and Earth would change places, and all its other Bodyes rather act contrary to their own Nature, than suffer it. For, if by a *Vacuum* we will understand a place perfectly devoid of all corporeal Substance, it may be in∣deed then, as we formerly noted, be plau∣sibly enough maintain'd, that there is [Page  247](https://quod.lib.umich.edu/e/eebo/A29003.0001.001/276?vid=56393) no such thing in the world; but that the generality of the Plenists, (especially till of late yeares some of them grew more wary) did not take a *Vacuum* in so strict • Sense, may appear by the Experiments formerly, and ev'n to this Day imploy'd by the Deniers of a *Vacuum,* to prove it impossible that there can be any made. For when they alleadge (for Instance) that when a man sucks Water through a long Pipe, that heavy Liquor, contrary to its Nature, ascends into the Sucker's mouth, only, to fill up that room made by the Dilatation of his Brest and Lungs, which otherwise will in part be empty. And when they tell us, that the reason why if a long Pipe exactly clos'd at one end be fill'd top-ful of Water, and then inverted, no Liquor will fall out of the open Orifice; Or, to use a more familiar Example, when they teach, that the cause why in a Gardiner's watering Pot shap'd conically, or like a Sugar-Loaf fill'd with Water, no Liquor fals down through the numerous holes at the bottome, whilst the Gardiner keeps his Thumb upon the Orifice of the litle hole at the top; and no longer, must be that if in the case proposed the Water [Page  248](https://quod.lib.umich.edu/e/eebo/A29003.0001.001/277?vid=56393) should descend, the Air being unable to succeed it, there would be left at the up∣per and deserted part of the Vessel a *Va∣cuum,* that would be avoided if the hole at the top were open'd. When (I say) they alleadge such Experiments, the Tendency of them seems plainly to im∣port, that they mean, by a *Vacuum,* any space here below that is not fill'd with a visible body, or at least with Air, though it be not quite devoy'd of all Body what∣soever. For why should Nature, out of her detestation of a *Vacuum,* make Bo∣dies act contrary to their own Tendency, that a place may be fill'd with Air, if its being so were not necessary to the avoi∣ding of a *Vacuum.*

Taking then a *Vacuum* in this vulgar and obvious sence, the common opinion about it seems lyable to several Exce∣ptions, whereof some of the chief are suggested to us by our Engine.

It will not easily then be intelligibly made out, how hatred or aversation, which is a passion of the Soule, can either for a *Vacuum,* or any other object, be sup∣pos'd to be in Water, or such like inani∣mate Body, which cannot be presum'd to know when a *Vacuum* would ensue; if [Page  249](https://quod.lib.umich.edu/e/eebo/A29003.0001.001/278?vid=56393) they did not bestirre themselves to pre∣vent it, nor to be so generous as to act contrary to what is most conducive to their own particular preservation for the publique good of the Universe. As much then of intelligible and probable Truth, as is contain'd in this Metaphoricall Ex∣pression, seems to amount but to this; That by the Wise Author of Nature (who is justly sayd to have made all things in number, weight, and measure,) the Universe, and the parts of it, are so contriv'd, that it is as hard to make a *Va∣cuum* in it, as if they studiously conspir'd to prevent it. And how far this it selfe may be granted, deserves to be further consider'd.

For in the next place, our Experiments seem to teach, that the supposed Aversa∣tion of Nature to a *Vacuum* is but acci∣dental, or in consequence partly of the Weight and Fluidity, or, at least, Fluxi∣lity of the Bodies here below; and partly, and perhaps principally, of the Spring of the air, whose restless endeavor to expand it selfe every way, makes it either rush in it selfe, or compel the interpos'd bo∣dys into all spaces, where it finds no grea∣ter resistance than it can furmount. And [Page  250](https://quod.lib.umich.edu/e/eebo/A29003.0001.001/279?vid=56393) that in those motions which are made *ob fugam Vacui* (as the common phrase is) Bo∣dys act without such generosity & Con∣sideration, as is wont to be ascrib'd to them, is apparent enough in our 32d Ex∣periment, where the torrent of Air, that seem'd to strive to get into the Empty'd Receiver, did plainly prevent its own Designe, by so impelling the Valve, as to make it shut the only Orifice the Air was to get in at. And if afterwards ei∣ther Nature, or the internal Air, had a de∣signe the external Air should be attra∣cted, they seem'd to prosecute very un∣wisely by continuing to suck the Valve so strongly, when they found that by that Suction the Valve it selfe could not be drawn in: Whereas by forbearing to suck, the Valve would by it's own weight have fall'n down, and suffer'd the exclu∣ded Air to returne freely, and to fill again the exhausted Vessel.

And this minds me to take notice of another deficiency, pointed at by our Ex∣periments in the common Doctrine of those Plen•sts we reason with; for many of those unusual motions in Bodies, that are sayd to be made to escape a *Vacuum,* seem rather made to fill it. For why, [Page  251](https://quod.lib.umich.edu/e/eebo/A29003.0001.001/280?vid=56393) to instance in our newly mention'd Ex∣periment, assoon as the Valve was de∣press'd by the weight we hung at it, should the Air so impetuously and copi∣ously rush into the cavity of the Receiver; it there were before no vacant room there to receive it? and if there were, then all the while the Valve kept out the Air, those l•tle spaces in the Receiver, which the corpuscles of that Air afterwards fill'd, may be concluded to have remain'd em∣pty. So that the seeming violence, imploy'd by Nature on the occasion of the evacuating of the Vessel, seems to have come too late to hinder the making of Vacuities in the Receiver, and only to have, assoon as we permitted, fill'd up with Air those that were already made.

And as for the Care of the Publique Good of the Universe ascrib'd to dead and stupid Bodies, wee shall only de∣mand, why in our 19th Experiment, upon the Exsuction of the ambient Air, the Water deserted the upper half of the Glass-Tube; and did not ascend to fill it up, till the external Air was let in upon it: whereas by its easy and sudden regai∣ning that upper part of the Tube, it [Page  252](https://quod.lib.umich.edu/e/eebo/A29003.0001.001/281?vid=56393) appear'd both that there was there much space devoid of Air, and that the Water might with small or no resistance have ascended into it, if it could have done so without the impulsion of the readmitted Air; which, it seems, was necessary to mind the Water of its formerly neglected Duty to the Universe.

Nay, for ought appeares, ev'n when the excluded Air, assoon as 'twas per∣mitted, rusht violently into our exhau∣sted Receiver, that flowing in of the Air proceeded rather from the deter∣minate Force of the Spring of the neighbouring Air, then from any endea∣vour to fill up, much less to prevent va∣cuity's. For though when as much Air as will, is gotten into our Receiver our pre∣sent Opponents take it for granted that it is full of Air; yet if it be remembred that when we made our 17th Experiment we crouded in more Air to our Rece••er than it usually holds; and if we also con∣sider (which is much more) the Air of the same consistence with that in our Receiver may in wind-guns, as is known, and as we have try'd, be compressed at least into halfe its wonted room (I say at least, because some affirme, that the Air [Page  253](https://quod.lib.umich.edu/e/eebo/A29003.0001.001/282?vid=56393) may be thrust into an 8th, or a yet smaller part of its ordinary extent) it seems ne∣cessary to admit either a notion of conden∣sation & rarefaction that is not intelligi∣ble, or that in the capacity of our Recei∣ver when presum'd to be full of Air, there yet remain'd as much of space as was ta∣ken up by all the aërial corpuscles unpos∣sessed by the Air. Which seemes plainly, to infer that the Air that rush'd into our empty'd vessel did not doe it precisely to fill up the Vacuities of it, since it left so many unfill'd, but rather was thrust in by the pressure of the contiguous Air; which as it could not, but be always ready to ex∣pand it selfe, where it found least resi∣stance, so was it unable to fill the Recei∣ver any more, then until the Air within was reduc'd to the same measure of Com∣pactness with that without.

We may also from our two already of∣ten mention'd Experiments further de∣duce, that, (since Natures hatred of a *Vacuum* is but Metaphorical and Ac∣cidental, being but a consequence or re∣sult of the pressure of the Air and of the Gravity, and partly also of the Fluxility of some other bodies) The power shee makes use of to hinder a Vacuum, is not [Page  254](https://quod.lib.umich.edu/e/eebo/A29003.0001.001/283?vid=56393) (as we have else-where also noted) any such boundless thing as men have been pleas'd to imagine. And the reason, why in the former Experiments, mentioned in favour of the Plenists, Bodies seem to forget their own Natures to shun a *Va∣cuum,* seems to be but this; That in the alleadged cases the weight of that Wa∣ter that was either kept from falling or impell'd up, was not great enough to surmount the pressure of the contiguous Air; which, if it had been, the Water would have subsided, though no Air could have succeeded. For not to repeat that Experiment of Monsieur *Paschal* (for∣merly mention'd to have been try'd in a Glass exceeding 32 Foot) wherein the inverted Pipe being long enough to con∣tain a competent weight of Water, that Liquor freely ran out at the lower Orifice: Not to mention this (I say) we saw in our nineteenth Experiment, that when the pressure of the ambient Air was suffi∣ciently weaken'd, the Water would •all out apace at the Orifice even of a short Pipe, though the Air could not succeed into the room deserted by it. And it were not amiss if tryal were made on the tops of very high Mountains, to discover with [Page  255](https://quod.lib.umich.edu/e/eebo/A29003.0001.001/284?vid=56393) what ease a *Vacuum* could be made near the confines of the Atmosphere, where the Air is probably but light in compari∣son of what it is here below. But our present (three and thirtieth) Experiment seems to manifest, not onely that the power, exercis'd by Nature, to shun or re∣plen•sh a *Vacuum,* is limited, but that it may be determin'd even to Pounds and Ounces: Insomuch that we might say, such a weight Nature will sustain or will lift up to resist a *Vacuum* in our Engine; but if an Ounce more be added to that weight, it will surmount Her so much magnifi'd detestation of Vacuities. And thus, My Lord, our Experiments may not onely answer those of the Plenists, but enable us to retort their Arguments against themselves: since, if that be true which they alleadge, that, when Water falls not down according to its nature, in a Body wherein no Air can succeed to fill up the place it must leave, the suspensi∣on of the Liquor is made *Ne detur Vacu∣um,* (as they speak) it will follow, that if the Water can be brought to subside in such a case, that deserted space may be deem'd empty, according to their own Doctrine; especially, since Nature (as [Page  256](https://quod.lib.umich.edu/e/eebo/A29003.0001.001/285?vid=56393) they would perswade us) bestirs her self so mightily to keep it from being de∣serted.

I hope I shall not need to reminde Your Lordship, that I have all this while been speaking of a *Vacuum,* not in the strict and Philosophical sense, but in that more obvious and familiar one that has been formerly declar'd.

And therefore I shall now proceed to observe in the last place, that our 33d Ex∣periment affords us a notable proof of the unheeded strength of that pressure which is sustain'd by the Corpuscles of what we call the free Air, and presume to be un∣compress'd. For, as fluid and yielding a Body as it is, our Experiment teaches us, That ev'n in our Climate, and without any other compression then what is (at least here below) Natural, or (to speak more properly) ordinary to it, it bears so strongly upon the Bodies whereunto it is contiguous, that a Cylinder of this free Air, not exceeding three Inches in Dia∣meter is able to raise and carry up a weight, amounting to between sixteen and seventeen hundred Ounces. I said, [Page  257](https://quod.lib.umich.edu/e/eebo/A29003.0001.001/286?vid=56393) even in our Climate,[\*](https://quod.lib.umich.edu/e/eebo/A29003.0001.001?id=DLPS42;lvl=1;note=inline;rgn=main;view=trgt) because that is tem∣perate enough; and as far as my obser∣vations assist me to conjecture, the Air in many other more Northern Countries may be much thicker, and able to support a greater weight: which is not to be doubted of, if there be no mistake in what is Recorded concerning the *Hollan∣•ers,* that were forc'd by the Ice to Win∣ter in *Nova Zembla,* namely, That they found there so condens'd an Air, that they could not make their Clock goe, ev'n by a very great addition to the weights that were wont to move it.

I suppose Your Lordship will readily take notice, that I might very easily have discoursed much more fully and accuratly then I have done, against the common o∣pinion touching Suction, and touching na∣tures hatred of a *Vacuum.* But I was willing to keep my self to those considerations touching these matters, that might be ve∣rifi'd by our Engine it self, especially, since, as I said at first, it would take up too much time to insist particularly upon all the Re∣flections that may be made even upon our two last Experiments. And therefore, [Page  258](https://quod.lib.umich.edu/e/eebo/A29003.0001.001/287?vid=56393) passing to the next, I shall leave it to your Lordship to consider how far these tryals of ours will either confirm or disfavor the new Doctrine of several eminent Na∣turalists, who teach, That in all motion there is necessarily a Circle of Bodies, as they speak, moving together; and whe∣ther the Circles in such motion be an Ac∣cidental or Consequential thing or no.

[\*](https://quod.lib.umich.edu/e/eebo/A29003.0001.001?id=DLPS43;lvl=1;note=inline;rgn=main;view=trgt)TIs a known thing to those that are con∣vesant in the Hydrostaticks, That two Bodies which in the Air are of equal weight, but of unequal bulk, as Gold, for instance and Iron, being afterwards weighed in Water, will lose their *Aequi∣librium* upon the change of the ambient Body, so that the Gold will sink lower then the Iron; which, by reason of its greater bulk, has more Water to lift or displace, that it may sink. By Analogy to this Experiment, it seem'd probable, that if two weights did in our Engine ballance each other, when the Glass was full of Air; upon the exsuction of a great part of that Air, so notable a change in the consistence of the ambient Body, [Page  259](https://quod.lib.umich.edu/e/eebo/A29003.0001.001/288?vid=56393) would make them lose their *Aequili∣brium.*

But being desirous at the same time to make a tryal, for a certain Design that needs not here be mention'd, we took for one of our weights a dry Bladder, strongly tyed at the Neck, and about half fill'd with Air (that being a weight both flight, and that would expand it self in the evacuated Glass) and fastning that to one part of our formerly menti∣on'd exact ballance (which turns with the 32d part of a Grain) we put a Metalline counterpoise into the opposite Scale; and so the two weights being brought to an *Aequilibrium,* the ballance was convey'd into the Receiver, and suspended from the Cover of it.

But before we proceed further, we must note, That presently after the laying on of the Cover, the Bladder appear'd to preponderate, whereupon the Scales being taken out, and reduc'd very near to an *Ae∣quilibrium,* yet so, that a little advantage remain'd on that side to which the Metal∣line weight belong'd; they were again let down into the Receiver, which was pre∣sently made fast with Plaister, and a hot Iron: Soon after which, before the Pump [Page  260](https://quod.lib.umich.edu/e/eebo/A29003.0001.001/289?vid=56393) was employ'd, the Bladder seem'd again a little to pre•onderate. Afterwards the Air in the Glass being begun to be drawn out, the Bladder began (according to the formerly mention'd Observations) to expand it self, and manifestly to out∣weigh the opposite weight, drawing down the Scale to which it was fastned very much beneath the other, especially when the Air had swell'd it to its full ex∣tent.

This done, we very leisurely let in the external Air; and observ'd, that upon the flagging of the Bladder, the Scale whereto it was fastned, not onely by de∣grees return'd to an *Aequilibrium* with the other, but at length was a little out∣weighed by it.

But because we suspected there might have interven'd some unheeded Circumstance in this last part of the Ex∣periment, we would not presently take out the Scales, nor meddle with the Co∣ver, but leaving things as they were, we perceiv'd, that after a little while the Bladder began again to preponderate, and by degrees to sink lower and lower for divers hours; wherefore, leaving the Vessel clos'd up all night, we repair'd to it [Page  261](https://quod.lib.umich.edu/e/eebo/A29003.0001.001/290?vid=56393) next Morning, and found the Bladder fallen yet lower. As if the very substance of it, had imbibed some of the moisture wherewith the Air (the Season being ve∣ry rainy) did then abound: As Lute∣strings, which are made likewise of the Membranous parts of Guts, strongly wreath'd, are known to swell so much, oftentimes as to break in rainy and wet weather. Which conjecture is the more to be regarded, because congruously unto it one of the company having a little warm'd the Bladder, found it then lighter then the opposite weight. But this must be look'd upon as a bare conjecture, till we can gain time to make further tryals about it. In the mean while we shall adde, that without removing the Scales or the Co∣ver of the Receiver, we again caus'd the A•r to be drawn out (the weather conti∣ing very moist) but found not any manifest alteration in the ballance; whether be∣cause the *Aequilibrium* was too far lost to let a small change appear, we determine not.

But to make the Experiment with a Body less apt to be altered by the tempe∣rature of the Air, then was the Bladder; we brought the Scales again to an *Aequi∣librium*[Page  262](https://quod.lib.umich.edu/e/eebo/A29003.0001.001/291?vid=56393) with two weights, whereof the one was of Lead, the other of Cork. And having evacuated the Receiver, we obser∣ved, that both upon the exsuction, and after the return of the Air, the Cork did manifestly preponderate, and much more a while after the Air had been let in again, then whilst it was kept out. Wherefore, in the room of the Cork, we substituted a piece of Char-coal, as less likely to im∣bibe any moisture from the Air, but the event proved much the same with that newly related: So that this Experiment seems more liable to Casualties then any, excepting one we have made in our En∣gine. And as it is difficult to prevent them, so it seems not very easie to dis∣cover the causes of them, whereof we shall therefore at present forbear mention∣ing our Conjectures.

[\*](https://quod.lib.umich.edu/e/eebo/A29003.0001.001?id=DLPS44;lvl=1;note=inline;rgn=main;view=trgt)SOme Learned Mathematicians have of late ingeniously endeavored to reduce Filters to *Siphons*; but still the true cause of the ascension of Water, and other Li∣quors, both in *Siphons* and in Filtration, needing (for ought we have yet found) a clearer Discovery and Explication, we [Page  263](https://quod.lib.umich.edu/e/eebo/A29003.0001.001/292?vid=56393) were desirous to try whether or no the pressure of the Air might reasonably be suppos'd to have either the principal, or at least a considerable Interest in the raising of those Liquors. But because we found that we could not yet so evacuate our Re∣ceiver, but that the remaining Air, though but little in comparison of the exhausted, would be able to impell the the Water to a greater height then is usual in ordinary Filtrations: we resolved, instead of a List of Cotton, or the like Filtre, to make use of a *Siphon* of Glass, delineated in the third Figure, consist∣ing of three pieces, two straight, and the third crooked to joyn them toge∣ther; whose Junctures were diligently clos'd, that no Air might finde entrance at them. One of the Legs of this *Si∣phon* was (as it should be) somewhat longer then the other, and was pervious at the bottom of it onely, by a hole al∣most as slender as a hair, that the Water might but very leasurely drop out of it, lest it should all run out before the Experiment were compleat∣ed. The other and shorter Leg of the *Siphon* was quite open at the end, and of the same widenesse with the [Page  264](https://quod.lib.umich.edu/e/eebo/A29003.0001.001/293?vid=56393) rest of the Pipe, whose bore was about •/4 of an Inch. The whole Siphon made up of these several pieces put together, was design'd to be about a Foot and a half long; that the remaining Air, when the Vessel was exhausted after the wont∣ed manner, might not be able to impell the Water to the top of the *Siphon*; which being inverted, was fill'd with Wa∣ter, and of which the Shorter leg being let down two or three Inches deep into a Glass Vessel full of Water, and the up∣per parts of it being fasten'd to the inside of the Cover of the Receiver, we pro∣ceeded to close first, and then to empty the Vessel.

The effect of the tryal was this, that till a pretty quantity of Air had been drawn out, the Water dropp'd freely out at the lower end of the lower leg of the *Siphon,* as if the Experiment had been performed in the free Air. But afterwards, the Bubbles (as had been apprehended) began to disclose themselves in the Wa∣ter, and ascending to the top of the *Si∣phon,*imbodyed themselves there into one, which was augmented little by little by the rising of other bubbles that from time to time broke into it, but much [Page  265](https://quod.lib.umich.edu/e/eebo/A29003.0001.001/294?vid=56393) more by its own dilatation, which en∣creas'd proportionably to the exsuction that was made of the Air out of the Re∣ceiver. So that at length the Water in the shorter Leg of the *Siphon*was re∣duc'd partly by the extraction of the am∣bient Air, and partly by the expansion of the great Bubble at the upper part of the *Siphon,* to be but about a Foot high, if so much; whereby it came to pass, that the course of the Water in the *Si∣phon* was interrupted, and that which re∣main'd in the longer Leg of it, continu'd suspended there without dropping any longer. But upon the turning of the Stop-cock, the outward Air (being let into the Receiver) got into the *Siphon* by the little hole at which the Water former∣ly dropt out; and traversing all the in∣cumbent Cylinder of Water, in the form of Bubbles, joyn'd it self with that Air that before possess'd the top of the *Si∣phon.*

To prevent the inconveniences arising from these Bubbles, two Glass Pipes, like the former, were so placed, as to termi∣nate together in the midst of the Belly of a Glass Viol, into whose Neck they were carefully fastned with Cement; and [Page  266](https://quod.lib.umich.edu/e/eebo/A29003.0001.001/295?vid=56393) then both the Viols and the Pipes being (which was not done without difficulty) totally fill'd with Water, the *Siphon* describ'd in the fifth Figure, was plac'd with its shorter Leg in the Glass of Wa∣ter, as formerly; and the Experiment be∣ing prosecuted after the same manner, much more Air then formerly was drawn out, before the Bubbles disclosing them∣selves in the Water were able to disturb the Experiment; because that in the ca∣pacity of the Viol there was room enough for them to stretch themselves, without depressing the Water below the ends of the Pipes; and, during this time, the Water continued to drop out of the pro∣pending Leg of the *Siphon.* But at length the Receiver being very much em∣pty•d, the passage of the Water through the *Siphon* ceas'd, the upper ends of the Pipes beginning to appear a little above the remaining Water in the Viol, whose dilated Air appear'd likewise to press down the Water in the Pipes, and fill the upper part of them. And hereby the con∣tinuity of the Water, and so the Expe∣riment it self being interrupted, we were invited to let in the Air again, which, ac∣cording to its various proportions of [Page  267](https://quod.lib.umich.edu/e/eebo/A29003.0001.001/296?vid=56393) pressure to that of the Air in the Viol and the Pipes, did for a good while exhi∣bite a pleasing variety of *Phaenomena,* which we have not now the leisure to re∣c•te. And though upon the whole mat∣ter there seem'd little or no cause to doubt, but that, if the Bubbles had not disturb'd the Experiment, it would mani∣festly enough have appear'd that the course of Water through *Siphons* de∣pends upon the pressure of the Air: yet we resolv'd, at our next leisure and con∣veniency, to try the Experiment again, with a quantity of Water before freed from Bubbles by the help of the same Engine.

