

# PHILOSOPHICAL TRANSACTIONS.

Munday, July 2. 1666.

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### An Account

*Of a New kind of Baroscope, which may be called Statical; and of some Advantages and Conveniencies it hath above the Mercurial: Communicated, some while since, by the Honourable Robert Boyle.*



**S** for the New kind of Baroscopes, which, not long agoe, \* I intimated to you, that my \* See Num. II. p. haste would not permit me to give 185. *Phil. Trans-* you an account off; since your Let. *actions.*

ters acquaint me, that you still design a Communicating to the Curious

Curious as much Information, as may be, in reference to *Baroscopes*; I shall venture to send you some Account of what I did but name (in my former Letter) to you.

Though by a Passage, you may meet with in the 19th and 20th Pages of my *Thermometrical Experiments and Thoughts*, you may find, that I did some years agoe think upon this New kind of Baroscope; yet the Changes of the Atmosphere's Weight not happening to be then such, as I wish'd, and being unwilling to

☞ *The Scales here meant were before competent Eye-witnesses made to turn manifestly with the thousandth part of a grain.*

deprive my self of all other use of the exactest Ballance\*, that I (or perhaps any man) ever had, I confess to you, that successive avocations put this attempt for two or three years out of my thoughts; till afterwards returning to a place, where I chanc'd to find two or three pairs of Scales, I had left there, the sight of them brought it into my mind; and though I were then unable to procure exacter, yet my desire to make the Experiment some amends for so long a neglect, put me upon considering, that if I provided a *Glass-bubble*, more than ordinary large and light, even such Ballances, as those, might in some measure perform, what I had tried with the strangely nice ones above-mention'd.

I caused then to be blown at the Flame of a Lamp some *Glass-bubbles* as large, thin and light, as I could then procure, and choosing among them one, that seem'd the least unfit for my turn, I counterpois'd it in a pair of Scales, that would loose their *Equilibrium* with about the 30th part of a Grain, and were suspended at a Frame. I placed both the Ballance and the Frame by a good Baroscope, from whence I might learn the present weight of the Atmosphere. Then leaving these Instruments together; though the Scales, being no nicer than I have express'd, were not able to shew me all the Variations of the Air's weight, that appear'd in the *Mercurial* Baroscope, yet they did what I expected, by shewing me variations no greater, than alter'd the height of Quicksilver half a quarter of an Inch, and perhaps much smaller, than those: Nor did I doubt, that, if I had had either tender Scales, or the means of supplying the Experiment with convenient accommodations, I should have discerned

scerned far smaller Alterations of the Weight of the Air, since I had the pleasure to see the Buble sometimes in an *æquilibrium* with the counterpoise; sometimes, when the Atmosphere was high, preponderate so manifestly, that the Scales being gently stirr'd, the Cock would play altogether on that side, at which the Buble was hung; and at other times (when the Air was heavier) that, which was at the first but the Counterpoise, would preponderate, and, upon the motion of the Ballance, make the Cock vibrate altogether on its side. And this would continue sometimes many daies together, if the Air so long retain'd the same measure of gravity; and then (upon other changes) the Buble would regain an *æquilibrium*, or a preponderance; so that I had oftentimes the satisfaction, by looking first upon the *Statical* Baroscope (as for distinctions sake it may be call'd) to foretell, whether in the *Mercurial* Baroscope the Liquor were high or low. Which Observations though they hold as well in Winter, and several times in Summer (for I was often absent during that season) as the Spring, yet the frequency of their Vicissitudes (which perhaps was but accidental) made them more pleasant in the latter of these seasons.

So that, the matter of Fact having been made out by variety of repeated Observations, and by sometimes comparing severall of those new *Baroscopes* together, I shall add some of those Notes about this Instrument, which readily occur to my memory, reserving the rest till another opportunity.