This occasion I have had to take notice of *Siphons,* puts me in minde of an odde kinde of *Siphon* that I caus'd to be made a pretty while ago, and which has been since, by an Ingenious Man of Your ac∣quaintance, communicated to divers o∣thers. The occasion was this, An emi∣nent Mathematician told me one day, that some inquisitive French Men (whose Names I know not) had observ'd, That, in case one end of a slender and perforated Pipe of Glass be dipt in Water, the Li∣quor [Page  268](https://quod.lib.umich.edu/e/eebo/A29003.0001.001/297?vid=56393) will ascend to some height in the Pipe, though held perpendicular to the plain of the Water. And, to satisfie me that he mis related not the Experiment, he soon after brought two or three small Pipes of Glass, which gave me the opportunity of trying it: though I had the less reason to distrust it, because I re∣member I had often in the long and slen∣der Pipes of some Weather Glasses, which I had caus'd to be made after a somewhat peculiar fashion, taken notice of the like ascension of the Liquor, though (presuming it might be casual) I had made but little reflection upon it. But after this tryal, beginning to suppose, that though the Water in these Pipes that were brought me, rise not above a quar∣ter of an Inch, (if near so high) yet, i• the Pipes were made slender enough, the Water might rise to a very much greater height; I caus'd several of them to be, by a dexterous Hand, drawn out at the flame of a Lamp, in one of which that was almost incredibly slender, we found that the Water ascended (as it were of it self) five Inches by measure, to the no small wonder of some famous Mathematicians, who were Spectators of some of these [Page  269](https://quod.lib.umich.edu/e/eebo/A29003.0001.001/298?vid=56393) Experiments. And this height the Wa∣ter reach'd to, though the Pipe were held in as erected a posture as we could: For if it were inclin'd, the Water would fill a greater part of it, though not rise higher in it. And we also found, that when the inside of the Pipe was wetted before-hand, the Water would rise much better then otherways: But we caus'd not all our slender Pipes to be made straight, but some of them crooked, like *Siphons:* And having immers'd the shorter Leg of one of these into a Glass that held some fair Water, we found, as we expected, that the Water arising to the top of the *Si∣phon,* though that were high enough, did of it self run down the longer Leg, and continue running like an ordinary *Siphon.* The cause of this ascension of the Wa∣ter, appear'd to all that were present so difficult, that I must not stay to enumerate the various Conjectures that were made at it, much less to examine them; espe∣cially, having nothing but bare Conje∣ctures to substitute in the room of those I do not approve. We try'd indeed, by conveying a very slender Pipe and a small Vessel of Water into our Engine, whe∣ther or no the Exsuction of the ambient [Page  270](https://quod.lib.umich.edu/e/eebo/A29003.0001.001/299?vid=56393) Air would assist us to finde the cause of the ascension we have been speaking of: But though we imploy'd red Wine in∣stead of Water, yet we could scarce cer∣tainly perceive thorow so much Glass, as was interpos'd betwixt our Eyes and the Liquor, what happen'd in a Pipe so slen∣der, that the redness of the Wine was scarce sensible in it. But as far as we could discern, there happen'd no great altera∣tion to the Liquor▪ which seem'd the less strange, because the Spring of that Air that might depress the Water in the Pipe, was equally debilitated with that which remain'd to press upon the surface of the Water in the little Glass. Wherefore, in favor of his Ingenious Conjecture who ascrib'd the *Phaenomenon,* under conside∣ration to the greater pressure made upon the Water by the Air without the Pipe, then by that within it, (where so much of the Water (consisting perhaps of Corpu∣scles more pliant to the internal surfaces of the Air) was contiguous to the sides) it was shown, that in case the little Glass Vessel that held the Water, of which a part ascended into the slender Pipe, were so clos'd, that a Man might with his mouth suck the Air out of it, the Water would [Page  271](https://quod.lib.umich.edu/e/eebo/A29003.0001.001/300?vid=56393) immediately subside in the small Pipe. And this would indeed infer, that it as∣cended before onely by the pressure of the incumbent Air: But that it may (how justly I know not) be objected, that peradventure this would not hap∣pen, in case the upper end of the Pipe were in a *Vacuum*: And that 'tis very probable the Water may subside, not because the pressure of the internal Air is taken off by Exsuction, but by reason of the Spring of the external Air, which impels the Water it findes in its way to the Cavity deserted by the other Air, and would as well impell the same Water upwards, as make it subside, if it were not for the acci∣dental posture of the Glasses. How∣ever, having not now leisure to exa∣mine any further this Matter, I shall onely minde Your Lordship, that if You will prosecute this Speculation, it will be pertinent to finde out likewise, Why the surface of Water (as is manifest in Pipes) uses to be concave, being de∣press'd in the middle, and higher on eve∣ry side? and Why in Quick-silver on the contrary, not onely the surface is wont [Page  272](https://quod.lib.umich.edu/e/eebo/A29003.0001.001/301?vid=56393) to be very convex, or swelling, in the middle; but if you dip the end of a slen∣der Pipe in it, the surface of the Li∣quor (as 'tis call'd) will be lower within the Pipe, then without▪ Which *Phaeno∣mena,* whether, and how far, they may be deduc'd from the Figure of the Mer∣curial Corpuscles, and the Shape of the Springy Particles of the Air, I willingly leave to be consider'd.

[\*](https://quod.lib.umich.edu/e/eebo/A29003.0001.001?id=DLPS45;lvl=1;note=inline;rgn=main;view=trgt)SEveral ways we have met with pro∣pos'd, partly by the excellent *Galileo,* and partly by other ingenious Writers, to manifest that the Air is not devoid of weight; some of these, require the previ∣ous absence of the Air to be weighed; and others, the violent condensation of it. But if we could lift a pair of Scales above the Atmosphere, or place them in a *Va∣cuum,* we might there weigh a parcel of Air it self, as here we do other Bodies in the Air, because it would there be heavi∣er then that which surrounds it, as are grosser Bodies we commonly weigh, then the medium or ambient Air. Where∣fore, though we have above declin'd to affirm, that our Receiver, when empty∣ed, [Page  273](https://quod.lib.umich.edu/e/eebo/A29003.0001.001/302?vid=56393) deserves the name of a true *Vacuum,* and though we cannot yet perfectly free it from Air it self, yet we thought fit to try how far the Air would manifest its gravity in so thin a medium, as we could make in our Receiver, by evacuating it. We caus'd then to be blown at the Flame of a Lamp, a Glass-bubble of about the bigness of a small Hen-egge, and of an Oval form, save that at one end there was drawn out an exceeding slender Pipe, that the Bubble might be seal'd up, with as little rarifaction as might be, of the Air included in the great or ovall Cavi∣ty of it. This Glass being seal'd, was fa∣stened to one of the Scales of the exact pair of Ballances formerly mention'd; and being counterpois'd with a weight of Lead, was convey'd into the Receiver, and clos'd up in it. The Beam appearing to continue Horizontal, the Pump was set awork, and there scarce past above two or three Exsuctions of the Air, before the Ballance lost its *Aequilibrium,* and began to incline to that side on which the Bubble was; which, as the Air was further and further drawn out, did mani∣festly more and more preponderate, till he that pump'd began to grow weary of [Page  274](https://quod.lib.umich.edu/e/eebo/A29003.0001.001/303?vid=56393) his Imployment: after which the aire be∣ing leasurely let in againe, the scales by degrees returned to their former *Aequili∣brium.* After that we tooke them out, and casting into that scale to which the lead belong'd three quarters of a grain, we convey'd the ballance into the Recei∣ver, which being closed up, and exhau∣sted as before, we observ'd, that as the aire was drawne out more and more, so the glasse bubble came neerer and neer∣er to an *Aequilibrium* with the other weight, till at length the beame was drawne to hang horizontall; which (as we had found by another tryall) wee could not bring it to do, when a quar∣ter of a Graine more was added to the scale, to which the lead belong'd: though it seem'd questionlesse, that if wee could have perfectly empty'd the Receiver of the contain'd aire, that in∣cluded in the bubble would have weigh∣ed above a grain, notwithstanding its having been probably somewhat Rari∣fy'd by the flame by the help of which, the bubble was seald up. Let us adde, that on the regresse of the excluded air, the Lead, and the weight cast into the [Page  275](https://quod.lib.umich.edu/e/eebo/A29003.0001.001/304?vid=56393) same scale, did againe very much pre∣ponderate.

We likewise convey'd into the Re∣ceiver, the same bubble, open'd at the end of the slender pipe above men∣tioned, but having drawne out the aire, after the accustomed manner, we found not as before, the bubble to out-weigh the opposite lead, so that by the help of our Engine, we can weigh the Aire, as we weigh other Bodies, in its na∣turall or ordinary consistence, without at all condensing it: Nay, which is re∣markable, having convey'd a Lamb's bladder about halfe full of Aire into the Receiver, wee observed, that though upon the drawing out of the ambient aire the imprisoned Air so expanded it self, as to distend the Bladder so, as to seem ready to break it; yet this rarified Air did manifestly depress the Scale whereunto it was annexed.

Another thing, we must not forget to mētion, that happend to us, whil'st we were making tryals cōcerning the weight of the Air; namely, That having once caus'd the [Page  276](https://quod.lib.umich.edu/e/eebo/A29003.0001.001/305?vid=56393) Pump to be somewhat obstinately ply'd, to discover the better what may be ex∣pected from the thinness of the medium in this Experiment; the Imprison'd Air broke its brittle Prison, and throwing the greatest part of it against the side of the Receiver, dash•d it against that th•ck Glass into a multitude of pieces. Which Acci∣dent I mention, partly that it may con∣firm what we deliver'd in our Reflections, upon the first Experiment, where we con∣sider'd what would probably be done by the Spring of the Air Imprison'd in such Glasses, in case the ballancing pressure of the ambient Air were withdrawn; and partly, that we may thence discern of how close a Texture Glass is, since so very thin a film of Glass (if I may so call it) prov'd so impervious to the Air, that it could not get away through the Pores, but was forc'd to break the glass in pieces to free it self; and this, notwithstanding the time and advantage it had to try to get out at the Pores. And this I mention, that neither our Experiments, nor those of divers Learned Men, might receive any prejudice from an Experiment which I happen'd to make divers years ago, and, which having been so much taken notice [Page  277](https://quod.lib.umich.edu/e/eebo/A29003.0001.001/306?vid=56393) of by curious Men, may be drawn to countenance their erroneous Opinion, who would fain perswade us, That Glass is penetrable by Air properly so called. Our Experiment was briefly this: We were distilling a certain substance, that much a∣bounded with subtle Spirits and volatile Salt, in a strong Earthen-vessel of an un∣usual shape, to which was luted a large Receiver, made of the courser sort of Glass, (which the Trades-men are wont to call Green-glass) but in our absence, the Fire, though it were to be very strong, was by the negligence or mistake of those we appointed to attend it, so excessively increas'd, that when we came back to the Fornace we found the Spirituous and Sa∣line Corpuscles pour'd out (if I may so call it) so hot, and so copiously into the Receiver, that they made it all opacous, and more likely to flie in pieces, then fit to be touch'd. Yet, being curious to ob∣serve the effects of a Distillation, prose∣cuted with so intense and unusual degree of heat, we ventur'd to come near, and observ'd, among other things, that on the out-side of the Receiver, at a great di∣stance from the juncture, there was setled a round whitish Spot or two, which at [Page  278](https://quod.lib.umich.edu/e/eebo/A29003.0001.001/307?vid=56393) first we thought might be some stain up∣on the Glass; but after, finding it to be in divers Qualities like the Oyl, and Salt of the Concrete we were Di∣stilling, we began to suspect that the most subtle and fugitive parts of the im∣petuously ascending Steams, had pene∣trated the substance (as they speak) of the Glass, and by the cold of the am∣bient Air were condens'd on the sur∣face of it. And though we were ve∣ry backward to credit this suspition, and therefore call'd in an Ingenious Person or two, both to assist us in the Ob∣servation, and have Witness of its e∣vent, we continued a while longer to watch the escape of such unctuous Fumes, and upon the whole matter unanimously concluded, That all things consider'd, the subtle parts of the distill'd matter being violently agitated, by the exces∣sive heat had pass'd through the Pores of the Glass, widen'd by the same heat. But this having never happen'd but once in any of the Distillations we have either made or seen, though these be not a few, it is much more reasonable to suppose, that the perviousness of our Receiver to a Body much more [Page  279](https://quod.lib.umich.edu/e/eebo/A29003.0001.001/308?vid=56393) subtle then Air, proceeded partly from the looser Texture of that particular parcel of Glass the Receiver was made of (for Experience has taught us, that all Glass is not of the same compact∣ness and solidity) and partly from the enormous heat, which, together with the vehement agitation of the pene∣trant Spirits, open'd the Pores of the Glass; then to imagine that such a substance as Air, should be able to per∣meate the Body of Glass contrary to the testimony of a thousand Chymical and Mechanical Experiments, and of many of those made in our Engine, e∣specially that newly recited: Nay, by our fifth Experiment it appears, that a thin Bladder will not at its Pores give passage even to rarified Air. And on this occasion we will annex an Ex∣periment, which has made some of those we have acquainted with it, doubt, whether the Corpuscles of the Air be not lesse subtle then those of Water.

But without examining here the reasonablenesse of that doubt, we will proceed to recite the Experiment it self, which seems to teach, That though Air, [Page  280](https://quod.lib.umich.edu/e/eebo/A29003.0001.001/309?vid=56393) when sufficiently compress'd, may per∣chance get entrance into narrower holes and crannies then Water; yet unless the Air be forc'd in at such very little holes, it will not get in at them, though they may be big enough to let Water pass through them.

The Experiment then was this: I took a fair Glass *Siphon,* the lower end o• whose longest Leg was drawn by degrees to such a slenderness, that the Orifice, at which the Water was to fall out, would hardly admit a very small Pin: This *Si∣phon* being inverted, the matter was so order'd that a little Bubble of Air was intercepted in the slenderest part of the *Siphon,*betwixt the little hole newly men∣tion'd, and the incumbent Water, upon which, it came to pass, that the Air be∣ing not to be forc'd through so narrow a passage, by so light a Cylinder of Water, though amounting to the length of divers Inches, as lean'd upon it, hinder'd the further Efflux of the Water, as long as I pleas'd to let it stay in that narrow place: whereas, when by blowing a little at the wider end of the *Siphon,* that little par∣cel of Air was forc'd out with some Wa∣ter, the remaining Water, that before [Page  281](https://quod.lib.umich.edu/e/eebo/A29003.0001.001/310?vid=56393) continu'd suspended, began freely to drop down again as formerly. And if you take a Glass Pipe, whether it be in the form of a *Siphon,* or no, that being for the most part of the thickness of a Mans Finger, is yet towards one end so slen∣der, as to terminate in a hole almost as small as a Horse-hair; and if you fill this Pipe with Water, you will finde that Li∣quor to drop down freely enough tho∣row the slender Extream: But if you then invert the Pipe, you will finde that the Air will not easily get in at the same hole through which the Water pass'd. For in the sharp end of the Pipe, some Inches of Water will remain suspended, which 'tis probable would not happen, if the Air could get in to succeed it, since if the hole were a little wider, the Water would immediatly subside. And though it be true, that if the Pipe be of the length of many Inches, a great part of the Wa∣ter will run down at the wider Orifice, yet that seems to happen for some other rea∣son, then because the Air succeeds it at the upper and narrow Orifice, since all the slender part of the Pipe, and perhaps some Inches more, will continue full of Water.

[Page  282](https://quod.lib.umich.edu/e/eebo/A29003.0001.001/311?vid=56393)And on this occasion I remember, that whereas it appears by our fifth Experi∣ment, That the Aërial Corpuscles (ex∣cept perhaps some that are extraordinari∣ly fine) will not passe thorow the Pores of a Lambs Bladder, yet Particles of Wa∣ter will, as we have long since observ'd, and as may be easily try'd, by very close∣ly tying a little *Alcalizate* Salt (we us'd the Calx of Tartar, made with Nitre) in a fine Bladder, and dipping the lower end of the Bladder in Water; for if you hold it there for a competent while, you will finde that there will strain thorow the Pores of the Bladder Water enough to dissolve the Salt into a Liquor.

But I see I am slipt into a Digression, wherefore I will not examine, whether, the Experiment I have related, proceed∣ed from hence, That the springy Texture of the Corpuscles of the Air, makes them less apt to yield and accommodate themselves easily to the narrow Pores o• Bodies, then the more flexible Particles of Water; or whether it may more pro∣babiy be ascrib'd to some other Cause. Nor will I stay to consider how far we may hence be assisted to ghess at the cause of the ascension of Water in the slender [Page  283](https://quod.lib.umich.edu/e/eebo/A29003.0001.001/312?vid=56393) Pipes and *Siphons* formerly mention'd, but will return to our Bubble; and take notice, That we thought fit also to en∣deavor to measure the capacity of the Bubble we had made use of, by filling it with Water, that we might the better know how much Water answered in weight to ¾ of a Grain of Air, but not∣withstanding all the diligence that was used to preserve so brittle a Vessel, it broke before we could perfect what we were about, and we were not then pro∣vided of another Bubble fit for our turn.

The haste I was in, My Lord, when I sent away the last Sheet, made me forget to take notice to you of a Problem that occurr'd to my thoughts, upon the oc∣casion of the slow breaking of the Glass Bubble in our evacuated Receiver. For it may seem strange, since by our sixth Experiment it appears, that the Air, when permitted, will by its own internal Spring expand it selfe twice as much as *Mer∣sennus* was able to expand it, by the heat even of a candent *Aeolipile:* Yet the *Elater* of the Air was scarce able to break a very thin Glass Bubble, and ut∣terly [Page  284](https://quod.lib.umich.edu/e/eebo/A29003.0001.001/313?vid=56393) unable to break one somewhat thic∣ker, within whose cavity it was impri∣son'd; whereas Air pent up and agitated by heat is able to perform so much more considerable effects, that (not to mention those of Rarefaction that are more obvi∣ous) the Learned Jesuit *Cabaeus* (he that writ of the Load-stone) relates,[\*](https://quod.lib.umich.edu/e/eebo/A29003.0001.001?id=DLPS46;lvl=1;note=inline;rgn=main;view=trgt) That he saw a Marble Pillar (so vast, that three men together with display'd arms could not imbrace it, and that 1000 Yoke of Oxen drawing it several ways with all their strength, could not have torn it assunder) quite broken off in the midst, by reason of some Wood, which hap∣pening to be burnt just by the Pillar, the heat proceeding from the neighboring Fire, so rarified some Air or Spirituous Matter which was shut up in the cavities of the Marble, that it broke through the solid Body of the Stone to obtain room to expand it self.

I remember I have taken notice that probably the reason why the included Air did not break the hermetically seal'd Bub∣bles that remain'd intire in our emptyed Receiver, was, That the Air, being some∣what rarefied by the Flame imploy'd to close the Glass, its Spring, upon the re∣cess [Page  285](https://quod.lib.umich.edu/e/eebo/A29003.0001.001/314?vid=56393) of the heat, grew weaker then before. But though we reject not that ghess, yet it will not in the present case serve the turn, because that much smaller Glass bubbles exactly clos'd, will, by the in∣cluded Air (though agitated but by the heat of a very moderate Fire) be made to fly in pieces. Whether we may be assisted to salve this Problem, by consi∣dering that the heat does from within ve∣hemently agitate the Corpuscles of the Air, and adde its assistance to the Spring they had before, I shall not now examine: since I here but propose a Problem, and that chiefly that by this memorable Story of *Cabaeus,* notice may be taken of the prodigious power of Rarefaction, which hereby appears capable of performing stranger things then any of our Experi∣ments have hitherto ascrib'd to it.