And *First*, if the ground, on which I went in framing this *Baroscope*, be demanded, the answer in short may be; 1. That, though the Glas-buble, and the Glas-counterpoise, at the time of their first being weigh'd, be in the Air, wherein they both are weigh'd, exactly of the same weight; yet they are nothing near of the same bulk; the Buble, by reason of its capacious cavity (which contains nothing but Air, or something that weighs less than Air) being perhaps a hundred or two hundred times (for I have not conveniency to measure them) bigger than the Metalline counterpoise. 2. That according to a *Hydrostatical* Law (which you know I have lately had occasion to make out) If two Bodies of equal gravity, but unequal bulk come to be weigh'd in another *Medium*, they will be no longer

equiponderant; but if the new *Medium* be heavier, the greater Body, as being lighter in *Specie*, will lose more of its weight, than the lesser and more compact; but if the new *Medium* be lighter than the first, then the bigger Body will outweigh the lesser: And this disparity, arising from the change of *Medium's*, will be so much the greater, by how much the greater inequality of bulk there is between the Bodies formerly equiponderant.

3. That, laying these two together, I consider'd, that 'twould be all one, as to the effect to be produced, whether the Bodies were weigh'd in *Medium's* of differing gravity, or in the same *Medium*, in case its (*specifick*) gravity were considerably alter'd: And consequently, that since it appear'd by the *Baroscope*, that the weight of the Air was sometimes heavier, and sometimes lighter, the alterations of it, in point of gravity, from the weight, it was off at first counterpoising of the Buble of it, would *unequally* affect so large and hollow a Body, as the Buble, and so small and dense a one, as a Metallin weight: And when the Air by an increase of gravity should become a heavier *Medium*, than before, it would buoy up the Glas more than the Counterpoise; and if it grew lighter, than it was at first, would suffer the former to preponderate: (The Illustrations and Proof can scarce be added in few words; but, if it be desired, I may, God permitting, send you them at my next leisure:) And though our English Air be about a thousand times lighter, than water, the difference in weight of so little Air, as is; but equal in bulk to a Buble, seem'd to give small hopes, that it would be sensible upon a Ballance; yet, by making the Buble very large and light, I supposed and found the Event, I have already related.

*Secondly*, The hermetically seal'd Glas-buble, I employed, was of the bigness of a somewhat large *Orange*, and weigh'd about 1. drachme and 10. grains. But I thought it very possible, if I had been better furnish'd with conveniencies (wherein I afterwards found, I was not mistaken) to make (among many, that might be expected to miscarry) some, that might be preferable to this, either for capacity or lightnes, or both; especially if care be taken, that they be not seal'd up, whilst they are too hot. For, though one would think, that it were advantageous

ragious to rarify and drive out the Air as much as is possible, because in such seal'd Bubles the Air it self (as I have elsewhere shewn) has a weight; yet this advantage countervails not the inconvenience of being obliged to increase the weight of the Glass, which when it includes highly rarified Air, if it be not somewhat strong, will be broken by the pressure of the External Air, as I have sufficiently tryed.

*Thirdly*, I would have tryed, whether the *Dryness* and *Moisture* of the Air would in any measure have alter'd the weight of the Buble, as well as the Variation of Gravity produced in the *Atmosphere* by other causes; but the extraordinarily constant absence of Fogs, kept me from making Observations of this kind; save that one morning early, being told of a mist, I went to see (being my self in bed) whether it made the Air so heavy as to buoy up the Buble; but did not learn, that that mist had any sensible operation on it.

*Fourthly*, By reason of the difficulties and casualties, that may happen about the procuring and preserving such large and light Bubles, as I have been lately mentioning; it may in some cases prove a convenience to be inform'd; That I have sometimes, instead of one sufficiently large Buble, made use of two, that were smaller. And, though a single Buble of competent bignesse be much preferable, by reason that a far less quantity and weight of Glass is requisite to comprise an equal capacity, when the Glass is blown into a single Buble; than when it is divided into two; yet I found, that the employing of two instead of one, did not so ill answer my expectations, but that they may for a need serve the turn instead of the other; than which they are more easier to be procured: And if the Ballance be strong enough to bear so much Glass, without being injur'd: by employing two or a greater number of large Bubles, the effect may be more conspicuous, than if only a single Buble (though a very good one) were employed.