We should hence, My Lord, imme∣diatly proceed to the next Experiment, but that we think it fit, on this occasion, to acquaint You with what some former tryals (though not made in our Engine) have taught us, concerning what we would have discover'd by the newly mention'd Bubble that broke. And this the rather, because (a great part of this [Page  286](https://quod.lib.umich.edu/e/eebo/A29003.0001.001/315?vid=56393) letter supposing the gravity of the Aire) it will not be impertinent to determine more particularly then hitherto we have done, what gravity we ascribe to it.

We tooke then an *Aeolipile* made of copper, weighing six ounces, five drachms, and eight and forty graines: this being made as hot as we durst make it, (for feare of melting the mettle, or at least the So∣dar) was removed from the fire and im∣mediately stopped with hard wax that no Aire at all might get in at the little hole wont to be left in *Aeolipiles* for the fumes to issue out at: Then the *Aeolipile* being suffer'd leasurely to coole was again weighed together with the wax that stopt it, and was found to weigh (by reason of the additionall weight of the wax) six ounces, sixe drachmes, and 39 graines. Lastly, the wax being perforated without taking any of it out of the Scale, the externall Aire was suffered to rush in (which it did with some noyse) and then the *Aeolipile* and wax, being againe weighed amounted to six ounces, six drachmes, and 50. graines. So that the *Aeolipile* freed as farre as our fire could free it, from it's Aire, weighed lesse then [Page  287](https://quod.lib.umich.edu/e/eebo/A29003.0001.001/316?vid=56393) it selfe when replenished with Air, full eleven graines. That is, the Air contain∣able within the cavity of the *Aeolipile* a∣mounted to eleven graines and somewhat more; I say somewhat more, because of the particles of the Air, that were not driven by the fire out of the *Aeolipile.* And by the way (if there be no mistake in the observations of the diligent *Mer∣sennus*) it may seeme strange that it should so much differ from 2. or 3. of ours; in none of which we could rarifie the Air in our *Aeolipile* (though made red hot almost all over, and so immediately plung'd into cold water) to halfe that degree which he mentions, namely to 70. times it's natu∣rall extent, unlesse it were that the *Aeo∣lipile* he imploy'd was able to sustaine a more vehement heat then ours (which yet we kept in so great an one, that once the soder melting, it fell asunder into the two Hemispheres it consists of.)

The fore-mentioned way of weighing the Air by the help of an *Aeolipile,* seems somewhat more exact then that which *Mersennus* used, In that in ours the *Aeoli∣pile* was not weighed, till it was cold; whereas in his, being weighed red hot, it is [Page  288](https://quod.lib.umich.edu/e/eebo/A29003.0001.001/317?vid=56393) subject to loose of it's substance in the cooling, for (as we have elsewhere noted on another occasion) Copper heated red hot is wont in the cooling to throw off little thin scales in such plenty, that having purposely watcht a Copper *Aeolipile* du∣ring its refrigeration, we have seen the place round about it almost covered with those little scales it had every way scat∣ter'd: which, however they amount not to much, ought not to be over-looked, when 'tis so light a body as Air, that is to be weighed. We will not examine, whether the *Aeolipile* in cooling may not receive some little increment of weight, either from the vapid or faline Steames that wander up and downe in the Air: But we will rather mention, that (for the grea∣ter exactnesse) we imployed to weigh our *Aeolipile,* both when fill'd onely with Air and when replenisht with Water, a paire of scales that would turne (as they speak) with the fourth part of a grain.

As to the proportion of weight be∣twixt Air and Water, some learned men have attempted it by wayes so unaccurate that they seeme to have much mistaken it. For (not to mention the improbable accounts of *Kepler* and others.) The lear∣ned [Page  289](https://quod.lib.umich.edu/e/eebo/A29003.0001.001/318?vid=56393) and diligent *Ricciolus,* having pur∣posely endeavoured to investigate this proportion by meanes of a thin blad∣der, estimates the weight of the Air to that of the Water to be as one to ten thousand, or thereabouts. And indeed I re∣member that having formerly, on a cer∣tain occasion, weighed a large bladder full of Air, and found it when the Air was all squeesed out, to have contained fourteen graines of Air. I found the same bladder afterwards fill'd with water to containe very neer 14. pound of that liquor: accor∣ding to which account, the proportion of Air to Water was almost as a graine to a pound, that is, as one to above 7600. To this we may adde, that on the other side, *Galileo* himselfe using another, but an un∣accurate way too, defined the Air to be in weight to Water, but as one to 4. hun∣dred. But the way formerly proposed of weighing the Air by an *Aeolipile,* seemes by great oddes more exact; and (as farre as we could ghesse) seemed to agree well enough with the experiment made in our Receiver. Wherefore it will be best to trust our *Aeolipile* in the enquiry we are a∣bout, and according to our observations the water it contained amounting to one [Page  290](https://quod.lib.umich.edu/e/eebo/A29003.0001.001/319?vid=56393) and twenty ounces and an halfe, and as much Air as was requisite to fill it weigh∣ing eleven graines, the proportion in gra∣vity of Air to Water of the same bulk will be as one to 938. And though we could not fill the *Aeolipile* with water, so exactly as we would, yet in regard we could not either as perfectly as we would, drive the Air out of it by heat; we think the proportion may well enough hold: but those that are delighted with round numbers (as the phrase is) will not be much mistaken if they reckon water to be neere a thousand times heavier than Air. And (for further proof that we have made the proportion betwixt these two bodies rather greater then lesser then indeed it is; and also to confirme our former observa∣tion of the weight of the Air) we will adde, That, having another time put some Wa∣ter into the *Aeolipile* before we set it on the fire, that the copious vapours of the rarefied liquor might the better drive out the Air, we found, upon tryall carefully made, that when the *Aeolipile* was refrige∣rated, and the included vapours were by the cold turned againe into water (which could not have happen'd to the Air, that the preceeding Steams expell'd) the Air, [Page  291](https://quod.lib.umich.edu/e/eebo/A29003.0001.001/320?vid=56393) when it was let in, increas'd the weight of the *Aeolipile* as much as before, namely, Eleven Grains; though there were alrea∣dy in it twelve Drachmes and a half, be∣sides a couple of Grains of Water, which remain'd of that we had formerly put in∣to it to drive out the Air.

*Mersennus* indeed tells us, that by his account Air is in weight to Water, as 1 to 1356. And adds, that we may, without any danger, believe that the gravity of Water to that of Air of a like bulk, is not less then of 1300 to 1. And conse∣quently, that the quantity of Air to a quantity of Water equiponderant there∣to, is as 1300 to 1. But why we should relinquish our own carefully repeated try∣als, I see not. Yet I am unwilling to re∣ject those of so accurate and useful a Wri∣ter: And therefore shall propose a way of reconciling our differing Observations, by presenting, that the discrepance be∣tween them may probably arise from the differing consistence of the Air at *London* and at *Paris*: For our Air being more cold and moist, then that which Your Lord∣ship now breaths, may be suppos'd also to be a fourth or fifth part more heavy. I leave it to be consider'd, whether it be of [Page  292](https://quod.lib.umich.edu/e/eebo/A29003.0001.001/321?vid=56393) any moment that our Observations were made in the midst of Winter, whereas his were perhaps made in some warmer time of the Year. But I think it were not a∣miss that, by the method formerly pro∣pos'd, the gravity of the Air were ob∣serv'd both in several Countries, and in the same Country, in the several Seasons of the Year and differing Temperatures of the Weather. And I would give some∣thing of value to know the weight of such an *Aeolipile* as ours full of air in the midst of Winter in *Nova Zembla,* if that be true which we formerly took notice of, namely, That the *Hollanders,* who Win∣tered there, found that Air so thick that their Clock would not go.

If Your Lordship should now ask me, if I could not by the help of these, and our other Observations, decide the Con∣troversies of our Modern Mathematici∣ans about the height of the Air or Atmo∣sphere, by determining how high it doth indeed reach: I should answer, That though it seems easie enough to shew that divers Famous and Applauded Writers have been mistaken in assigning the heigth of the Atmosphere: Yet it seems very difficult precisely to define of what height [Page  293](https://quod.lib.umich.edu/e/eebo/A29003.0001.001/322?vid=56393) it is. And because we have hitherto but lightly touch'd upon a matter of such im∣portance, we presume it wil not be thought impertinent, upon this occasion, to annex something towards the Elucidation of it.

What we have already try'd and newly set down, allows us to take it for granted, that (at least about *London*) the propor∣tion of gravity betwixt Water and Air, of equal bulk, is as of a thousand to one.

The next thing therefore that we are to enquire after, in order to our present design, is the difference in weight betwixt Water and Quick-silver: And though this hath been defin'd already by the Il∣lustrious *Verulam,* and some other inqui∣sitive Persons, that have compar'd the weight of several Bodies, and cast their Observations into Tables, yet we shall not scruple to annex our own tryals about it: Partly, because we finde Authors considerably to dis-agree; partly, because we us'd exacter Scales, and a somewhat more wary method then others seem to have done: And partly also, because ha∣ving prosecuted our inquiry by two or three several ways; the small difference [Page  294](https://quod.lib.umich.edu/e/eebo/A29003.0001.001/323?vid=56393) between the events may assure us that we were not much mistaken.

We took then a Glass Pipe, of the form of an inverted *Siphon,* whose shape is delineated in the sixteenth Figure: And pouring into it a quantity of Quick silver, we held it so, that the superficies of the Liquor, both in the longer and shorter leg, lay in a Horizontal Line, denoted in the Scheme by the prick'd Line EF; then pouring Water into the longer Leg of the *Siphon,* till that was almost fill'd, we ob∣serv'd the surface of the Quick-silver in that leg to be, by the weight of the Wa∣ter, depress'd, as from E to B; and in the shorter leg, to be as much impell'd upward as from F to G: Whereupon ha∣ving formerly stuck marks, as well at the point B, as at the opposite point D, we measur•d both the distance DC to have the height of the Cylinder of Quick-sil∣ver, which was rais•d above the Point D (level with the surface of the Quick-silver in the other leg) by the weight of the Wa∣ter, and the distance BA which gave us the height of the Cylinder of Water. So that the distance D C amounting to 2 ••/•• Inches, and the height of the Water a∣mounting 30 45/5• Inches; and the whole [Page  295](https://quod.lib.umich.edu/e/eebo/A29003.0001.001/324?vid=56393) numbers on both sides, which the annex∣ed Fractions being reduc'd to improper Fractions of the same denomination, the proportion appear'd to be (the denomi∣nators beng left out as equal on both sides) as 121 to 1665; or by reduction, as one to 13 ••/••.

Besides this unusual way of determi∣ning the gravity of some things, we mea∣sur'd the proportion betwixt Quick-silver and Water, by the help of so exact a bal∣lance, as looses its *Aequilibrium* by the hundredth part of a Grain. But because there is wont to be committed an over∣sight in weighing Quick-silver and Wa∣ter, especially if the Orifice of the Vessel wherein they are put be any thing wide, in regard that men heed not that the surface of Water in Vessels will be concave, but that of Quick-silver, notably convex or protuberant: To avoid this usual over∣sight (I say) we made use of a glass bubble, blown very thin at the Flame of a Lamp, that it might not be too heavy for the Ballance, and terminating in a very slender neck, wherein the concavity or convexity of a Liquor could not be considerable: This Glass weighing 23 1/• Grains, we fill'd [Page  296](https://quod.lib.umich.edu/e/eebo/A29003.0001.001/325?vid=56393) almost with Quick-silver, and fastning a mark over against the middle of the pro∣tuberant Superficies as near as our Eyes could judge, we found that the Quick-silver alone weighed 299 •/3• Grains: Then the Quick-silver being pour'd out, and the same Glass being fill'd as full of com∣mon Water, we found the Liquor to weigh 21 7/8 Grains. Whereby it appear'd that the weight of Water to Quick-silver, is as one to 13 •9/2•: Though our Il∣lustrious *Verulam* (questionless not for want of Judgement or Care, but of ex∣act Instruments) makes the proportion betwixt those two Liquors to be greater then of 1 to 17. And to adde, that up∣on the by, since Quick-silver and well rectified Spirit of Wine, are (how justly I say not) accounted, the one the hea∣viest, and the other the lightest of Li∣quors; we thought to fill in the same Glass, and with the same Scales to ob∣serve the difference betwixt them, which we found to be as of 1 to 16 64•/•0•4; where∣by it appear'd, That the difference be∣twixt Spirit of Wine, that may be made to burn all away, (such as was ours) and common Water, is as betwixt 1 and 1 ••/•••

[Page  297](https://quod.lib.umich.edu/e/eebo/A29003.0001.001/326?vid=56393)We might here take occasion to ad∣mire, that though Water (as appear'd by the Experiment formerly mention'd of the Pewter Vessel) seems not capable of •ny considerable condensation, and seems not to have interspers'd in it any store of Air; yet Quick-silver, of no greater bulk then Water, should weigh near fourteen times as much. But having onely point∣ed at this as a thing worthy of considera∣tion, we will proceed in our inquiry after the heigth of the Atmosphere: And to avoid the trouble of Fractions, we will assume that Quick-silver is fourteen times as heavy as Water, since it wants so little of being so.

Wherefore having now given us the proportion of Air to Water, and Water to Quick-silver, it will be very easie to finde the proportion betwixt Air and Quick-silver, in case we will suppose the Atmosphere to be uniformly of such a consistence as the Air we weighed here below. For since our Engine hath suffi∣ciently manifested that 'tis the *Aequili∣brium* with the external Air, that in the *Torricellian* Experiment keeps the Quick-silver from subsiding; And since, by our accurate Experiment formerly mention'd, [Page  298](https://quod.lib.umich.edu/e/eebo/A29003.0001.001/327?vid=56393) it appears that a Cylinder of Mercury, able to ballance a Cylinder of the whole Atmosphere, amounted to near about thirty Inches; and since, consequently we may assume the proportion of Quick-silver to Air to be as fourteen thousand to one; it will follow, that a Cylinder of Air, capable to maintain an *Aequilibrium,* with a Mercurial Cylinder of two Foot and an half in height, must amount to 35000 Feet of our English Measure; and consequently (reckoning five Foot to a Geometrical Pace, and one thousand such Paces to a Mile) to seven full Miles.

But this (as we lately intimated) pro∣ceeds upon the supposition, that the Air is every where of the same consistence that we found it near the surface of the Earth; but that cannot with any safety be concluded, not onely for the reason I finde to have been taken notice of by the Antients, and thus exprest in *Seneca: Omnis Aër* (says he) *quo propior est terris hoc crassior;*[\*](https://quod.lib.umich.edu/e/eebo/A29003.0001.001?id=DLPS47;lvl=1;note=inline;rgn=main;view=trgt)*quemadmodum in aqua & in omni humore faex ima est, ita in Aëre spis∣sissima quae{que} desidunt*; but much more, because the springy Texture of the Aërial Corpuscles, makes them capable of a [Page  299](https://quod.lib.umich.edu/e/eebo/A29003.0001.001/328?vid=56393) very great compression, which the weight of the incumbent part of the Atmo∣sphere is very sufficient to give those that be undermost and near the surface of the Earth. And if we recall to minde those former Experiments, whereby we have manifested, That Air, much rarefied with∣out heat, may easily admit a further ra∣refaction from heat; and that the Air, even without being expanded by heat, is capa∣ble of being rarefied to above one hundred and fifty times the extent it usually pos∣sesses here below; How can it be demon∣strated that the Atmosphere may not, for ought we know, or at least for ought can be determin'd by our Statical and Mecha∣nical Experiments, rise to the height of Five and twenty *German*Leagues, if not of some hundred of common Miles?

And this conjecture it self may appear very injurious to the height whereunto Exhalations may ascend,[\*](https://quod.lib.umich.edu/e/eebo/A29003.0001.001?id=DLPS48;lvl=1;note=inline;rgn=main;view=trgt) if we will allow that there was no mistake in that strange Observation made at *Tolous* in a clear Night in *August,* by the diligent Ma∣thematician *Emanuel Magnan,* and thus Recorded by *Ricciolus,* (for I have not at hand the Authors own Book) *Vidit* (says he) *ab hor a undecima post meridiem us{que} ad* [*Page  300*](https://quod.lib.umich.edu/e/eebo/A29003.0001.001/329?vid=56393) *mediam noctem Lunâ infra horizontem posit â, nubeculam quandam lucidam prope Meridianum fere usque ad Zenith diffusam quae consideratis omnibus non poterat nisi à sole illuminari; ideoque altior esse debuit tota umbra terrae. Addit* (continues *Ricci∣olus) simile quid evenisse Michaeli Angelo Riccio apud Sabinos versanti nempe viro in Mathesi eruditissimo.*

Various Observations made at the feet, tops, and interjacent parts of high Mountains, might perchance somewhat assist us to make an estimate in what pro∣portion, if in any certain one, the higher Air is thicker then the lower, and ghess at the dis-form consistence, as to laxity and compactness of the Air at several distances from us. And if the difficul∣ties about the refractions of the Celestial Lights, were satisfactorily determin'd, that might also much conduce to the pla∣cing due limits to the Atmosphere (whose Dimensions those Observations about Refractions seem hitherto much to con∣tract.) But for the present we dare not pronounce any thing peremptorily con•cerning the height of it, but leave it to further inquiry: contenting our selves to have manifested the mistake of divers [Page  301](https://quod.lib.umich.edu/e/eebo/A29003.0001.001/330?vid=56393) eminent Modern Writers, who will not allow the Atmosphere to exceed above two or three Miles in height (as the Fa∣mous *Kepler* will not the *Aër refractivus*) and to have rendred a reason why in the mention we made in the Notes upon the first Experiment, touching the height of the Atmosphere, we scrupled not to speak of it, as if it might be many Miles high.

WE will now proceed to recite a *Phaenomenon,*[\*](https://quod.lib.umich.edu/e/eebo/A29003.0001.001?id=DLPS49;lvl=1;note=inline;rgn=main;view=trgt) which, though made amongst the first, we thought fit not to mention till after many others, that we might have the opportunity to ob∣serve as many Circumstances of it as we could, and so present Your Lordship at once, most of what we at several times have taken notice of concerning so odde a *Phaenomenon.*

Our Engine had not been long finish'd, when, at the first leasure we could steal from our occasions to make tryal of it, we caus'd the Air to be pump'd out of the Receiver; and whil'st I was busied in entertaining a Learned Friend that just then came to visit me, an Ingenious By∣stander, [Page  302](https://quod.lib.umich.edu/e/eebo/A29003.0001.001/331?vid=56393) thought he perceiv'd some new kind of Light in the Receiver, of which giving me hastily notice, my Friend and I presently observ'd, that when the Suc∣ker was drawn down, immediately upon the turning of the Key, there appear'd a kinde of Light in the Receiver, almost like a faint flash of Lightening in the Day-time, and almost as suddenly did it appear and vanish. Having, not with∣out some amazement, observ'd divers of these Apparitions of Light, we took notice that the Day was clear, the hour about ten in the Morning, that the onely Window in the Room fac'd the North; and also, that by interposing a Cloak, or any opacous Body between the Receiver and the Window, though the rest of the Room were sufficiently enlightned, yet the flashes did not appear as before, un∣less the opacous Body were remov'd. But not being able on all these Circum∣stances to ground any firm Conjecture at the cause of this surprising *Phaenome∣non,* as soon as Night was come, we made the Room very dark; and plying the Pump as in the Morning, we could not, though we often try'd, find, upon the turning of the Key, so much as the [Page  303](https://quod.lib.umich.edu/e/eebo/A29003.0001.001/332?vid=56393) least glimmering of Light; whence we inferr'd, that the flash appearing in the Receiver, did not proceed from any new Light generated there, but from some reflections of the light of the Sun, or other Luminous Bodies plac'd without it; though whence that Reflection should proceed, it pos'd us to conje∣cture.

Wherefore the next Morning, ho∣ping to inform our selves better, we went about to repeat the Experiment, but though we could as well as former∣ly exhaust the Receiver, though the place wherein we made the tryal was the very same; and though other Circum∣stances were resembling, yet we could not discover the least appearance of Light all that Day, nor on divers o∣thers on which tryal was again fruitles∣ly made; nor can we to this very time be sure a Day before hand that these Flashes will be to be seen in our great Receiver. Nay, having once found the Engine in a good humour (if I may so speak) to shew this trick, and sent notice of it to our Learned Friend Doctor *Wallis,* who express'd a great [Page  304](https://quod.lib.umich.edu/e/eebo/A29003.0001.001/333?vid=56393) desire to see this *Phaenomenon,* though he were not then above a Bow-shoot off, and made haste to satisfie his Curiosity; yet by that time he was come, the thing he came for was no longer to be seen; so that having vainly endeavored to exhibit again the *Phaenomenon* in his presence, I began to apprehend what he might think of me, when unexpectedly the Engine presented us a flash, and after that a second, and as many more, as suffic'd to satisfie him that we might very well confidently relate, that we have our selves seen this *Phaenomenon,* though not confidently pro∣mise to shew it others.