This instrument may be much improved by divers Accommodations. As

*First*, There may be fitted to the *Ansa* (or Checks of the Ballance) an Arch (of a Circle) divided into 15. or 20. deg. (more or less, according to the goodnes of the Ballance) that the Cock resting over against these Divisions, may readily  
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and without Calculation shew the quantity of the Angle, by which, when the scales propend either way, the Cock declines from the Perpendicular, and the beam from its Horizontall parallelism.

*Secondly*, Those, that will be so curious, may, instead of the Ordinary Counterpoise (of Brass) employ one of Gold, or at least of Lead, whereof the *latter* being of equal weight with Brass, is much less in Bulk, and the *former* amounts not to half its bigness.

*Thirdly*, These parts of the Ballance, that may be made of Copper or Brass, without any prejudice to the exactness, will, by being made of one of those Mettals, be less subject, than Steel, (which yet, if well hardned and polish'd, may last good a great while) to rust with long standing.

*Fourthly*, Instead of the scales, the Buble may be hung at one end of the Beam, and only a Counterpoise to it at the other, that the Beam may not be burthen'd with unnecessary weight.

*Fifthly*, The whole instrument, if placed in a small Frame, like a square Lanthorn with Glas-windows, and a hole at the top for the Commerce of the internal and external Air, will be more free from dust, and irregular agitations: to the latter of which, it will otherwise be sometimes incident.

*Sixthly*, This instrument being accommodated with a light Wheele and an Index (such as have been applyed by the excellent Dr. *Chr. Wren* to open Weather glasses, and by the ingenious Mr. *Hook* to *Baroscopes*) may be made to shew much more minute variations, than otherwise.

*Seventhly*, And the length of the Beam, and exquisiteness of the Ballance, may easily, *without* any of the foregoing helps (and much more *with* them) make the instrument far exacter, than any of those, I was reduced to employ. And to these Accommodations divers others may be suggested by a farther consideration of the nature of the thing, and a longer practice.

Though in some respects this *Statical* Baroscope be inferior to the *Mercurial*; yet in others it has its own advantages and conveniencies above it.

And *1.* It confirms *ad oculum* our former Doctrine, that the falling and rising of the *Mercury* depends upon the varying weight of the Atmosphere; since in this Baroscope it cannot