And this unsuccessfulness whereto our Experiment is lyable, being such, that by all our watchfulness and tryals, we could never reduce it to any certain Rules or Observations; since in all constitutions of the Weather, times of the Day, *&c.* it will sometimes answer, and sometimes dis-appoint our Expectations; We are much discourag'd from venturing to frame an *Hypothesis* to give an account of it: which if the Experiment did constantly succeed, might the more hopefully be at∣tempted; by the help of the following *Phaenomena* laid together: some of them [Page  305](https://quod.lib.umich.edu/e/eebo/A29003.0001.001/334?vid=56393) produc'd upon tryals purposely made to examine the validity of the conjectures, other tryals had suggested.

First then we observ'd, that the Appa∣rition of Light may be made as well by Candle-light, as by Day-light; and in whatever position the Candle be held, in reference to the Receiver, as on this or that hand of it, above it, beneath it, or any other way, provided the Beams of Light be not hinder'd from falling upon the Vessel.

Next, we noted that the flash appears immediately upon the turning of the Key, to let the Air out of the Receiver into the empty'd Cylinder, in so much that I remember not that when at any time in our great Receiver, the Stop-cock was open'd before the Cylinder was ex∣hausted (whereby it came to pass that the Air did rather descend, then rush into the Cylinder) the often mention'd flash ap∣pear'd to our eyes.

Yet, we further observ'd, that when in∣stead of the great Receiver we made use of a small Glass, not containing above a pound and a half of Water, the *Phaeno∣menon* might be exhibited though the Stop-cock were open, provided the [Page  306](https://quod.lib.umich.edu/e/eebo/A29003.0001.001/335?vid=56393) Sucker were drawn nimbly down.

We noted too, that when we began to empty the Receiver, the appearances of Light were much more conspicuous then towards the latter end, when little Air at a time could pass out of the Re∣ceiver.

We observ'd also, that when the Suc∣ker had not been long before well Oyl'd, and instead of the great Receiver, the smaller Vessel above-mention'd was em∣ploy'd; We observ'd, I say, that then, upon the opening of the Stop-cock, as the Air descended out of the Glass in∣to the empty'd Cylinder, so at the same time there ascended out of the Cylinder into the Vessel a certain Steam, which seem'd to consist of very little Bubbles, or other minute Corpuscles thrown up from the Oyl, rarefied by the attrition it suffered in the Cylinder. For at the same time that these Steams ascended into the Glass, some of the same kinde manifestly issued out like a little Pillar of Smoke at the Orifice of the Valve, when that was occasionally open'd. And these Steams frequently enough presenting themselves to our view, we found, by exposing the Glass to a clear Light, that [Page  307](https://quod.lib.umich.edu/e/eebo/A29003.0001.001/336?vid=56393) they were wont to play up and down •n it, and so by their whiteishness, to e∣mulate in some measure the apparition of Light.

For we likewise sometimes found, by watchful observation, that when the Flash was great, not onely at the very instant the Receiver lost of its transpa∣rency, by appearing full of some kinde of whitish substance; but that for some short time after the sides of the Glass continued somewhat opacous, and seem'd to be darken'd, as if some whitish Steam adher'd to the inside of them.

He that would render a Reason of the *Phaenomenon,* whereof all these are not all the Circumstances, must doe two things; whereof the one is diffi∣cult, and the other little less then im∣possible: For he must give an Ac∣count not onely whence the appearing whiteness proceeds, but wherefore that whiteness does sometimes appear and sometimes not.

For our part, we freely confesse our selves at a losse about rendering [Page  308](https://quod.lib.umich.edu/e/eebo/A29003.0001.001/337?vid=56393) a Reason of the less difficult part of the Problem: And though Your Lord∣ship should ev'n press us to declare what Conjecture it was, that the above-recited Circumstances suggested to us, we should propose the thoughts we then had, no o∣therwise then as bare Conjectures.

In case then our *Phaenomenon* had con∣stantly and uniformly appear'd, we should have suspected it to have been produc'd after some such manner as follows.

First, we observ'd that, though that which we saw in our Receiver seem'd to be some kinde of Light, yet it was indeed but a whiteness which did (as hath alrea∣dy been noted) opacate (as some speak) the inside of the Glass.

Next we consider'd, that our com∣mon Air abounds with Particles or little Bodies, capable to reflect the Beams of Light. Of this we might easily give di∣vers proofs, but we shall name but two: The one, that vulgar observation of the Motes that appear in Multitudes swim∣ming up and down in the Air, when the Sun-beams shooting into a Room, or any other shady Place discover them, though otherwise the eye cannot distinguish them [Page  309](https://quod.lib.umich.edu/e/eebo/A29003.0001.001/338?vid=56393) from the rest of the Air: The other proof we will take from what we (and no doubt very many others) have observ'd, touch∣ing the Illumination of the Air in the Night. And we particularly remember, that, being at some distance from *London* one Night, that the People, upon a very well-come Occasion, testified their Joy by numerous Bon-fires; though, by rea∣son of the Interposition of the Houses, we could not see the Fires themselves, yet we could plainly see the Air all enlighten'd over and near the City; which argu'd, that the lucid Beams shot upwards from the Fires, met in the Air with Corpuscles opacous enough to reflect them to our Eyes.

A third thing that we considered, was, That white may be produc'd (without excluding other ways, or denying invisi∣ble Pores in the solidest Bodies) when the continuity of a Diaphanous Body happens to be interrupted by a great num∣ber of Surfaces, which, like so many little Looking-glasses, do confusedly re∣present a multitude of little and •eeming∣ly contiguous Images of the elucid Body. We shall not insist on the explanation of this, but refer You for it to what we have [Page  310](https://quod.lib.umich.edu/e/eebo/A29003.0001.001/339?vid=56393) said in another Paper (touching Co∣lours.) But the Instances that seem to prove it are obvious: For Water or whites of Eggs beaten to froth, do lose their transparency and appear white. And ha∣ving out of one of our lesser Receivers carefully drawn out the Air, and so order'd it, that the hole by which the Water was to get in, was exceeding small, that the Liquor might be the more broken in its passage thorow it, we observ'd with plea∣sure, That, the Neck being held under Water, and the little hole newly men∣tion'd being open'd, the Water that rush'd in was so broken, and acquired such a mul∣titude of new Surfaces, that the Receiver seem'd to be full rather of Milk then Wa∣ter. We have likewise found out, That by heating a lump of Crystal to a certa•n degree, and quenching it in fair Water, it would be discontinu'd by such a multi∣tude of Cracks, (which created new Sur∣faces within it) that though it would not fall asunder, but retain its former shape, yet it would lose its transparency, and ap∣pear white.

Upon these Considerations, My Lord, and some others, it seem'd not absur'd to imagine, That upon the rushing of the Air [Page  311](https://quod.lib.umich.edu/e/eebo/A29003.0001.001/340?vid=56393) out of the Receiver into the empty'd Cy∣linder, the Air in the Receiver being sud∣denly and vehemently expanded, the Tex∣ture of it was as suddenly alter'd, and the parts made so to shift places (and perhaps some of them to change postures) as du∣ring their new and vehement Motion and their varied Scituation, to disturb the wonted continuity and so the Diapha∣neity of the Air; which (as we have alrea∣dy noted) upon its ceasing to be a tran∣sparent Body, without the interposition of colour'd things, must easily degene∣rate into white.

Several things there were that made this Conjecture seem the less improba∣ble. As first, That the whiteness al∣ways appear'd greater when the Exsucti∣on began to be made, whil'st there was store of Air in the Receiver, then when the Air was in great part drawn out. And next, That, having exhausted the Re∣ceiver, and apply'd to the hole in the Stop-cock a large bubble of clear Glass, in such a manner, that we could at pleasure let the Air pass out at the small Glass into the great one, and easily fill the small one with Air again, We observ'd with pleasure, [Page  312](https://quod.lib.umich.edu/e/eebo/A29003.0001.001/341?vid=56393) That upon the opening the passage be∣twixt the two Glasses, the Air in the smaller having so much room in the great∣er to receive it, the Dissilition of that Air was so great, that the small Viol seem'd to be full of Milk; and this Expe∣riment we repeated several times. To which we may adde, That, having pro∣vided a small Receiver, whose upper Ori∣fice was so narrow that I could stop it with my Thumb, I observ'd, that when upon the Exsuction of the Air the capacity of the Glass appear'd white, if by a sudden removal of my Thumb I let in the out∣ward Air, that whiteness would imme∣diately vanish. And whereas it may be objected, That in the Instance formerly mention'd, Water turning from perspi∣cuous to white, there intervenes the Air, which is a Body of a Heterogeneous na∣ture, and must turn it into Bubbles to make it lose its transparency. We may borrow an Answer from an Experiment we deliver in another Treatise, where we teach how to make two very volatile Li∣quors, which being gently put together are clear as Rock-water, and yet will al∣most in a moment, without the sub-ingres∣sion of Air to turn them into Bubbles, so [Page  313](https://quod.lib.umich.edu/e/eebo/A29003.0001.001/342?vid=56393) alter the disposition of their insensible parts, as to become a white and consistent Body. And this happens not as in the precipitation of *Benjamin,* and some o∣ther Resinous Bodies, which being dis∣solv'd in Spirit of Wine, may, by the effu∣sion of fair Water, be turn'd into a seem∣ingly Milky substance. For this white∣ness belongs not to the whole Liquor, but to the Corpuscles of the dissolv'd Gum, which after a while sub•iding leave the Li∣quor transparent, themselves onely re∣maining white: Whereas in our case, 'tis from the vary'd texture of the whole for∣merly transparent fluid Body, and not from this or that part that this whitenesse results: For the Body is white thorowout, and will long continue so; and yet may, in process of time, without any addition, be totally reduc'd into a transparent Bo∣dy as before.

But besides the Conjecture insisted on all this while, we grounded another upon the following Observation, which was, That having convey'd some smoke into our Receiver plac'd against a Window, we observ'd, that upon the exsuction of the Air, the Corpuscles that were swimming •n it, did manifestly enough make the Re∣ceiver [Page  314](https://quod.lib.umich.edu/e/eebo/A29003.0001.001/343?vid=56393) seem more opacous at the very moment of the rushing out of the Air: For considering that the whiteness, whose cause we enquire of, did but sometimes ap∣pear, it seem'd not impossible but that at such times the Air in the Receiver might abound with Particles, capable of re∣flecting the Light in the manner requisite to exhibit a white colour, by their being put into a certain unusual Motion. As may be in some measure illustrated by this, That the new motion of the freshly mention'd Fumes, made the inside of the Receiver appear somewhat darker then before: And partly by the nature of our formerly mention'd smoking Liquor, whose parts though they seem'd transpa∣rent whil'st they compos'd a Liquor, yet when the same Corpuscles, upon the un∣stopping of the Glass, were put into a new motion, and dispos'd after a new manner, they did opacate that part of the Air they mov'd in, and exhibited a great∣er whiteness then that which sometimes appears in our Pneumatical Vessel. Nor should we content our selves with this sin∣gle Instance, to manifest, That little Bo∣dies, which being rang'd after one manner, are Diaphanous and Colourless, may, by [Page  315](https://quod.lib.umich.edu/e/eebo/A29003.0001.001/344?vid=56393) being barely agitated, dispers'd, and con∣sequently otherways rang'd, exhibite a colour, if we were not unwilling to rob our Collection of Experiments concern∣ing Colours.

But, My Lord, I foresee You may make some Objections against our pro∣posed ghess, which perhaps I shall scarce be able to answer, especially, if You in∣sist upon having me render a Reason why our *Phaenomenon* appears not constant∣ly.

I might indeed answer, that probably it would do so, if instead of our great Receiver we use such a small Viol as we have lately mention'd, wherein the Dissi∣lition of the Air being much greater, is like to be the more conspicuous: Since I remember not that we ever made our try∣al with such small Vessels, without find∣ing the expected whiteness to appear. But it would remain to be explicated, why in our great Receiver the *Phaenomenon* should sometimes be seen, and oftentimes not ap∣pear. And though that Conjecture which we last made should not be rejected, yet if we were further press'd to assign a reason why the Air should abound with such Par∣ticles, as we there suppose, more at one [Page  316](https://quod.lib.umich.edu/e/eebo/A29003.0001.001/345?vid=56393) time then another, we are not yet pro∣vided of any better Answer, then this general one, That the Air about us, and much more that within the Receiver, may be much alter'd by such causes as few are aware of: For, not to repeat those probable Arguments of this Assertion which we have occasionally mention'd here and there in the former part of this Epistle, we will here set down two or three Instances to verifie the same Propo∣sition. First, I finde that the Learned *Iosephus Acosta,*[\*](https://quod.lib.umich.edu/e/eebo/A29003.0001.001?id=DLPS50;lvl=1;note=inline;rgn=main;view=trgt) among other Judicious Observations he made in *America,*hath this concerning the Effects of some Winds; *There are* (says he) *Winds which naturally trouble the Water of the Sea, and make it green, and black; others, clear as Crystal.* Next, we have observ'd, That though we conveyd into the Receiver our Scales, and the *Pendula* formerly men∣tion'd, clean and bright; yet after the Re∣ceiver had been empty'd, and the Air let in again, the gloss or lustre both of the one, and of the other, appear'd tarnish'd by a beginning rust. And in the last place, we will subjoyn an Observation we made some Years ago, which hath been heard of by divers Ingenious Men, and seen [Page  317](https://quod.lib.umich.edu/e/eebo/A29003.0001.001/346?vid=56393) by some of them: We had, with pure Spirit of Wine, drawn a Tincture out of a certain Concrete which uses to be rec∣koned among Mineral Bodies; And this Tincture being very pure and transparent, we did, because we put a great value upon it, put into a Crystal Viol which we care∣fully stopp'd, and lock'd up in a Press a∣mong some other things that we special∣ly priz'd. This Liquor being a Chy∣mical Rarity, and besides, very defecate and of a pleasing Golden Colour; we had often occasion to look upon it, and so to take notice, that one time it seem'd to be very much troubled, and not clear as it was wont to be: Whereupon we ima∣gined, that though it would be something strange, yet it was not impossible that some Precipitation of the Mineral Cor∣puscles was then happening, and that thence the Liquor was opacated; but, finding after some days that though the expected Precipitation had not been made, yet the Liquor, retaining its for∣mer vivid Colour, was grown clear again as before; we somewhat wondered at it, and locking it up again in the same Press, we resolved to observe, both whether the like changes would again appear in [Page  318](https://quod.lib.umich.edu/e/eebo/A29003.0001.001/347?vid=56393) our Tincture; and whether in case they should appear, they would be ascribable to the alterations of the Weather. But though, during the greatest part of a Win∣ter and a Spring, we took pleasure to ob∣serve, how the Liquor would often grow turbid, and after a while clear again: Yet we could not finde that these Mutations depended upon any that were manifest in the Air, which would be often dark and clouded, when the Tincture was clear and transparent; as on the other side, in clear Weather the Liquor would appear some∣times troubled, and more opacous. So that being unable to give an account of these odde changes in our Tincture (which we suppose we have not yet lost, though we know not whether it have lost its fickle Nature) either by those of the Air, or any thing else that occurr'd to our thoughts; we could not but suspect that there may be in divers Bodies, as it were Spontaneous Mutations, that is, such changes as depend not upon manifest Causes. But, My Lord, what has been all this while said concerning our *Phaeno∣menon,* is offer'd to You, not as contain∣ing a satisfactory Account of it, but to assist You to give Your self one.

[Page  319](https://quod.lib.umich.edu/e/eebo/A29003.0001.001/348?vid=56393)WE took a Glass Vessel,[\*](https://quod.lib.umich.edu/e/eebo/A29003.0001.001?id=DLPS51;lvl=1;note=inline;rgn=main;view=trgt) open at the top, and into it we put a mixture of Snow and common Salt (such a mixture as we have in another Treatise largely discoursed of) and in∣to the midst of this mixture we set a Glasse, of a Cylindrical form, closely stopp'd at the lower end with Plaister, and open at the upper, at which we fill'd it with common Water. These things being let down into the Recei∣ver, and the Pump being set awork, the Snow began to melt somewhat fa∣ster then we expected; whether upon the account of the Exsuction of the Air, or because there was but little of the Snow, or whether for any other Reason, it appeared doubtfull. But however, by that time the Receiver had been considerably exhausted, which was done in lesse then ¼ of an hour, we perceived the Water near the bot∣tom of the Glass Cylinder to Freeze, and the Ice by a little longer stay, seem'd to encrease, and to rise somewhat higher [Page  320](https://quod.lib.umich.edu/e/eebo/A29003.0001.001/349?vid=56393) then the surface of the surrounding Li∣quor, whereinto almost all the Snow and Salt were resolv'd. The Glass being ta∣ken out, it appear'd that the Ice was as thick as the inside of the Glass it fill'd, though into that I could put my Thumb. The upper surface of the Ice was very concave, which whether it were due to any unheeded accident, or to the exsu∣ction of the Air, we leave to be deter∣min'd by further tryal. And lastly, the Ice held against the Light, appear'd not destitute of Bubbles, though some By∣standers thought they were fewer then would have been found if the Water had been frozen in the open Air. The like Experiment we try'd also another time in one of our small Receivers, with not un∣like success.

And on this occasion, My Lord, give me leave to propose a Problem, which shall be this: Whence proceeds that strange force that we may sometimes ob∣serve in frozen Water, to break the Bo∣dies that Imprison it; though hard and so∣lid? That there is such a force in Wa∣ter expos'd to Congelation, may be ga∣ther'd not onely from what may be often observ'd in Winter, of the bursting of [Page  321](https://quod.lib.umich.edu/e/eebo/A29003.0001.001/350?vid=56393) Glasses too close stopp'd; fill'd with Wa∣ter or aqueous Liquors, but by Instances as much more considerable as less obvi∣ous. For I remember, that an Ingenious Stone-cutter not long since complain'd to me, That sometimes, through the negli∣gence of Servants, the Rain being suffer∣ed to soak into Marble Stones, the super∣vening violent Frosts would burst the Stones, to the Professors no small dam∣age. And I remember another Trades∣man, in whose House I had Lodgings, was last Winter complaining, that even Im∣plements made of Bell-metal, being care∣lesly expos'd to the wet, have been broken and spoil'd by the Water, which, having gotten into the little Cavities and Cran∣nies of the Metal, was there afterwards frozen and expanded into Ice. And to these Relations,[\*](https://quod.lib.umich.edu/e/eebo/A29003.0001.001?id=DLPS52;lvl=1;note=inline;rgn=main;view=trgt) we can adde one of the formerly mention'd *Cabaeus's,* whereby they not onely may be confirm'd, but are surpass'd: For he tells us, That he saw a huge Vessel of exceeding hard Marble, split asunder by congel'd Water, whose Rarefaction, says our Author, prov'd so vehement, that the hardness of the Stone yielded to it; and so a Vessel was broken, which would not have been so by 100 [Page  322](https://quod.lib.umich.edu/e/eebo/A29003.0001.001/351?vid=56393) Yoke of Oxen drawing it several ways. I know, My Lord, that to solve this Pro∣blem, it will be said, That Congelation does not (as is commonly, but erroneously presum'd) reduce water into less room then it possess'd before, but rather makes it take up more. And I have elsewhere prov'd by particular Experiments, That whether or no Ice may be truly said to be Water rarefi'd (for that seems question∣able) it may be said to take up more room then the Water did before Glaciation. But though we grant that freezing makes Water swell, yet, how Cold (which in Weather-Glasses manifestly condences the Air) should expand either the Water, or the intercepted Air so forcibly, as to perform such things as we have newly re∣lated, will yet remain a Problem.

[\*](https://quod.lib.umich.edu/e/eebo/A29003.0001.001?id=DLPS53;lvl=1;note=inline;rgn=main;view=trgt)WE took an Oval Glass, clear and (least it should break) pretty strong, with a short Neck at the obtuser end; through this Neck, we thrust almost to the bottom, a Pipe of Glass, which was closely Cemented to the newly mention'd Neck, the upper part of which Pipe, was drawn in some places more slender [Page  323](https://quod.lib.umich.edu/e/eebo/A29003.0001.001/352?vid=56393) then a Crows Quill, that the changes of the Air in that Glass Egge might be the more conspicuous; Then there was con∣vey'd into the Glass five or six Spoon∣fulls of Water, part of which, by blow∣ing Air into the Egge, was rais'd into the above-mention'd slender part of the Pipe, so that the Water was interpos'd between the external Air, and that included in the Egge. This Weather-glass (delineated in the fourteenth Figure) was so plac'd, and clos'd up in the cavity of one of our small Receivers, that onely the slender part of the Pipe, to the heigth of four or five Inches, passing thorow a hole in the Cover, remain'd expos'd to the open Air.

The Pump being set a work, upon the Exsuction of the Air, the Water in the Pipe descended about a quarter of an Inch, and this upon two or three reitera∣ted tryals; which seem'd sufficiently to argue that there was no heat produc'd in the Receiver upon the Exsuction of the Air: For even a little heat would pro∣bably have been discover'd by that Wea∣ther-glass, since upon the bare applica∣tion of my hand to the outside of the Receiver, the warmth having after some [Page  324](https://quod.lib.umich.edu/e/eebo/A29003.0001.001/353?vid=56393) time been communicated or propagated through both the Glasses, and the inter∣val betwixt them to the Imprison'd Air, did so rarifie that, as to inable it, by pres∣sing upon the subjacent Water, to impel that in the Pipe very many times as far as it had fallen downwards upon the Exsucti∣on of the Air.

Yet shall not we conclude, that in the cavity of the Receiver the cold was great∣er after the Exsuction of the Air then be∣fore.

For if it be demanded what then could cause the fore-mention'd subsiding of the Water? it may be answered, That pro∣bably it was the reaching of the Glass Egge, which, upon the Exsuction of the ambient Air, was unable to resist alto∣gether as much as formerly the pressure of the included Air, and of the Atmosphere, which▪ by the intervension of the Water, press'd upon its concave surface: Which seem'd probable, as well by what was a∣bove deliver'd, in the Experiment about the breaking of the Glass by the force of the Atmosphere; as by this notable. Cir∣cumstance (which we divers times ob∣serv'd) That when by drawing the Air out of the Receiver, the Water in the Pipe [Page  325](https://quod.lib.umich.edu/e/eebo/A29003.0001.001/354?vid=56393) was subsided, upon the readmission of the external Air to press against the convex surface of the Egge, the Water was pre∣sently re-impell'd to its former height: Which would perhaps appear less strange to Your Lordship, if You had yet seen what we have heretofore taught in ano∣ther Treatise concerning the Spring that may be discover'd in Glass, as rigid and •••lexible a Body as it is generally e∣steem'd. And in the mean while it may se•ve the turn to cause a Glass Egge to be blown exceeding thin, and then, having broken it, try how far you can by degrees bend some narrow parts of it; and how readily, upon the removal of what kept it bent, it will restore it self to its former state or posture. But to return to our Experiment, From thence it seems pro∣bable, either that there succeeds no Bo∣dy in the room of the Air drawn out of our Receiver, or that it is not every Mat∣ter that is subtle enough readily to pass through the Pores of Glass, that is al∣ways agitated enough to produce Heat where ever it is plentifully found. So that if no *Vacuum* be to be admitted, this Ex∣periment seems to invite us to allow a great disparity, either as to bulk, or as to [Page  326](https://quod.lib.umich.edu/e/eebo/A29003.0001.001/355?vid=56393) agitation, or as to both, betwixt some parts of the Etherial Substance, and those that are wont here below to produce Heat and Fire.

We try'd also what Operation the drawing out of the Air would have upon Camphire, that being a Body, which, though not a Liquor, consists of such Volatile or Fugitive parts, that without any greater agitation then that of the open Air it self, they will copiously flie away. But we found not that even this loose Body was sensibly alter'd by the Exsucti∣on of the ambient Air.

[\*](https://quod.lib.umich.edu/e/eebo/A29003.0001.001?id=DLPS54;lvl=1;note=inline;rgn=main;view=trgt)IT may seem well worth trying, whether or no in our exhausted Glass the want of an ambient Body, of the wonted thic∣ness of Air, would disable even light and little Animals, as Bees, and other winged Insects, to flie. But though we easily foresaw how difficult it would be to make such an Experiment; yet not to omit our endeavors, we procur'd a large Flesh-fly, which we convey'd into a small Receiver. We also another time shut into a great Receiver a Humming Bee, that appear'd strong and lively, though we had rather [Page  327](https://quod.lib.umich.edu/e/eebo/A29003.0001.001/356?vid=56393) have made the tryal with a Butter-fly, if the cold Season would have permitted us to finde any. [\*](https://quod.lib.umich.edu/e/eebo/A29003.0001.001?id=DLPS55;lvl=1;note=inline;rgn=main;view=trgt) The Fly, af∣ter some Exsuctions of the Air, dropp'd down from the side of the Glass whereon she was walking: But, that the Experiment with the Bee m•ght be the more instructive, we convey'd in with her a bun∣••e of Flowers, which re∣main'd suspended by a string near the upper part of the Receiver: And having provok'd the Bee, we excited her to flie up and down the capacity of the Vessel, till at length, as we desir'd, she lighted upon the Flowers; whereupon we presently began to draw out the Air, and observ'd, That though for some time the Bee seem'd to take no notice of it, yet within awhile after she did not flie, but fall down from the Flowers, without appear∣ing to make any use of her Wings to help her self▪ But whether this fall of the Bee, and the other Insect, proceeded from the mediums being too thin for them to fl•e in, or barely from the weakness, and as it were swooning of the Animals themselves▪ you will easily gather from the following Ex∣periment.

[Page  328](https://quod.lib.umich.edu/e/eebo/A29003.0001.001/357?vid=56393)[\*](https://quod.lib.umich.edu/e/eebo/A29003.0001.001?id=DLPS56;lvl=1;note=inline;rgn=main;view=trgt)TO satisfie our selves in some measure, about the account upon which Respira∣tion is so necessary to the Animals, that Nature hath furnish'd with Lungs, we took (being then unable to procure any other lively Bird, small enough to be put into the Receiver) a Lark, one of whose Wings had been broken by a shot, of a Man that we had sent to provide us some Birds for our Experiment; but nothwith∣standing this hurt, the Lark was very lively, and did, being put into the Recei∣ver, divers times spring up in it to a good height. The Vessel being hastily, but carefully clos'd, the Pump was diligently ply'd, and the Bird for a while appear'd lively enough; but upon a greater Ex∣suction of the Air, she began manifestly to droop and appear sick, and very soon after was taken with as violent and irregu∣lar Convulsions, as are wont to be ob∣serv'd in Poultry, when their heads are wrung off: For the Bird threw her self over and over two or three times, and dy∣ed with her Breast upward, her Head downwards, and her Neck awry. And though upon the appearing of these Con∣vulsions, [Page  329](https://quod.lib.umich.edu/e/eebo/A29003.0001.001/358?vid=56393) we turn'd the Stop-cock, and let in the Air upon her, yet it came too late; whereupon, casting our eyes upon one of those accurate Dyals that go with a *Pendulum,* and were of late ingeniously invented by the Noble and Learned *Hu∣genius,* we found that the whole Tragedy had been concluded within ten Minutes of an hour, part of which time had been im∣ploy'd in cementing the Cover to the Re∣ceiver. Soon after we got a Hen-spar∣row, which being caught with Bird-lime was not at all hurt; when we put her into the Receiver, almost to the top of which she would briskly raise her self, the Ex∣periment being try'd with this Bird, as it was with the former, she seem'd to be dead within seven minutes, one of which were imploy'd in cementing on the Co∣ver: But upon the speedy turning of the Key, the fresh Air flowing in, began slow∣ly to revive her, so that after some pant∣ings she open'd her eyes, and regain'd her feet, and in about a ¼ of an hour, after threatned to make an escape at the top of the Glass, which had been unstopp'd to let in the fresh Air upon her: But the Re∣ceiver being clos'd the second time, she [Page  330](https://quod.lib.umich.edu/e/eebo/A29003.0001.001/359?vid=56393) was kill'd with violent Convulsions, within five Minutes from the beginning of the Pumping.

A while after we put in a Mouse, new∣ly taken, in such a Trap as had rather af∣frighted then hurt him; vvhil'st he vvas leaping up very high in the Receiver, vve fasten'd the Cover to it, expecting that an Animal used to live in narrow holes vvith very little fresh Air, vvould endure the vvant of it better then the lately men∣tion'd Birds: But though, for a vvhile af∣ter the Pump vvas set avvork, he conti∣nued leaping up as before; yet 'tvvas not long ere he began to appear sick and gid∣dy, and to stagger, after vvhich he fell dovvn as dead, but vvithout such violent Convulsions as the Birds died vvith. Whereupon, hastily turning the Key, we let in some fresh Air upon him, by vvhich he recovered, after a vvhile, his senses and his feet, but seem'd to continue weak and sick: But at length, grovving able to skip as formerly, the Pump vvas plyed again for eight minutes, about the mid∣dle of vvhich space, if not before, a very little Air by a mischance got in at the Stop-cock; and about tvvo minutes after that, the Mouse divers times leap'd up [Page  331](https://quod.lib.umich.edu/e/eebo/A29003.0001.001/360?vid=56393) lively enough, though after about two mi∣nutes more he fell down quite dead, yet with Convulsions far milder then those wherewith the two Birds expired. This alacrity so little before his death, and his not dying sooner then at the end of the eighth minute, seem'd ascribable to the Air (how little soever) that slipt into the Receiver. For the first time, those Con∣vulsions (that, if they had not been sud∣denly remedied, had immediately dis∣patch'd him) seis'd on him in six minutes after the Pump began to be set awork. These Experiments seem'd the more strange, in regard, that during a great part of those few minutes the Engine could but considerably rarefie the Air (and that too, but by degrees) and at the end of them there remain'd in the Receiver no incon∣siderable quantity; as may appear by what we have formerly said of our not being able to draw down Water in a Tube, with∣in much less then a Foot of the bottom: with which we likewise consider'd, that by the exsuction of the Air and intersper∣sed Vapors, there was left in the Recei∣ver a space some▪ hundreds of times ex∣ceeding the bigness of the Animal, to re∣ceive the fuliginous Steams, from which, [Page  332](https://quod.lib.umich.edu/e/eebo/A29003.0001.001/361?vid=56393) expiration discharges the Lungs; and, which in the other cases hitherto known, may be suspected, for want of room, to stifle those Animals that are closely pent up in too narrow Receptacles.

I forgot to mention, that having caus'd these three Creatures to be open'd, I could, in such small Bodies, discover lit∣tle of what we sought for, and what we might possibly have found in larger Ani∣mals; for though the Lungs of the Birds appear'd very red, and as it were inflam'd, yet that colour being usual enough in the Lungs of such winged Creatures, deserves not so much our notice, as it does, That in almost all the destructive Experiments made in our Engine, the Animals appear'd to die with violently Convulsive Moti∣ons: From which, whether Physicians can gather any thing towards the Discovery of the Nature of Convulsive Distem∣pers, I leave to them to consider.

Having proceeded thus far, though (as we have partly intimated already) there appear'd not much cause to doubt, but that the death of the fore-mention'd Ani∣mals proceeded rather from the want of Air, then that the Air was over-clogg'd by the steams of their Bodies, exquisite∣ly [Page  333](https://quod.lib.umich.edu/e/eebo/A29003.0001.001/362?vid=56393) pent up in the Glass; yet I, that love not to believe any thing upon Conje∣ctures, when by a not over-difficult Ex∣periment I can try whether it be True or no, thought it the safest way to obviate Objections, and remove Scruples, by shut∣ting up another Mouse as close as I could in the Receiver, wherein it liv'd above three quarters of an hour; and might pro∣bably have done so much longer, had not a *Virtuoso* of quality, who in the mean while chanc'd to make me a Visit, desir'd to see whether or no the Mouse could be kill'd by the exsuction of the ambient Air, whereupon we thought fit to open, for a little while, an intercourse betwixt the Air in the Receiver, and that without it, that the Mouse might thereby (if it were needful for him) be refresh•d, and yet we did this without uncementing the Cover at the top, that it might not be objected, that perhaps the Vessel was more closely stopp'd for the exsuction of the Air then before.

The Experiment had this event, that after the Mouse had liv'd ten Minutes, (which we ascrib'd to this, that the Pump, for want of having been lately Oyl'd, could move but slowly, and could not by [Page  334](https://quod.lib.umich.edu/e/eebo/A29003.0001.001/363?vid=56393) him that manag'd it, be made to work as nimbly as it was wont) at the end of that time he dy'd with Convulsive Fits, where∣in he made two or three bounds into the Air, before he fell down dead.

Nor was I content with this, but for Your Lordships further satisfaction, and my own, I caus'd a Mouse, that was very hungry, to be shut in all Night, with a Bed of Paper for him to rest upon: And to be sure that the Receiver was well clos'd, I caus'd some Air to be drawn out of it, whereby, perceiving that there was no sensible leak, I presently re-ad∣mitted the Air at the Stop-cock, left the want of it should harm the little Animal; and then I caus'd the Engine to be kept all Night by the Fire side, to keep him from being destroy'd by the immoderate cold of the Frosty Night. And this care succeeded so well, that the next Morning I found that the Mouse not onely was a∣live, but had devour'd a good part of the Cheese that had been put in with him. And having thus kept him alive full twelve hours, or better, we did, by sucking out part of the Air, bring him to droop, and to appear swell'd; and by letting in the Air again, we soon reduc'd him to his for∣mer liveliness.

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### A Digression containing some Doubts touching Respi∣ration.

I Fear Your Lordship will now expect, that to these Experiments I should add my Reflections on them, and attempt, by their assistance, to resolve the Diffi∣culties that occur about Respiration; since at the beginning I acknowledg'd a further Enquiry into the Nature of that, to have been my Design in the related Tryals. But I have yet, because of the inconve∣nient Season of the Year, made so few Experiments, and have been so little sa∣tisfied by those I have been able to make, that they have hitherto made Respiration appear to me rather a more, then a less Mysterious thing, then it did before. But yet, since they have furnish'd me with some such new Considerations, concern∣ing the use of the Air, as confirms me in my Diffidence of the Truth of what is commonly believ'd touching that matter; That I may not appear sullen or lazy, I am content not to decline employing a [Page  336](https://quod.lib.umich.edu/e/eebo/A29003.0001.001/365?vid=56393) few hours in setting down my Doubts, i• presenting Your Lordship some Hints, and in considering whether the Tryals made in our Engine, will at least assist us to discover wherein the Deficiency lies that needs to be supply'd.

And this, My Lord, being all my pre∣sent Design, I suppose You will not ex∣pect that (as if You knew not, or had for∣gotten what Anatomists are wont to teach) I should entertain You with a need∣less Discourse of the Organs of Respira∣tion, and the variety of their Structure in several Animals; though if it were ne∣cessary, and had not been perform'd by o∣thers, I should think,[\*](https://quod.lib.umich.edu/e/eebo/A29003.0001.001?id=DLPS57;lvl=1;note=inline;rgn=main;view=trgt) with *Galen,* that by treating of the Fabricks of living Bodies, I might compose Hymns to the wise Au∣thor of Nature, who, in the excellent con∣trivance of the Lungs, and other parts of (those admirable Engines) Animals, ma∣nifests himself to be indeed what the Elo∣quent Prophet most justly speaks him, *Wonderful in Councel,*[\*](https://quod.lib.umich.edu/e/eebo/A29003.0001.001?id=DLPS58;lvl=1;note=inline;rgn=main;view=trgt)*and excellent in working.*

Nor shall we any further meddle with those Controversies so much agitated a∣mong the Moderns, namely, *Whether the motion of the Lungs in Respiration be their* [*Page  337*](https://quod.lib.umich.edu/e/eebo/A29003.0001.001/366?vid=56393) *own, or but consequent to the motion of the Thorax, Diaphragme, and* (as some Learn∣ed Men would have it) *the Abdomen; And, Whence it is that the Air swells the Lungs in Inspiration,* any further then they may receive light from our Engine: But that it may appear what kinde of service it is that may be expected from it on this oc∣casion, we must premise a few Words to shew wherein the strength of the Obje∣ction we are to answer, lies: In favor then of those that would have the Lungs ra∣ther passive then active in the business of Respiration, it may against the common opinion be alledg'd, That as the Lungs be∣ing destitute of Muscles and of Fibres, are unfit to dilate themselves, so it ap∣pears, that without the motion of the *Thorax* they would not be fill'd with Air. Since as our Learned Friend Dr. *High∣more* has well (and congruously, to what our selves have purposely try'd) ob∣serv'd, if a live Dog have a great wound made in his Chest, the Lobes of the Lungs on that side of the *Mediasti∣•um* will subside and lie still; the *Tho∣rax* and the Lobes on the other side of the *Mediastinum,* continuing their former motion. And if suddenly at once [Page  338](https://quod.lib.umich.edu/e/eebo/A29003.0001.001/367?vid=56393) the Muscles of the Chest be on both sides dissected, upon the Ingress of the Air, the whole Lungs, though untouch'd, will remain moveless, at least, as to any ex∣pansion or contraction of their substance.

To which we may adde the Observati∣on of the diligent *Bartholinus,* who af∣firms the like of the *Diaphragme* al∣so, namely, That it being wounded, the Lungs will fall together, and the Respi∣ration cease, which my Experiments op∣pose not, provided the Wound be any thing great. And indeed the *Diaphragme* seems the principal Instrument of ordina∣ry and gentle Respiration, although to restrain'd Respiration (if I may so call it) the intercostal Muscles, and perhaps some others may be allowed eminently to concur. But the chief of the Contro∣versies formerly pointed at, is not yet de∣cided, namely, what it is that conveys the Air into the Lungs. For when, to coun∣terballance all that has been alledg'd, those that plead for the Lungs, demand what it is that should bring the Air into the Lungs, if themselves do not attract it, their Antagonists disagree about the Re∣ply. For when to this question some of the best Modern Philosophers answer, [Page  339](https://quod.lib.umich.edu/e/eebo/A29003.0001.001/368?vid=56393) that by the dilatation of the Chest the contiguous Air is thrust away, and that pressing upon the next Air to it, and so onwards, the Propulsion is continued till the Air be driven into the Lungs, and so dilate them: When this (I say) is an∣swered, it is Objected even by *Bartholine* himself, as a convincing Reply, that, ac∣cording to this Doctrine, a Man could not fetch his Breath from a great Vessel full of Air, with a slender Neck, because, that when his Mouth covers the Orifice of the Neck, the dilatation of his *Thorax* could not propell the Air in the Vessel into his Lungs, by reason of its being separated by the inclosing Vessel from the •mbient Air; and yet, say they, Experience wit∣nesses that out of such a Vessel a Man may suck Air. But of this difficulty our Engine furnishes us with an easie Solution, since many of the former Experiments have ma∣nifested, That in the case proposed, there needs not be made any (though 'tis true that in ordinary Respiration there is wont to be made some) propulsion of the Air by the swelling *Thorax* or *Abdomen* into the Lungs; since upon the bare Dilatation of the *Thorax,* the Spring of that internal Air, or halituous substance that is wont [Page  340](https://quod.lib.umich.edu/e/eebo/A29003.0001.001/369?vid=56393) to possess as much of the Cavity of the Chest as the Lungs fill not up, being much weaken'd, the external and contiguous Air must necessarily press in at the open Winde-Pipe into the Lungs, as finding there less resistance then any where else a∣bout it.

And hence (by the way) we may derive a new assistance to judge of that famous Controversie disputed among Naturalists and Physicians, ever since *Galens* time, some maintaining that the Chest, with the contained Lungs, may be resembled to a pair of Bellows, which comes therefore to be fill'd because it was dilated: And o∣thers pleading to have the comparison made to a Bladder, which is therefore di∣lated because it is fill'd. For as to the *Thorax,* it seems evident from what has been lately said, that it, like a pair of Bel∣lows, happens to be partly fill'd with Air, but because it was dilated: But as for the Lungs themselves, who want Fibres to distend them, they may fitly enough be compar'd to a Bladder; since they are di∣lated by being fill'd namely, by that Air which rushes into them upon the dilatation of the Chest, in whose increased Cavity it findes (as we freshly noted) less resist∣ance [Page  341](https://quod.lib.umich.edu/e/eebo/A29003.0001.001/370?vid=56393) to its Spring then elsewhere. And this brings into my minde that strange Observation of *Nicolaus Fontanus,* a Phy∣sitian at *Amsterdam,*[\*](https://quod.lib.umich.edu/e/eebo/A29003.0001.001?id=DLPS59;lvl=1;note=inline;rgn=main;view=trgt) who testifies, That in a Boy of the same Town, four years old, there was found, instead of Lungs, a certain Membranous Bladder; which be∣ing fill'd with Wind, and furnish'd with little Veins, had its origination from the Wind-Pipe it self; which being suppos'd true, how well it will agree with most of the Opinions touching Respiration, I leave to be considered.