be pretended, that a *Fuga vacui*, or a *Funiculus*, is the cause of the changes, we observe. 2. It shews, that not only the Air has weight, but a more considerable one, than some Learned men, who will allow me to have prov'd, it has some weight, will admit; since even the variation of weight in so small a quantity of Air, as is but equal in bulk to an *Orange*, is manifestly discoverable upon such Ballances, as are none of the nicest. 3. This *Statical* Baroscope will oftentimes be more parable, than the other: For many will finde it more easie, to procure a good pair of Gold-scales, and a Buble or two, than a long Cane seal'd, a quantity of *Quick-silver*, and all the other requisits of the *Mercurial* Baroscope; especially if we comprise the trouble and skill, that is requisite to free the deserted part of the Tube from Air. 4; And whereas the difficulty of removing the *Mercurial* Instrument has kept men from so much as attempting to do it, even to neighbouring places; the Essential parts of the *Scale-Baroscope* (for the Frame is none of them) may very easily in a little room be carried, whither one will, without the hazard of being spoil'd or injur'd. 5. There is not in *Statical* Baroscopes, as in the other, a danger of uncertainty, as to the goodness of the Instruments, by reason, that in *these* the Air is, in some more, and in some less perfectly excluded; whereas in *those*, that consideration has no place. (And by the way, I have sometimes, upon this account, been able to discover by our new Baroscope, that an esteem'd *Mercurial* one, to which I compar'd it, was not well freed from Air.) 6. It being, as I formerly intimated, very possible to discover *Hydrostatically*, both the bigness of the Buble, and the Contents of the cavity, and the weight and dimensions of the Glasse substance (which together with the included Air make up the Buble,) much may be discover'd by this Instrument, as to the Weight of the Air, *absolute* or *relative*. For, when the *Quick-silver* in the *Mercurial* Baroscope is either very high, or very low, or at a middle station between its greatest and least height, bringing the *Scale-Barometer* to an Exact *Æquilibrium*; (I with very minute divisions of a Graine,) you may, by watchfully observing, when the *Mercury* is risen or fallen just an inch, or a fourth, or half an inch &c. and putting in the like minute divisions of a Grain to the lighter Scale, till you have again brought the Ballance to an  
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exquisite *Æquilibrium*; you may, I say, determine, What known weight in the *Statical* Baroscope answers such determinate Altitudes of the ascending and descending Quick-silver in the *Mercurial*. And if the Ballance be accommodated with a divided Arch, or a Wheel and Index, these Observations will assist you for the future to determine readily, by seeing the inclination of the Cock or the degree mark'd by the Index, what pollency the Buble hath, by the change of the *Atmospheres* weight, acquired or lost. Some Observations of this nature I watchfully made, sometimes putting in a 64<sup>th</sup> sometimes a 32<sup>th</sup> sometimes a 16<sup>th</sup>. and sometimes heavier parts of a Grain, to the lighter Scale. But one, that knew not, for what uses those little papers were, coming to a window, where my Baroscopes stood, so unluckily shook them out of the Scales, and confounded them, that he robb'd me of the opportunity of making the nice Observations I intended, though I had the satisfaction of seeing, that they were to be made. 7. By this *Statical* Instrument we may be assisted to compare the *Mercurial* Baroscopes of *several* places (though never so distant) and to make some Estimates of the Gravities of the Air therein. As if, for instance, I have found by Observation, that the Buble, I employ, (and one may have divers Bubbles of several sizes, that the one may repaire any mischance, that may happen to another) weigh'd just a Drachme, when the *Mercurial* Cylinder was at the height of 29½ inches (which in some places I have found a *moderate* altitude;) and that the Addition of the 16<sup>th</sup> part of a gr. is requisite to keep the Buble in an *Æquilibrium*, when the *Mercury* is risen an 8<sup>th</sup>, or any determinate part of an inch above the former station: When I come to another place, where there is a *Mercurial* Barometer, as well freed from Air as mine (for that must be supposed) if taking out my *Scale* instrument, it appeare to weigh precisely a Drachme, and the *Mercury* in the Baroscope there stand at just 29½ inches, we may conclude the Gravity of the Atmosphere not to be sensibly unequal in both those two places, though very distant. And though there be no Baroscope there, yet if there be an additional weight, as for instance, the 16<sup>th</sup> part of a Grain requisite to be added to the Buble, to bring the scales to an *Æquilibrium*, it will appear that the Air at this second place is; at that time



so much heavier, than the Air of the former place was, when the *Mercury* stood at  $29\frac{1}{2}$  inches.

But in making such comparisons, we must not forget to consider the Situation of the several places, if we mean to make Estimates not only of the weight of the Atmosphere, but of the weight and density of the Air. For, though the Scales will shew (as has been said) whether there be a difference of weight in the Atmosphere at the two places; yet, if one of them be in a Vale or bottom, and the other on the top or some elevated part of a Hill, it is not to be expected, that the Atmosphere, in this latter place, should gravitate as much, as the Atmosphere in the former, on which a longer Pillar of Air does lean or weigh.

And the mention, I have made of the differing Situation of Places, puts me in mind of something, that may prove another use of our *Statical* Baroscope, and which I had thoughts of making tryal off, but was Accidentally hindred from the opportunity of doing it. Namely, that by exactly poysing the Buble at the foot of a high Steeple or Hill, and carrying it in its close Frame to the top, one may, by the weight requisite to be added to Counterpoise there to bring the Beam to its Horizontal position, observe the difference of the weight of the Air at the bottom, and at the top; and, in case the Hill be high enough, at some intermediate Stations. But how far this may assist men, to estimate the *Absolute* or *Comparative* height of Mountains, and other elevated Places; and what other Uses the Instrument may be put to, when it is duly improved; and the Cautions, that may be requisite in the several cases, that shall be proposed, I must leave to more leasure, and farther Consideration.

### *The Particulars.*

*Of those Observations of the Planet Mars, formerly intimated to have been made at London in the Months of February and March A. 1661.*

To perform, what was promised *Num. 11.* of these Papers, pag. 198; 'tis thought fit now to publish the Particular Observations, concerning the spots in *Mars*, and their motion, as they were made with a 36 foot Telescope, and produced in