And thus may the grand Objection of *Bartholine,* and others, be answered: But I leave to Anatomists to consider what is to be said to some Observations that seem to contradict those Anatomical Experi∣ments already mention'd: Such was par∣ticularly that which I remember I have read in *Sennertus* (from the observation of his Farther-in-law *Schato*) of a Melancho∣ly Student, who having stabb'd himself, and pierced the *Diaphragme* in the thinner or tendonous part (call'd by many the Nervous Circle) lived seven Moneths af∣ter he had so wounded himself, though af∣ter his death (preceded by violent Vomit∣ings) [Page  342](https://quod.lib.umich.edu/e/eebo/A29003.0001.001/371?vid=56393) the Wound (perchance dilated by those strainings) appear'd so great, that the whole Stomack was found to have got in by it into the left side of the *Thorax.* And such also was the accident that hap∣pen'd to a Noble Man, whom I remem∣ber I have seen, and who is yet alive, in whose Chest there has, for these many years, remain'd a hole so great, that the motion of his Heart may be perceiv'd by it. These (I say) and some other Obser∣vations, I shall now forbear to insist on, because I hold it not unfit, before we come to consider the use of Respiration, that we acquaint Your Lordship with an Ingenious Conjecture, that was made at the cause of the hasty death of the Ani∣mals our Engine kill'd: namely, That it was not the want of Air that destroy'd them, but the Pressure of the innate Air in the cavity of the Chest; as if the Spring of this Air being no longer coun∣terballanc'd by the ambient Air, was there∣by become so strong, that it kept the *Thorax* forcibly distended, and hinder'd its wonted contraction; and so compress'd the Lungs and their Vessels, as to obstruct the Circulation of the Blood. And this [Page  343](https://quod.lib.umich.edu/e/eebo/A29003.0001.001/372?vid=56393) Conjecture, as it is specious enough, so I might have admitted it for true, but that I consider'd, that (not to mention that one, especially of the Animals kill'd in our Engine, seem'd manifestly for a pret∣ty while, and not long before he dy'd, to move his *Thorax,* as if he exercis'd Respi∣ration) the diligent *Wallaeus* relates, That he divers times observ'd, in the Dissecti∣on of live Bodies, that the Membrane that invests the Lungs, had Pores in it as big as the larger sort of Peas, which a∣grees with the Observations of Chyrur∣gions and Physitians, *viz.* That matter collected in the *Thorax,* has penetrated in∣to the Lungs, and been discharged by coughing. And I remember too, that most of the Animals we kill'd in our Engine were Birds, of whose Lungs *Harvey* somewhere informs us, That he ob∣serv'd them very manifestly to open at their Extremities into the *Abdomen.* And by such Perforations we may well suppose the passage free betwixt the exter∣nal Air and that in the *Abdomen*: But 〈◊〉Conjecture may be further 〈◊〉Besides, to show that the Anim•••〈◊〉died in our Glasses, need not be 〈◊〉[Page  344](https://quod.lib.umich.edu/e/eebo/A29003.0001.001/373?vid=56393) to have been kill'd by the want of Air, we foresee another Argument that we must deal so ingeniously with Your Lordship, as not to conceal. You very well know, that besides the generality of the Schools, there are many new Philosophers who, though they dissent from the old Peripateticks in other things, do, as they, deny the possibility of a *Vacuum*; and hold, that those spaces which are devoid of Air, and other grosser Bodies, are all of them exactly replenished with a certain Etherial Matter, so thin and subtle, that it can freely permeate the Pores of the compactedst and closest Bodies, and ev'n of Glass it self. Now some of those Na∣turalists that are of this perswasion may object, That the Animals that died in our Receivers, did so, not so much for lack of Air, as by reason that the Air that was pump'd out was necessarily succeeded by an Etherial Substance; which consisting of parts vehemently agitated, and so very small, as without resistance to pass in and out through the very Pores of Glass; it may well be suppos'd, that a considerable quantity of this restless and subtle Mat∣ter, meeting together in the Receiver, [Page  345](https://quod.lib.umich.edu/e/eebo/A29003.0001.001/374?vid=56393) with the excessive heat of it, may be quickly able to destroy a little Animal, or at least, make the Air too intemperately hot to be fit for Respiration.

But though this be a Difficulty not so easily to be resolv'd without the assistance of our Engine, yet I suppose we have al∣ready answer'd the Objection by our 38th and 39thExperiments; which though we made partly for other purposes, yet we premis'd them onely to clear up the diffi∣culty propos'd.

Another suspition we should have en∣tertain'd concerning the death of our Ani∣mals, namely, That upon the sudden re∣moval of the wonted pressure of the am∣bient Air, the warm Blood of those Ani∣mals was brought to an Effervescence or Ebullition, or at least so vehemently ex∣panded, as to disturb the Circulation of the Blood, and so disorder the whole Oe∣conomy of the Body. (This (I say) I should have had some suspition of) but that Animals of a hot Constitution are not the sole ones that cannot in our ex∣hausted Engine exercise the Function of Life. But I must not now dwell upon matters of this nature, because I think it high time to proceed to the considerati∣on [Page  346](https://quod.lib.umich.edu/e/eebo/A29003.0001.001/375?vid=56393) of the principal subject of our Engine, namely, The use of Respiration; or ra∣ther, The use of the Air in Respiration. For whereas of the divers uses of it men∣tion'd by Anatomists the most, such as the Production and Modulation of the Voice by the Elision of the Air, the *La∣rynx* &c. the expulsion of Excrements by Coughing, the conveying in of Odours by Inspiration, and some others, rather convenient for the well being of an Ani∣mal, then absolutely necessary to his Life: Whereas (I say) the other uses are such as we have said, The great *Hippocrates* him∣self gives this notable Testimony to the use of the Air, as to Animals endow'd with Lungs, *Mortalibus* (says he) *hic* (spi∣ritus) *tum vitae, tum morborum aegrotis cau∣sa est. Tantáque corporibus omnibus spi∣ritûs inest necessitas, ut siquidem aliis om∣nibus & cibis & potionibus, quis abstineat, duos tamē aut tres, vel plures dies possit vi∣tam ducere: At si quis spiritus in corpus vias intercipiat, vel exiguâ diei parte, ho∣mini pereundum sit; Ad•o necessarius est usus spiritûs in corpore. Ad haec quo{que}, quum omnibus aliis actionibus homines qu•∣escant, quod mutationibus innumeris vita sit exposita, ab hâc tamen solá actione nun∣quam* [*Page  347*](https://quod.lib.umich.edu/e/eebo/A29003.0001.001/376?vid=56393) *desistant animantia, quin aut spiritum adducant, aut reddant.*

But touching the account upon which the Inspiration and Exspiration of Air (both which are comprehended in 〈 in non-Latin alphabet 〉 Respiration) is so necessary to Life, both Naturalists and Physitians do so disagree, that it will be very difficult either to re∣concile their Opinions, or determine their Controversies.

For first, Many there are who think the chief (if not sole) use of Respiration to be the Cooling and tempering of that Heat in the Heart and Blood, which other∣wise would be immoderate: And this O∣pinion, not onely seems to be most recei∣ved amongst Scholastick Writers, but di∣vers of the new Philosophers, Cartesians, and others, admitted with some variation; teaching, That the Air is necessary, by its coldness, to condense the Blood that pas∣ses out of the right Ventricle of the Heart into the Lungs, that thereby it may obtain such a consistence, as is requisite to make it fit Fewel for the vital Fire or Flame, in the left Ventricle of the heart. And this Opinion seems favor'd by this, That Fishes, and other cold Creatures, whose Hearts have but one cavity, are al∣so [Page  348](https://quod.lib.umich.edu/e/eebo/A29003.0001.001/377?vid=56393) unprovided of Lungs, and by some o∣ther considerations. But though it need not be deny'd, that the inspir'd Air may sometimes be of use by refrigerating the Heart; yet (against the Opinion that makes this Refrigeration, the most genuine and constant use of the Air) it may be Obje∣cted, That divers cold Creatures (some of which, as particularly Frogs, live in the Water) have yet need of Respiration, which seems not likely to be needed for Refrigeration by them that are destitute of any sensible heat, and besides, live in the cold Water: That even decrepid old Men, whose natural heat is made very languid, and almost extinguish'd by rea∣son of age, have yet a necessity of fre∣quent Respiration: That a temperate Air is fittest for the generality of breathing Creatures; and as an Air too hot, so al∣so an Air too cold, may be inconvenient for them (especially, if they be troubled with an immoderate degree of the same Quality which is predominant in the Air:) That in some Diseases the natural heat is so weaken'd, that in case the use of Respi∣ration were to cool, it would be more hurtful then beneficial to breath; and the suspending of the Respiration, may sup∣ply [Page  349](https://quod.lib.umich.edu/e/eebo/A29003.0001.001/378?vid=56393) the place of those very hot Medicines that are wont to be employ'd in such Di∣stempers: That Nature might much bet∣ter have given the Heart but a moderate heat, then such an excessive one, as needs to be perpetually cool'd, to keep it from growing destructive; which the gentle, and not the burning heat of an Animals Heart, seems not intense enough so indi∣spensably to require. These, and other Objections, might be oppos'd, and press'd against the recited Opinion: But we shall not insist on them, but onely adde to them, That it appears not by our fore∣going Experiments (I mean the 38th and 39th) that in our exhausted Receiver, where yet Animals die so suddenly for want of Respiration, the ambient Body is sensibly hotter then the common Air.

Other Learned Men there are, who will have the very substance of the Air to get in by the Vessels of the Lungs, to the left Ventricle of the Heart, not onely to temper its heat, but to provide for the generation of Spirits. And these alledge for themselves the Authority of the An∣tients, among whom *Hippocrates* seems manifestly to favor their Opinion; and both *Aristotle* and *Galen* do sometimes [Page  350](https://quod.lib.umich.edu/e/eebo/A29003.0001.001/379?vid=56393) (for methinks they speak doubtfully e∣nough) appear inclinable to it. But for ought ever I could see in Dissections, it is very difficult to make out, how the Air is convey'd into the left Ventricle of the Heart, especially the *Systole* and *Diastole* of the Heart and Lungs, being very far from being Synchronical: Besides, that the Spirits seeming to be but the most subtle and unctuous Particles of the Blood, appear to be of a very differing Nature from that of the lean and incom∣bustible Corpuscles of Air. Other Ob∣jections against this Opinion have been propos'd, and prest by that excellent Ana∣tomist, and my Industrious Friend, Dr. *Highmore,* to whom I shall therefore refer you.

Another Opinion there is touching Re∣spiration, which makes the genuine use of it to be Ventilation (not of the Heart, but) of the Blood, in its passage thorow the Lungs; in which passage, it is dis∣burthened of those Excrementitious Steams, proceeding, for the most part, from the superfluous Serosities of the Blood, (we may adde) and of the *Chyle* too, which (by those new Conduits of late very happily detected by the famous [Page  351](https://quod.lib.umich.edu/e/eebo/A29003.0001.001/380?vid=56393)*Pecquet*) hath been newly mix'd with it in the Heart.) And this Opinion is that of the Industrious *Moebius,* and is said to have been that of that excellent Philoso∣pher *Gassendus*; and hath been in part an Opinion almost vulgar: But this *Hypo∣thesis* may be explicated two ways: For first, The necessity of the Air in Respi∣ration, may be suppos'd to proceed from hence; That as a Flame cannot long burn in a narrow and close place, because the Fuliginous Steams it uncessantly throws out, cannot be long receiv'd into the am∣bient Body; which after a while growing too full of them, to admit any more, sti∣fles the flame, so that the vital Fire in the Heart requires an ambient Body, of a yielding nature, to receive into it the su∣perfluous Serosities and other Recrements of the Blood, whose seasonable Expulsi∣on is requisite to depurate the Mass of Blood, and make it fit both to Circulate, and to maintain the vital heat residing in the Heart. The other way of explicating the above mention'd *Hypothesis,* is, by supposing, that the Air does not onely, as a Receptacle, admit into its Pores the Ex∣crementitious vapors of the Blood, when they are expell'd through the Wind-Pipe, [Page  352](https://quod.lib.umich.edu/e/eebo/A29003.0001.001/381?vid=56393) but does also convey them out of the Lungs, in regard that the inspired Air, reaching to all the ends of the *Aspera Ar∣teria,* does there associate it self with the Exhalations of the circulating Blood, and when 'tis exploded, carrys them away with it self, as we see that winds speedily dry up the surfaces of wet Bodies, not to say any thing of what we formerly observd touch∣ing our Liquor, whose fumes were strange∣ly elevated upon the Ingress of the Air.

Now of these two ways of explicating the use of Respiration, our Engine af∣fords us this Objection against the first; That upon the Exsuction of the Air, the Animals die a great deal sooner then if it were left in the Vessel; though by that Exsuction the ambient space is left much more free to receive the steams that are ei∣ther breathed out of the Lungs of the Animal, or discharg'd by insensible Tran∣spiration through the Pores of his Skin.

But if the *Hypothesis* propos'd, be taken in the other sense, it seems congruous e∣nough to that grand observation, which partly the *Phaenomena* of our Engine, and partly the relations of Travellers, have suggested to us, namely, That there is a [Page  353](https://quod.lib.umich.edu/e/eebo/A29003.0001.001/382?vid=56393) certain consistence of Air requisite to Re∣spiration; so that if it be too thick, and already over-charged with vapors, it will be unfit to unite with, and carry off those of the Blood, as Water will dissolve, and associate to it self but a certain proportion of saline Corpuscles; and if it be too thin or rarefied, the number or size of the Aërial Particles is too small to be able to assume and carry off the halituous Excre∣ments of the Blood, in such plenty as is requisite.

Now that Air too much thicken'd (and as it were clogg'd) with Steams, is unfit for Respiration, may appear by what is wont to happen in the Lead-Mines of *De∣vonshire,* (and, for ought I know, in those too of other Countrys, though I have seen Mines where no such thing was com∣plain'd of) for I have been inform'd by more then one credible Person (and parti∣cularly by an Ingenious Man, that has of∣ten, for curiosity, digg'd in those Mines, and been imploy'd about them) that there often rises Damps, as retaining the *Ger∣mane*Word by which they call them) which does so thicken the Air, that unless the Work-men speedily make signs to them that are above, they would (which [Page  354](https://quod.lib.umich.edu/e/eebo/A29003.0001.001/383?vid=56393) also sometimes happens) be presently stifled for want of Breath; and though their Companions do make haste to draw them up, yet frequently, by that time they come to the free Air, they are, as it were, in a swoon, and are a good while be∣fore they come to themselves again. And that this swooning seems not to proceed from any Arsenical or Poysonous Exhala∣tion contain'd in the Damp; as from its over-much condensing the Air, seems pro∣bable from hence; That the same Damps oftentimes leisurely extinguish the flames of their Candles or Lamps; and from hence also that it appears (by many Rela∣tions of Authentical Authors) that in those Cellars where great store of new Wine is set to work, men have been suffo∣cated by the too great plenty of the steams exhaling from the Must, and too much thickning the Air: as may be gathered from the custom that is now used in some hot Countrys, where those that have oc∣casion to go into such Cellars, carry with them a quantity of well kindled Coals, which they hold near their Faces; where∣by it comes to pass, that the Fire discus∣sing the Fumes, and rarefying the Air re∣duces the ambient Body to a consistence fit for Respiration.

[Page  355](https://quod.lib.umich.edu/e/eebo/A29003.0001.001/384?vid=56393)We will adde (by way of confirmati∣on) the following Experiment: In such a small Receiver, as those wherein we kill'd divers Birds, we carefully clos'd up one, who, though for a quarter of an hour he seem'd not much prejudiced by the close∣ness of his Prison, afterwards began first to pant very vehemently, and keep his Bill very open, and then to appear very sick; and last of all, after some long and violent strainings, to cast up some little matter out of his Stomack: which he did several times, till growing so sick, that he stag∣ger'd and gasp'd, as being just ready to die; we perceiv'd, that within about three quarters of an hour from the time that he was put in, he had so thickned and tainted the Air with the Steams of his Body, that it was become altogether unfit for the use of Respiration: Which he will not much wonder at, who has taken notice in *Sanctorius* his *Statica Medicina,*how much that part of our Aliments, which goes off by insensible Transpiration, ex∣ceeds in weight all the visible and grosser Excrements both solid and liquid.

That (on the other side) an Air too much dilated is not serviceable for the ends of [Page  356](https://quod.lib.umich.edu/e/eebo/A29003.0001.001/385?vid=56393) Respiration, the hasty death of the Ani∣mal we kill'd in our exhausted Receiver, seems sufficiently to manifest. And it may not irrationally be doubted, whether or no, if a Man were rais'd to the very top of the Atmosphere, he would be able to live many minutes, and would not quick∣ly dye for want of such Air as we are wont to breath here below. And that this Conjecture may not appear extrava∣gant, I shall on this occasion subjoyn a memorable Relation that I have met with in the Learned *Iosephus Acosta,* who tells us, That when he himself past the high Mountains of *Peru,* (which they call *Pariaecaca*) to which, he says, That the *Alps* themselves seem'd to them but as ordinary Houses, in regard of high Tow∣ers, he and his Companions were surpri∣sed with such extream Pangs of Straining and Vomiting, (not without casting up Blood too) and with so violent a Distem∣per, that he concludes he should undoubt∣edly have dyed, but that this lasted not a∣bove three or four hours, before they came into a more convenient and natural temperature of Air: To which our Learn∣ed Author addes an Inference, which be∣ing the principal thing I design'd in men∣tioning, [Page  357](https://quod.lib.umich.edu/e/eebo/A29003.0001.001/386?vid=56393) the Narrative I shall set down in his own Words: *I therefore* (says he) *per∣swade myself, That the Element of the Air is there so subtle and delicate, as it is not proportionable with the breathing of Man, which requires a more gross and temperate Air; and I believe it is the cause that doth so much alter the Stomack, and trouble all the Disposition.* Thus far our Author, whose Words I mention, that we may ghess by what happens somewhat near the Confines of the Atmosphere (though propably far from the surface of it) what would happen beyond the Atmosphere. That which some of those that treat of the height of Mountains, relate out of *Ari∣stotle,* namely, That those that ascend to the top of the Mountain *Olympus,* could not keep themselves alive, without car∣rying with them wet Spunges, by whose assistance they could respire in that Air, o∣therwise too thin for Respiration: (That Relation (I say) concerning this Moun∣tain) would much confirm what has been newly recited out of *Acosta,* if we had sufficient reason to believe it: But, I con∣fess, I am very diffident of the truth of it; partly because when I pass'd the *Alps,* I took notice of no notible change betwixt [Page  358](https://quod.lib.umich.edu/e/eebo/A29003.0001.001/387?vid=56393) the consistence of the Air at the top and at the bottom of the Mountain; partly because of a very punctual relation made by an English Gentleman, of his ascensi∣on on to the top of the Pike of *Tenariff* (which is by great odds higher then *Olym∣pus*) I finde no mention of any such dif∣ficulty of breathing; and partly also be∣cause the same Author tells us out of *A∣ristotle,* That upon the top of *Olympus* there is no motion of the Air, insomuch, that Letters traced upon the dust, have been, after many years, found legible, and not discompos'd; whereas that Inquisi∣tive *Busbequius* (who was Ambassador from the *German* to the *Turkish* Em∣peror) in one of his Eloquent Epistles,[\*](https://quod.lib.umich.edu/e/eebo/A29003.0001.001?id=DLPS60;lvl=1;note=inline;rgn=main;view=trgt) tells us, upon his own knowledge, *That* Olympus *may be seen from* Constantino∣ple, *blanch'd with perpetual Snow*; which seems to argue, That the top of that, as well as of divers other tall Hills, is not a∣bove that Region of the Air wherein *Me∣teors* are formed. Though otherwise, in that memorable Narrative which *David Fraelichius,*[\*](https://quod.lib.umich.edu/e/eebo/A29003.0001.001?id=DLPS61;lvl=1;note=inline;rgn=main;view=trgt) made of his ascent to the top of the prodigiously high *Hungarian* Mountain *Carpathus*: he tells us, *That when, having pass'd through very thick* [*Page  359*](https://quod.lib.umich.edu/e/eebo/A29003.0001.001/388?vid=56393) *Clouds, he came to the very top of the Hill, he found the Air so calm and subtle, that not a hair of his head moved, whereas in the Lower Stages of the Mountain he felt a ve∣hement Wind.* But this might well be casual, as was his, having a clear Air where he was, though there were Clouds, not onely beneath him, but above him.

But (though what has been hither∣to discours'd, incline us to look up∣on the Ventilation and Depuration of the Blood, as one of the principal and constant uses of Respiration; yet) methinks it may be suspected that the Air does something more then bare∣ly help to carry off what is thrown out of the Blood in its passage through the Lungs, from the right Ventricle of the Heart to the left. For we see, in Phlegmatick Constitutions and Dis∣eases, that the Blood will circulate to∣lerably well, notwithstanding its being excessively serous: And in Asthmatical Persons, we often see, that though the Lungs be very much stuff'd with tough Phlegm, yet the Patient may live some Moneths, if not some Years. So that [Page  360](https://quod.lib.umich.edu/e/eebo/A29003.0001.001/389?vid=56393) it seems scarce probable, that either the want of throwing out the superfluous *Se∣rum* of the Blood for a few Moments, or the detaining it, during so short a while, in the Lungs, should be able to kill a per∣fectly sound and lively Animal: I say, for a few moments, because, that having di∣vers times try'd the Experiment of killing Birds in a small Receiver, we commonly found, that within half a minute of an hour, or thereabouts, the Bird would be surpris'd by mortal Convulsions, and with∣in about a minute more would be stark dead, beyond the Recovery of the Air, though never so hastily let in. Which sort of Experiments seem so strange, that we were oblig'd to make it several times, which gain'd it the Advantage of having Persons of differing Qualities, Professi∣ons and Sexes, (as not onely Ladies and Lords, but Doctors and Mathematicians) to witness it. And to satisfie Your Lord∣ship, that it was not the narrowness of the Vessel, but the sudden Exsuction of the Air that dispatch'd these Creatures so soon; we will adde, That we once inclos'd one of these Birds in one of these small Receivers, where, for a while, he was so little sensible of his Imprisonment, that [Page  361](https://quod.lib.umich.edu/e/eebo/A29003.0001.001/390?vid=56393) he eat very chearfully certain Seeds that we convey'd in with him, and not onely liv'd ten minutes, but had probably liv'd much longer, had not a great Person, that was Spectator of some of these Experi∣ments, rescu'd him from the prosecution of the Tryal. Another Bird being with∣in about half a minute, cast into violent Convulsions, and reduc'd into a sprawling condition, upon the Exsuction of the Air, by the pitty of some Fair Lady's (related to Your Lordship) who made me hastily let in some Air at the Stop-cock, the gasping Animal was presently recover'd, and in a condition to enjoy the benefit of the Lady's Compassion. And another time also, being resolv'd not to be inter∣rupted in our Experiment, we did, at night, shut up a Bird in one of our small Recei∣vers, and observ'd, that for a good while he so little felt the alteration of the Air, that he fell asleep with his head under his wing; and though he afterwards awak'd sick, yet he continu'd upon his legs be∣tween forty minutes and three quarters of an hour; after which, seeming ready to expire, we took him out, and soon found him able to make use of the liberty we gave him for a compensation of his suffer∣ings.

[Page  362](https://quod.lib.umich.edu/e/eebo/A29003.0001.001/391?vid=56393)If to the foregoing Instances of the sudden destruction of Animals, by the re∣moval of the ambient Air, we should now annex some, that we think fitter to re∣serve till anon; perhaps Your Lordship would suspect, with me, that there is some use of the Air, which we do not yet so well understand, that makes it so conti∣nually needful to the Life of Animals. *Paracelsus* indeed tells us, *That as the Sto∣mack concocts Meat, and makes part of it useful to the Body, rejecting the other part, so the Lungs consume part of the Air, and proscribes the rest.* So that according to our Hermetick Philosopher (as his follow∣ers would have him stil'd) it seems we may suppose, that there is in the Air a little vital Quintessence (if I may so call it) which serves to the refreshment and re∣stauration of our vital Spirits, for which use the grosser and incomparably greater part of the Air being unserviceable, it need not seem strange that an Animal stands in need of almost incessantly draw∣ing in fresh Air. But though this Opini∣on is not (as of some of the same Author) absur'd, yet besides that, it should not be barely asserted, but explicated and prov'd; and besides that, some Objections may be [Page  363](https://quod.lib.umich.edu/e/eebo/A29003.0001.001/392?vid=56393) fram'd against it, out of what has been al∣ready argu'd against the Transmutation of Air into vital Spirits: Besides these things, it seems not probable, that the bare want of the Generation of the won∣ted quantity of vital Spirits, for less then one minute, should within that time be able to kill a lively Animal, without the help of any external violence at all.

But yet, on occasion of this Opinion of *Paracelsus,* perhaps it will not be im∣pertinent, if before I proceed, I acquaint Your Lordship with a Conceit of that de∣servedly Famous Mechanician and Chy∣mist, *Cornelius Drebell,* who among o∣ther strange things that he perform'd, is affirm'd (by more then a few credible Per∣sons) to have contriv'd for the late Learn∣ed King *Iames,* a Vessel to go under Wa∣ter; of which, tryal was made in the *Thames,* with admired success, the Vessel carrying twelve Rowers, besides Passen∣gers; one of which is yet alive, and rela∣ted it to an excellent Mathematician that inform'd me of it. Now that for which I mention this Story, is, That having had the curiosity and opportunity to make particular Enquiries among the Relations of *Drebell,* and especially of an Ingenious Phy∣sitian [Page  364](https://quod.lib.umich.edu/e/eebo/A29003.0001.001/393?vid=56393) that marry'd his daughter, concer∣ning the grounds upon which he concei∣ved it feasible to make men unaccustom'd to continue so long under water without suffocation, or (as the lastly mention'd Person that went in the vessell affirmes) without inconvenience. I was answer'd, that *Drebell* conceiv'd, that 'tis not the whole body of the Air, but a certain Quin∣tessence (as Chymists speake) or spiritu∣ous part of it, that makes it fit for respira∣tion, which being spent, the remaining grosser body, or carcase (if I may so call it) of the Air, is unable to cherish the vi∣tall flame residing in the heart: So that (for ought I could gather) besides the Mechanicall contrivance of his vessell he had a Chymicall liquor, which he accoun∣ted the chiefe Secret of his submarine Na∣vigation. For when from time to time he perceiv'd, that the finer and purer part of the Air was consum'd, or over clogg'd by the respiration, and steames of those that went in his ship, he would, by unstopping a vessell full of this liquor, speedily restore to the troubled Air such a proportion of Vitall parts, as would make it againe, for a good while, fit for Respiration, whe∣ther by dissipating, or precipitating the [Page  365](https://quod.lib.umich.edu/e/eebo/A29003.0001.001/394?vid=56393) grosser Exhalations, or by some other in∣telligible way, I must not now stay to examine. Contenting my selfe to add, that having had the opportunity to do some service to those of his Relations, that were most Intimate with him, and having made it my business to learne what this strange Liquor might be, they constantly affirm'd that *Drebell* would never disclose the Liquor unto any, nor so much as tell the matter whereof he made it, to above one Person, who himselfe assur'd me that it was.

This account of *Drebell's* performance, I mention, not that I any further assent to his opinion then I have already intimated, but because the man, and the Invention being extraordinary, I suppose Your Lordship will not be displeas'd to know the utmost I could learne about it; especi∣ally not having found it mention'd by any Writer. Wherefore I have been some∣times inclin'd to favourable thoughts of their opinion, who would have the Aire necessary to ventilate, and cherish the vi∣tall flame, which they do suppose to be continually burning in the heart. For we see, that in our Engine the flame of a Lamp will last almost as little after the Exsucti∣on [Page  366](https://quod.lib.umich.edu/e/eebo/A29003.0001.001/395?vid=56393) on of the Air, as the life of an Animall: Nay I remember, that though I devis'd a more promising way, to make a fire last in our exhausted Receiver, yet it would not succeed: We tooke a hard body made in the forme of a Clove, but twice as long, and proportionably thick, this body be∣ing made of such a Composition, that if it be kindl'd at the upper end, it will most certainly burn away to the very bot∣tome, much better then a Match; we con∣vey'd it diverse times kindl'd at the upper end, into one of our small Receivers, but still found, that though presently upon the Exsuction of the Air, it would leave smoaking, and seeme quite gone out, and againe begin to smoke as soon as the Air was let in upon it; yet if the Air were kept out but foure or five minutes, the fire would be totally, and irrevocably ex∣tinguish'd. To which wee will adde, that though we convey'd into a great Re∣ceiver, a small lamp with rectifi'd spirit of Wine, that being so pure as not to smut the Cotton weeke, or so much as a piece of white Paper held over it; yet we could not by divers tryalls make the flame last a couple of minutes after the Air was begun to be drawne out. But though our Engine [Page  367](https://quod.lib.umich.edu/e/eebo/A29003.0001.001/396?vid=56393) thus shews us a new kind of resemblance betwixt fire and life: yet the opinion we have last mention'd is not free from Dif∣ficulties. For though in the hearts of ma∣ny Animall's Blood be a warm liquor, and in some ev'n a hot one; yet it is not easie to conceive either how the Air (in sub∣stance) can get thither, or how, in case it could, it were able to encrease the heat. Since, however, the Air may encrease the heat of a coale by blowing off the ashes, and making the active Corpuscles pierce further into the kindl'd body, and shatter it the more, yet we see hot liquors have their heat allay'd, and not augmented, by having Air blown on them. And whereas some Eminent Naturalists think it not in∣convenient, to make the heat residing in the heart to be a true flame, provided they adde, that 'tis such a temperate, and almost insensible fire, as the flame of spirit of Wine, which will long burne upon fine white Linnen or Paper without consu∣ming either: give mee leave to wish that they had been more curious to make diffe∣ring trials with that liquor. For (as we ob∣serve in another Treatise) the reason why a Linnen cloth, dipp'd in common Spirit of Wine, is not burnt by the flame of it, is [Page  368](https://quod.lib.umich.edu/e/eebo/A29003.0001.001/397?vid=56393) because the Phlegm of the Liquor de∣fends the Cloth. And the Flame of Spi∣rit of Wine is so far from being too weak to burn a piece of Paper, or of Linnen, that I have us'd it in Lamps to distill Li∣quors out of tall Cucurbits, and found that the Spirit burn'd away indeed much faster then Sallet Oyl, but gave at least as great a heat: Nay, I have, for curiosity sake, melted crude Gold, and that rea∣dily enough, with the bare Flame of pure Spirit of Wine.

But not to press this any further, we will, on this occasion, venture to subjoyn an odde Observation, which may perhaps invite to a further Enquiry into the Opi∣nion we have for Discourse sake oppos'd. Our English *Democritus,* Dr. *Harvey,* pro∣poses this difficult and noble Problem to Anatomists, *Why a* faetus, *even out of the Womb, if involv'd in the secundines, may live a good while without a Respiration; but in case after having once begun to breath, its respiration be stopp•d, it will presently die.* We are far from pretending to solve so hard a Problem, but this we try'd in re∣lation to it; We took a Bitch that was said to be almost ready to whelp, and ha∣ving caus'd her to be hang'd, we presently [Page  369](https://quod.lib.umich.edu/e/eebo/A29003.0001.001/398?vid=56393) open'd her *Abdomen,* and found four Pup∣peys in her Womb; one of these we took out, and having freed him from the Tegu∣ments th•• involv'd him, and from the Liquor he swam in, we observ'd that he quickly open'd his Mouth very wide, mov'd his Tongue, and exercis'd Respi∣ration; then we open'd both his *Abdomen* and his Chest, and cut assunder the *Dia∣phragme,* notwithstanding which, he seem•d often to endeavor Respiring, and mov'd in a notable manner, both the In∣tercostal Muscles, part of the *Diaphragme,* the Mouth and the Tongue: But that which we mention this Puppy for, was this, That being desirous to try whether the other yong ones that had not yet breath'd at all, would long survive this or no; we took them also out of the Womb, and having open'd them, found none of them so much alive, as to have any perceptible motion in his heart, where∣as the heart of that Puppy which had once enjoy'd the benefit of Respiration, con∣tinu'd beating so long, that we our selves observ'd the Auricle to beat, after five or six hours; and a Servant that staid up and watch'd it after we were gone to Bed, af∣firm'd, That he saw the Pulsation conti∣nue [Page  370](https://quod.lib.umich.edu/e/eebo/A29003.0001.001/399?vid=56393) about two hours longer. I shall leave it to others to make Reflections upon this Observation, compar'd with Dr. *Har∣vey*'s Problem.

It is much doubted, whether Fishes breath under Water, and we shall not take upon us, as yet, to determine the Questi∣on either way, because we have not yet been able to procure little Fishes alive to make Experiments upon: That such as are not Setaceous (for such manifestly breath) have not Respiration, properly so call'd, such as is exercis'd by four footed Beasts, and Birds, may be argu'd from their having but one cavity in their Hearts, & from their want of Lungs, whence they are observ'd to be Mute; unless we say, what is not altogether absurd, That their Gills seem somewhat Analogous (as to their use) to Lungs. But that on the other side, Air is necessary to the Lives even of Fishes, and that therefore 'tis proba∣ble they have some obscure kinde of Re∣spiration, seems manifest by two or three Observations and Experiments, mention'd by divers Authors, who tell us, *That Fishes soon die in Ponds and Glasses quite fill'd with Water; if the one be so frozen over, and the other so closely stopp'd, that the Fishes cannot enjoy the benefit of the* [*Page  371*](https://quod.lib.umich.edu/e/eebo/A29003.0001.001/400?vid=56393) *Air,* if we allow them to be true. But because these Relations are not wont to be deliver'd by Writers upon their own Knowledge; as I shall not reject them, so I dare not build upon them, till I have op∣portunity to examine them by experience. In the mean time, we will adde, That our Engine has taught us two things that may illustrate the matter in hand: The one, That there is wont to lurk in Water, ma∣ny little parcels of interspers'd Air, where∣of it seems not impossible that Fishes may make some use, either by separating it when they strain the Water thorow their Gills, or by some other way: The other, what may be collected from the following Experiment.

We took a large Eele (being able to procure no other Fish alive) and removing it out of the Vessel of Water, wherein it was brought us, into our great Recei∣ver, we caus'd the Air to be pump'd out; and observ'd, That the Eele, after some motion to and fro in the Glass, seem'd somewhat dis-compos'd; and that when we had prosecuted the Exsuction of the Air somewhat obstinately, she turn'd up her Belly, as dying Fishes are wont to do, and from thence-forward lay altogether [Page  372](https://quod.lib.umich.edu/e/eebo/A29003.0001.001/401?vid=56393) moveless, just as if she were stark dead; and though I did not think her so, yet the continuing in that Posture, even after the Cover of the Receiver was taken off (whereby the Air was let in) I shoul• have been of the Opinion of the By standers, if the Diffidence I am wont to exercise in trying Experiments (especially such as are not usual) had not invited me to take the Fish out of the Receiver, upon which she shew'd her self, by her vivid motions, as much alive as before.

But that is most strange which we ob∣serv'd of a great, g•ay, House Snail (as they call it) which being clos•d up in one of our small Receivers, did not onely, not fall down from the side of the Glass, upon the drawing-out of the Air (For that may be ascrib'd to the tenacity of the Liquor wherewith S••il, use to stick themselves, even to the smoothest Bo∣dies) but was not so much as depriv'd of progressive motion by the recess of the Air: Though except this Snail, we ne∣ver put any living Creature into our Re∣ceiver, whom it did not either kill, or at least reduce to seem ready to dye. But as we shall not here examine what interest the glutinous, and uneasily dissipable Na∣ture [Page  373](https://quod.lib.umich.edu/e/eebo/A29003.0001.001/402?vid=56393) of the Juices of Snails, may have on this event; so whether this escape of our Eele be to be ascrib'd to the particular and vivacious Nature of this sort of Fishes; or to this, That the Air is not indeed ne∣cessary to the life of Fishes; or finally to this, That though these Animals need some Air, yet they need so little, that that which could not be drawn out of the Receiver, might (at least for a while) suf∣fice them, we will not now determine.

Nor are we at leisure to examine that Paradox of *Hippocrates,* which some Learned Physitians have of late reviv'd, namely, That the *Foetus* respires in the Womb: For on the one side it seems ve∣ry difficult to conceive, how Air should traverse the Body of the Mother, and the Teguments of the Childe: And since Nature has, in new-born Babes, contriv'd peculiar and temporary Vessels, that the Blood may circulate thorow other Passa∣ges, then it is wont to do in the same In∣dividuals when they come to have the free use of their Lungs, it seems unlikely, th•t Infants in the Womb do properly respire. But then since our Experiments have manifested, That almost all kinde of Liquors do, as well as Water, abound with [Page  374](https://quod.lib.umich.edu/e/eebo/A29003.0001.001/403?vid=56393) interspers'd Corpuscles of Air, it seems not altogether absurd to say; That when the *Foetus* is grown big, he may (especial∣ly the upper part of the involving *Amni∣os,* being destitute of Liquor, and fill'd onely with an halituous Substance) exer∣cise some obscure Respiration, especially, since 'tis not (as many wise Men think it) a Fable, That Children have been heard to cry in the Mothers Womb. For though it happens exceeding rarely, yet some∣times it has been observ'd. And I know a young Lady, whose Friends, when she was some Years since with Childe, com∣plain'd to me, That she was several times much frighted with the Cryes of her In∣fant, which, till I disabus'd Her, She and Her Friends look'd upon as Portentous. And such Observations are the more cre∣dible, because not onely Houswives, but more judicious Persons, mention it, as no very unfrequent thing to hear the Chick Pip or Cry in the Egg, before the Shell be broken. But this I mention but as a probable, not a cogent Argument, till I can discover whether an Elision of an halituous Substance, though noe true Air, may not at the top of the *Larynx*[Page  375](https://quod.lib.umich.edu/e/eebo/A29003.0001.001/404?vid=56393) produce a Sound, since I find that the Blade of a Knife, held in severall postures in the streame of Vapors (or rarified Wa∣ter) that issu's out of an *Aeolipile,* will af∣ford various and very audible Sounds.

I had thoughts of conveying into our Receiver young ones, ripped out of the wombe of their Dammes, with their in∣volving Coates intire, but could not pro∣cure them. And I have also had thoughts of trying whether it be not practicable, to make a Receiver, though not all of glasse, yet with little glasse windows, so placed, that one may freely look into it, capacious enough to hold a Man, who may observe severall things, both touching Respiration, and divers other matters; and, who in case of fainting, may, by giving a signe of his weaknesse, be immediately re∣liev'd by having air let in upon him. And it seems not impossible, but that by accusto∣mance, some Men may bring themselves to support the want of Air a pretty while, since we see that divers will live so much longer then other Men under Water: that those that dive for Pearles in the West Indies are said to be able to stay a whole houre under water. And *Cardan* tels us of one *Colanus* a Diver in *Sicily,* who was [Page  376](https://quod.lib.umich.edu/e/eebo/A29003.0001.001/405?vid=56393) able to continue (if *Cardan* neither mi∣stake,[\*](https://quod.lib.umich.edu/e/eebo/A29003.0001.001?id=DLPS62;lvl=1;note=inline;rgn=main;view=trgt) nor impose upon us) three or foure times as long. Not to mind Your Lord∣ship, that You have Your selfe often seen in *England,* a corpulent Man, who is wont to descend to the bottome of the *Thames,* and bring out of the deep holes at the bottome of the bankes, large fishes alive in his hands.[\*](https://quod.lib.umich.edu/e/eebo/A29003.0001.001?id=DLPS63;lvl=1;note=inline;rgn=main;view=trgt) And *Acosta* tels us, he saw in *Peru* the like manner of fishing, but more difficult, practised by the *Indians.*

I made mention of some Men, and of *Accustomance:* because there are but ve∣ry few, who, though they use themselves to it by degrees, are fit to support, for ma∣ny Minutes, the want of Air. Insomuch that an ingenious Man of my acquaintance, who is very famous for the usefull skill of drawing Goods, and ev'n Ordnance out of sunke Ships, being asked by mee, how long he was able to continue at the depth of 50. or 60. feet under water, without the use of Respiration, confessed to mee, that hee cannot continue above two mi∣nutes of an houre, without resorting to the Air, which he carries downe with him in a certaine Engine (whereof I can show your Lordship a Description.) Another thing I also learn'd of him by enquiry, that was [Page  377](https://quod.lib.umich.edu/e/eebo/A29003.0001.001/406?vid=56393) not despicable: For asking him, whether he found any use of chawing little spon∣ges dipt in oyle in his Mouth, when he was perfectly under water, and at a distance from his Engine, he told me, that by the help of these sponges he could much lon∣ger support the want of his wonted Respi∣ration, then he was able to do without them. The true cause of which would per∣haps, if discovered, teach us some thing pertinent to the Probleme touching the Respiration of Fishes

But the necessity of Air to the most part of Animals unaccustom'd to the want of it, may best be judg'd of by the follow∣ing Experiments, which we try'd in our En∣gine, to discover whether Insects them∣selves have not, either Respiration, or some other use of the Air equivalent thereunto.

We tooke then an humble-bee, one of those common flyes that are call'd flesh flyes, and one of those hairy wormes that resemble caterpillars, and are wont to be call'd Palmer-wormes: These three wee convey'd into one of our small Receivers, and observ'd to the great wonder of the Beholders, that not onely the Bee, and the Fly fell downe, and lay with their bellies [Page  378](https://quod.lib.umich.edu/e/eebo/A29003.0001.001/407?vid=56393) upwards; but the worme it selfe seem'd to be suddenly struck dead: all of them be∣ing reduc'd to lye without motion, or any other discernable signe of life, within somewhat lesse (if we mistake not) then one minute of an houre. And this, not∣withstanding the smalnesse of the Animals in proportion to the capacity of the ves∣sels: which circumstance we the rather mention, because we found that the vessell was not free from leaks. And to satisfie the Spectators, that 'twas the absence of the Air that caus'd this great and sudden change: we had no sooner re-admitted the Air at the stopcock, than all the three In∣sects began to shew signes of life, and little by little to recover. But when we had a∣gain drawn out the Air, their motions pre∣sently ceased, & they fell down seemingly dead as before, cōtinuing moveless, as long as, by continuing to pump, the vessell was kept exhausted. This invited us thankful∣ly to reflect upon the wise goodnesse of the Creator, who by giving the Air a spring, has made it so very difficult, as men find it, to exclude a thing so necessary to Animals: and it gave us also occasion to suspect that if Insects have no lungs, nor any part analogous thereunto, the ambient [Page  379](https://quod.lib.umich.edu/e/eebo/A29003.0001.001/408?vid=56393) Air affects them, and relieves them at the Pores of their Skin, it not being irratio∣nal to extend to these Creatures that of *Hippocrates*; who says, That a Living Body is throughout perspirable; or to use his expression, 〈 in non-Latin alphabet 〉, dispos'd to admit and part with what is Spirituous: Which may be somewhat Illustrated by what we have elsewhere noted▪ That the moister parts of the Air readily insinuate themselves into, and recede from the pores of the Beards of wilde Oates, and those of divers other wilde Plants; which almost continually wreath and unwreath themselves according to, even, the light variations of the temperature of the am∣bient Air.

This Circumstance of our Experiment we particularly took notice of, that when at any time, upon the Ingress of the Air, the Bee began to recover, the first sign of Life she gave, was a vehement pant∣ing, which appear'd near the Ta•l: Which we therefore mention, because we have observ'd the like in Bees drown'd in Wa∣ter, when they first come to be reviv'd by a convenient heat: As if the Air were in the one case as proper to set the Spirits [Page  380](https://quod.lib.umich.edu/e/eebo/A29003.0001.001/409?vid=56393) and Alimental Juice a moving, as heat is in the other; and this may perchance de∣serve a further consideration.

We may adde, That we scarce ever saw any thing that seem'd so much as this Ex∣periment, to manifest, That even living Creatures (Man always excepted) are a kinde of curious Engines, fram'd and con∣triv'd by nature (or rather the Author of it) much more skilfully then our gross Tools and unperfect Wits can reach to. For in our present Instance we see Ani∣mals, vivid and perfectly sound, depriv'd immediately of motion, and any discern∣able signs of life, and reduc'd to a condi∣tion that differs from death, but in that it is not absolutely irrecoverable. This (I say) we see perform'd without any, so much as the least external violence offered to the Engine; unless it be such as is offer'd to a Wind-Mill, when the Wind ceasing to blow on the Sayls, all the several parts remain moveless and useless, till a new Breath put them into motion again.

And this was further very notable in this Experiment; That whereas tis known, that Bees and Flies will not onely walk, but flie for a great while, after their heads [Page  381](https://quod.lib.umich.edu/e/eebo/A29003.0001.001/410?vid=56393) are off; and sometimes one half of the Body will, for divers hours, walk up and down, when it is sever'd from the other: Yet, upon the Exsuction of the Air, not onely the progressive motion of the whole Body, but the very motions of the Limbs do forthwith cease; as if the pre∣sence of the Air were more necessary to these Animals, then the presence of their own Heads.

But it seems, that in these Insects, that fluid Body (whether it bea Juice or Flame) wherein Life chiefly resides, is nothing near so easily dissipable, as in perfect Ani∣mals. For where, as we have above re∣cited, that the Birds we conveyed into our small Receiver were within two minutes brought to be past Recovery, we were unable (though by tyring him that pump'd) to kill our Insects by the exsu∣ction of the Air: For though, as long as the Pump was kept moving, they con∣tinued immovable, yet when we desisted from pumping, the Air that press'd in at the unperceiv'd Leaks, did (though slow∣ly) restore them to the free exercise of the functions of Life.

But, My Lord, I grow troublesome, and therefore shall pass on to other Expe∣riments: [Page  382](https://quod.lib.umich.edu/e/eebo/A29003.0001.001/411?vid=56393) Yet without dispairing of your pardon for having entertain'd you so long about the use of Respiration, because it is a subject of that difficulty to be ex∣plain'd, and yet of that importance to humane Life, that I shall not regret the trouble my Experiments have cost me, if they be found in any degree serviceable to the purposes to which they were design'd. And though I despair not but that here∣after our Engine may furnish us with di∣vers *Phaenomena* useful to Illustrate the Doctrine of Respiration; yet having not, as yet, had the opportunity to make the other tryals, of various kinds, that I judge requisite for my Information: I must confess to Your Lordship, that in what I have hitherto said, I pretend not so much to establish, or over-throw this or that *Hypothesis,* as to lay together di∣vers of the Particulars that occur'd to me, in order to a future inquiry. I say, di∣vers of the Particulars, because I could adde many others, but that I want time, and fear that I shall need Your Lordships pardon, for having been so prolix in Wri∣ting; and that of Physitians (which per∣haps I shall more easily obtain) for having invaded Anatomy, a Discipline which [Page  383](https://quod.lib.umich.edu/e/eebo/A29003.0001.001/412?vid=56393) they challenge to themselves, and indeed have been the almost sole Improvers of. Without denying then that the inspir'd and exspir'd Air may be sometimes very useful, by condensing and cooling the Blood that passes through the Lungs; I hold that the depuration of the Blood in that passage, is not onely one of the or∣dinary, but one of the principal uses of Respiration. But I am apt also to suspect, that the Air does something else in Respi∣ration, which has not yet been sufficient∣ly explain'd; and therefore, till I have ex∣amin'd the matter more deliberately, I shall not scruple to answer the Questions that may be asked me touching the ge∣nuine use of Respiration, in the excellent Words employ'd by the acute St. *Austin,* to one that ask'd him hard Questions: *Mallem quidem* (says he) *corum que à me quaesivisti, habere scientiam quam ig∣norantiam: sed quia id nondum potui, ma∣gis eligo cautam ignorantiam confiteri, quam falsam scientiam profiteri.*

[Page  384](https://quod.lib.umich.edu/e/eebo/A29003.0001.001/413?vid=56393)HAving (partly upon the consideration of some of the foregoing Experi∣ments,[\*](https://quod.lib.umich.edu/e/eebo/A29003.0001.001?id=DLPS64;lvl=1;note=inline;rgn=main;view=trgt) and partly upon grounds not now to be insisted on) entertain'd a suspition, that the action of Corrosive Liquors in the dissolving of Bodies, may be conside∣rably varied by the gravitation or pressure of the incumbent Air, and the removal of it; I thought fit to examine my Con∣jecture by the following Experiment.

I took whole pieces of red Coral, and cast them into as much Spirit of Vinager, as sufficed to swim above an Inch over them: These substances I made choice of, that the Ebullition upon the Solution might not be too great, and that the o∣peration might last the longer.

Having then put about half-a-score Sprigs of Coral, together with the *Men∣struum,* into a somewhat long neck'd Viol, whereof they seem'd scarce to fill a third part, we convey'd that Viol into one of our small *Pneumatical* Glasses, containing by ghess about a Quart of Water; and having fastned on the Cover, after the accustom'd manner, we suffered the Li∣quor [Page  385](https://quod.lib.umich.edu/e/eebo/A29003.0001.001/414?vid=56393) to remain unmov'd awhile, to ob∣serve whether the *Menstruum* would work upon the Coral otherwise then be∣fore. But finding there did onely arise, as formerly, a pretty number of small Bubbles, that made no sensible froth up∣on the surface of the distill'd Vinager, there were made two or three Exsuctions of the Air; upon which, there emerg'd from the Corall such a multitude of Bub∣bles, as made the whole Body of the *Menstruum* appear white; and soon af∣ter, a Froth, as big as all the rest of the Liquor, was seen to swim upon it: And the *Menstruum* plainly appear'd to boil in the Glass, like a seething Pot. And though, if we desisted but one minute from pumping, the decrement of the Froth and Ebullition, upon the getting in of a little Air at some leak or other, seem'd to argue, that the removal of the the pressure of the external Air was the cause, or, at least, the occasion of this effervescence: Yet to evince this the more clearly, we turn'd the Key, and let in the external Air at the Stop-cock; immedi∣ately upon whose entrance the Froth va∣nish'd, and so many of the Bubbles with∣in [Page  386](https://quod.lib.umich.edu/e/eebo/A29003.0001.001/415?vid=56393) the body of the Liquor disappear'd, that it lost its whiteness, & grew transparent again: The *Menstruum* also working as languidly upon the coral, as it did before they were put into the Receiver: But when we had again drawn out the Air, first the whiteness re-ap∣pear'd, then the ebulition was renewd, which, the pumping being a while longer & nimbly pursued, grew so great, that for 3 or 4 times one after another, when ever the Air was let out of the Receiver into the emptyed Cylin∣der; the frothy liquor over-flow'd the glass, & ran down by the sides of it: And yet, upon the readmitting of the excluded air, the boil∣ing Liquor grew immediatly as calm and as transparent as at first: as if indeed the operati∣on of it, upon the Coral, had been facilitated by the exsuction of the incumbent air, wch on its recess, left it more easie for the more active parts of the liquor to shew themselves such, then it was whilst the wonted pressure of the Air continued unremoved. It may indeed be suspected, that those vast & numerous Bub∣bles proceeded, not from the action of the *Menstruum* upon the Corall, but from the suddain emersion of those many little parcels of air that (as we formerly observd) are wont to be dispers'd in liquors, without excluding Spirit of Vinegar; but having had this suspi∣tion before we tryd the Experiment, we con∣vey'd [Page  387](https://quod.lib.umich.edu/e/eebo/A29003.0001.001/416?vid=56393) our distill'd Vinager alone into the Re∣ceiver, and kept it awhile there, to free it from its Bubbles (which were but very small) be∣fore ever we put the Corall into it. It may be suspected likewise, that the agitation of the Liqour, necessary following upon the shaking of the Glass, by pumping, might occasion the recited Ebullition, but upon tryal made, there appear'd not any notable change in the liquor, or its operation, though the containing Vessel were shaken, provided no Air were suck'd out of it. The former Experiment was another time tryd in another small Receiver, with Co∣ral grosly poudred, and the success was very much alike, scarce differing in any thing, but that the Coral being reduc'd to smaller parts, upon the ebullition of the liquor, so many lit∣tle lumps of Coral would be carryed & Boy'd up by the emerging Bubbles, as sometimes to darken the Viol; though the same Coralline Corpuscles would be let fall again upon the letting in of the Air.

Something also we try'd in our great Receiver, concerning the solution of Metals in *Aqua fortis,* and other Corrosive Liquors; but partly the stink, and partly some accidents, kept us from observing any thing peculiar & remarkable about those Solutions.

One thing we must not omit, that when the Spirit of Vinager was boiling upon the Coral, we took off the Cover of the Receiver, and took out the Viol, but could not finde, that notwithstanding so very late an Ebullition, the Liquor had any heat great enough to be at all sensible to our hands.

[Page  388](https://quod.lib.umich.edu/e/eebo/A29003.0001.001/417?vid=56393)[\*](https://quod.lib.umich.edu/e/eebo/A29003.0001.001?id=DLPS65;lvl=1;note=inline;rgn=main;view=trgt)WE will now subjoyn an Experi∣ment, which, if the former did not lessen, the wonder of it would pro∣bably appear very strange to Your Lord∣ship, as it did to the first Spectators of it.

The Experiment was this: We caus'd Water to be boyl'd a pretty while, that by the heat it might be freed from the la∣titant Air, so often already taken notice of in common Water: Then almost fil∣ling with it a Glass Viol, capable of con∣taining near four Ounces of that Liquor; we convey'd it, whil'st the Water was yet hot, into one of our small Receivers (big enough to hold about a pound of Water) and having luted on the Cover, we caus'd the Air to be drawn out: Upon the two first Exsuctions, there scarce appear'd any change in the Liquor, nor was there any notable alteration made by the third; but at the fourth, and afterwards, the Water appear'd to boyl in the Viol, as if it had stood over a very quick Fire; for the Bubbles were much greater then are usu∣ally found upon the Ebullition of very [Page  389](https://quod.lib.umich.edu/e/eebo/A29003.0001.001/418?vid=56393) much more Water then was contain'd in our Viol. And this Effervescence was so great in the upper part of the Water, that the Liquor boyling over the top of the Neck a pretty deal of it ran down into the Receiver, and sometimes continued (though more languidly) boyling there. Prosecuting this Experiment, we observ'd, that sometimes, after the first Ebullition, we were reduc'd to make divers Exsucti∣ons of the Air, before the Liquor would be brought to boyl again. But at other times, as often as the Key was turn'd to let the Air pass from the Receiver into the Pump, the Effervescence would be∣gin afresh, though the Pump were ply'd for a pretty while together; which seem'd to argue, that the boyling of the Water proceeded from hence, That upon the withdrawing the pressure of the incumbent Air, either the Fiery Corpuscles, or ra∣ther the Vapors agitated by the heat in the Water (which last, what we have for∣merly noted touching the rarefied Wa∣ter of an *Aeolipile,* manifest to be capa∣ble of an Elastical Power) were permit∣ted to expand themselves mightily in the evacuated Receiver; and did, in their [Page  390](https://quod.lib.umich.edu/e/eebo/A29003.0001.001/419?vid=56393) tumultuous Dilatio, lift up (as the Air is wont to do) the uppermost part of the Water, and turning it into Bubbles, made the Water appear boiling. This conjecture was further confirm'd by these additional Circumstances: First, The Effervescence was confin'd to the upper part of the Water, the lower remain∣ing quiet, unless the Liquor were but shallow. Next, although sometimes (as is already noted) the Ebullition began a∣gain, after it had ceas'd a pretty while, which seem'd to infer, That some concur∣rent cause (whatever that were) did a little Modifie the operation of heat; yet, when the water in the Viol could by no pum∣ping be brought to boil any more, the self-same Water, being in the very same Viol warm'd again, and reconvey'd into the Pneumatical Glass, was quickly brought to boyl afresh, and that vehe∣mently and long enough; not to menti∣on, that a new parcel, taken out of the same parcel of the boyled Water with the former, and put in cold, could by no pumping be brought to the least shew of Effervescence. Besides, having try'd this Experiment in hot Sallet Oyl, be∣ing [Page  391](https://quod.lib.umich.edu/e/eebo/A29003.0001.001/420?vid=56393) a much more tenacious Liquor, and requiring a stronger heat to make it boil, could not be brought to an Effer∣vescence in our Reciver; whereas the Chymical Oyl of Turpentine, being thinner and more volatile, was present∣ly made to boyl up, till it reach'd four or five times its former height in the Viol, in whose bottom it lay, and con∣tinu•d boyling till it was almost reduc'd to be but luke-warm. Wine also be∣ing a more thin and spirituous Liquor then Water, being convey'd in hot in∣stead of the Oyl, did, as I remember, at the very first Exsuction begin to boyl so vehemently, that, in a short time that the Pump was kept moving, four parts of five, by our ghess, boyl'd over out of the Viol, though it had a pretty long Neck. On which occasion we will adde, that even the Water it self, near one half, would sometimes boyl over into the Receiver before it became luke-warm. And it was also remarkable, that once, when the Air had been drawn out, the Liquor did, upon a single Exsucti∣on, boyl so long with prodigiously vast Bubbles, that the Effervescence lasted al∣most [Page  392](https://quod.lib.umich.edu/e/eebo/A29003.0001.001/421?vid=56393) as long as was requisite for the re∣hearsing of a *Pater Noster.* Now the Experiment having been try'd more then once, and found to succeed as to the main, seems much to countenance the conjecture we made at the beginning of this Letter, where we told your Lordship, That per∣haps the pressure of the Air might have an interest in more *Phaenomena* then men have hitherto thought. For as we had not then made this Experiment, so now we have made it, it seems to teach, That the Air, by its stronger or weaker pres∣sure, may very much Modifie (as the School-men speak) divers of the Opera∣tions of that vehement and tumultuous Agitation of the small parts of Bodies, wherein the nature of heat seems chiefly, if not solely, to consist. Insomuch that if a heated Body were convey'd above the Atmosphere, 'tis probable that the heat may have a differing operation, as to the power of dissipating the parts of it, from what it has here below.

To conclude, This Experiment might have been further prosecuted, but our want of leasure makes us content our selves to adde at present; That perhaps [Page  393](https://quod.lib.umich.edu/e/eebo/A29003.0001.001/422?vid=56393) it would not be lost labor if this were try'd, not onely with other Liquors, but with variety of heated, and especially soft or melted Bodies: But in such cases the Receiver ought to be so shap'd, as is most proper to preserve the Cement wherewith the Cover must be fastned on, from being melted by the heat of the included Mat∣ter; the inconvenience to be hereby a∣voided, having befallen us in the use of a Receiver too shallow, though otherwise capacious enough.

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## The Conclusion.

BEing come thus far, My Dear Lord, not without thoughts of proceeding further: The unwelcome Importunity of my Occasions becomes so prevalent, that it quite hinders, for the present, my de∣sign'd Progress; and reduces me, not onely to reserve for another opportunity that kinde of Experiments, which, at some distance from the beginning of this Letter, I call'd (as Your Lordship may remember) Experiments of the second sort; but to leave unessay'd some of the first sort, which I might try in the En∣gine, as it now is, were it not that my Avocations are grown so urgent, for my remove from the place where the Engine was set up, that I am put to write Your Lordship this Excuse, Weary, and in an Inne which I take in my way to my Dear∣rest [Page  395](https://quod.lib.umich.edu/e/eebo/A29003.0001.001/424?vid=56393) Brother *Corke*: Who being at length arriv'd in *England,* after I h•ve for diverse Yeares been deprived of His Company, and wish'd for it as long; what ever my other occasions may be, my first Businesse must be to wait on Him and Your Excellent Mother; in whose gratefull Company I may hope to forget a while those publick calami∣ties that distresse this too deservedly unhappy Nation. Since that is indear'd to me, both by their personall Merit; by the near Relation which Nature gives me to Him, Affinity to Her, and Friendship to both; and also by their many Favours, especially that of my owing them My *Lord of Dungarvan.* But I suffer my selfe to be transported too farre with these delightfull thoughts; To returne therefore to our Engine. Though I find this Letter is beyond my expectation swell'd, not only into a Book, but almost into a Volume; yet the Experiments already mentioned in it, are so farre from comprising all those that may be try'd by the help of our Engine, that I have not yet been able to try all those, which, presently occurring [Page  396](https://quod.lib.umich.edu/e/eebo/A29003.0001.001/425?vid=56393) to my thoughts, upon my first seeing the working of it, I Caus'd to be set down in a Catalogue within lesse then halfe an houre. But I doubt I have but too much cause to apprehend that the Affaires, and other things I complaine of, have made it needfull for me to A∣pologize, as well for the things I have set down, as for those I am necessitated to omit. For as partiall as men use to be to the children of their own Braines, as well as to those of their Loines, I must not deny that the foregoing Try∣als are not altogether free from such unaccuratenesses, nor the recitall of them from such imperfections, as I my selfe can now discerne, and could perhaps partly mend, if I had the leasure to re∣peate the Experiments, with the Cir∣cumstances that have since offer'd them∣selves to my thoughts, as things that might have been worth Observation or Enquiry. But the truth is, that I was reduc'd to make these Experiments, when my Thoughts had things that more concernd me to imploy them, and the same avocations made me set them down, for the most part, assoone as I [Page  397](https://quod.lib.umich.edu/e/eebo/A29003.0001.001/426?vid=56393) had made them, and in the same order, and that so fast that I had not over-fre∣quently the opportunity to mind any more then the bare Truth of what I set down; without allowing it any of those Advantages that Method, Style, and decent Embellishments, are wont to confe••e on the Composures they are imploy'd do adorne.

But, my Lord, though to invite and encourage You and your learned Friends at *Paris,* to make a further use of this Engine than I have yet been able to do, I am thus free to acknowledge the im∣perfections of the foregoing Letter: yet if some Intelligent Persons mistake not, by what has been done, such as it is, there is a way open'd, whereby Sagacious Wits will be assisted to make such fur∣ther Discoveries in some points of Na∣turall Philosophy, as are yet scarce dream'd of. And I am the more desirous to engage You to that Imployment, be∣cause I am apt to think, that if the Ma∣king and Writing of such Experiments shall cost You as much trouble as they have me, You will be inclin'd to Excuse me; and if the Discoveries give You [Page  398](https://quod.lib.umich.edu/e/eebo/A29003.0001.001/427?vid=56393) as much pleasure as they gave me, You will (perhaps) be invited to thank me. However, I think (my Lord) I may ju∣stly pretend, that the things I have set down have been faithfully Recorded, though not elaborately Written; and I suppose my former Papers may have long since satisfi'd You, that though many devise Experiments better that Your Ser∣vant, none perh•ps has related them more carefully and more truely: And particu∣larly of These; sometimes one, some∣times another hath been perform'd in the p•esence of Persons, diverse of them eminent for their Writings, and all for their Learning. Wherefore hav•ng in the foregoing Narratives made it my businesse to enoble them with the chiefe Requisites of H•storicall Composures, Candor, and Truth, I cannot despair that You will either Excuse their Imper∣fections, or at least Forgive them: Espe∣cially considering, that this unpolish'd Letter is as well a Production of Your Lordship's Commands and my Obedi∣ence, as a Testimony of my Desire to make others beholden to my Lord of [Page  399](https://quod.lib.umich.edu/e/eebo/A29003.0001.001/428?vid=56393)*Dungarvan,* by the same way by which I indeavour to expresse my selfe

*Bec•n's-fi•ld*this 20h. of Decem∣ber, 1659.

*His Lordships* Most obedient Servant, and Most affectionate Unckle, *ROBERT BOYLE.*

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## ERRATA.

Pag. *4.* line. *8.* dele that. *10.11.* d. within and without. *12.3.* out at the. *18.25.* devoid. *18.*〈…〉*27.11.* ai•'s spring. *28.27.* refraction•. *31.1.*〈◊〉*32.5.* de that. *34.16.* it bent. *46.22.*〈…〉*4•.21.* made even, by. *48.6.* not from. *69.19.*〈◊〉*73.26.* cloath of. *76.26.* wax candle. *102.23*〈◊〉*10•.6.* we vnited. *104.1.* d. l. *106.21.* in an. *106.24.*〈◊〉i•. *115.16.* an other tryll. *150.22.* time, after. *152.9.* it, is. *116.26.,* how ever, *172.15.* EF. *173.9.*〈◊〉S—. Canalis tortuosi (QR) vltimum orificium Z. *174.18.* raresaction. *182.9.* twenty first. *184 6.*〈…〉*194.19.* wo•t to. *128:11.* of the Atmosphere. *235 16. 〈…〉 246.27.* d. be. *247.19.* admit it. *257.* in margine. 〈◊〉general. *270.24.* the glasse. *277.24.* a degree. *290.8.*〈◊〉neither as. *294.27.* F to C. *294.* vlt. *30 45/54 299.24.* To∣louse. *1300.15.* difforme. *309.27.* Lucid. *321.10.* pos∣sessor's. *356.16.* Pariacaca. *358.3. 〈…〉••8.26.* Froelichius. *362.14.*proscribe. *362.26.* as some of

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