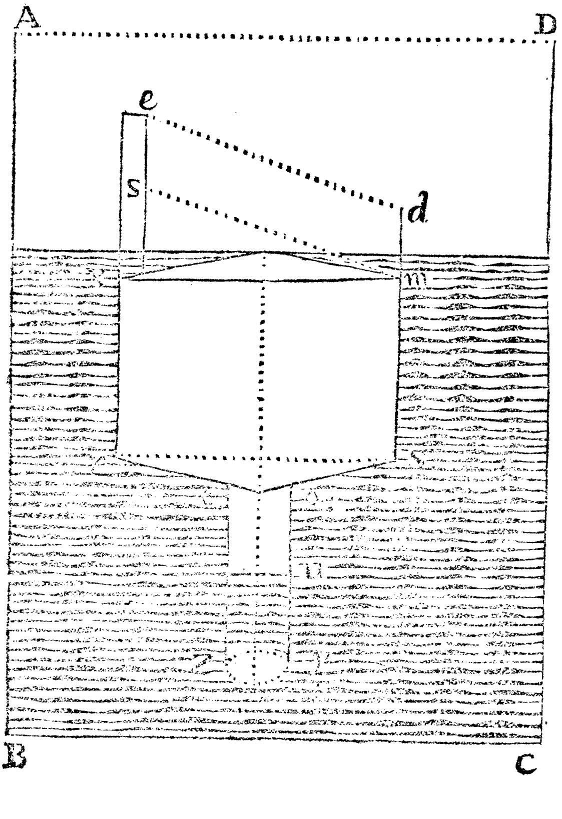
VI. *Part of a* LETTER *from Mr.* Caswell *of* Oxford, *F. R. S. to the Reverend Mr* Flamsteed, *M. R. S. S. giving an account of a new Baroscope, invented by him, and communicated by Mr* Hodgson, *F. R. S.*

SIR,

I Have made a new Sort of Baroscope, 'tis cheap and very exact, I here send you its Calculation as it occurr'd to my Thoughts before I made it. Suppose ABCD is a Bucket of Water, in it the Baroscope *xrezyosm* which consists of a Body *xrsm*, and a Tube *ezyo*, the Body and Tube are both concave Cylinders communicating with each other, and made of Tin (for want of Glass:) The Bottom of the Tube *zy* has a Lead-weight to sink it, so that the Top of the Body may just swim even with the Surface of the Water by the Addition of some Grain-weights on the Top. The Water when the Instrument is forc'd with its Mouth downwards gets up into the Tube to the height *yu*. There is added on the Top a small concave Cylinder, which I call the Pipe, to distinguish it from the bottom small Cylinder, which I call the Tube: This Pipe is to sustain the Instrument from sinking to the Bottom, *md* is a Wire *ms*, *de* are two Threads oblique to the Surface of the Water, which Threads perform the Office of Diagonals: For that while the Instrument sinks more or less by the Alteration of the Gravity of the Air, there where the Surface of the Water cuts the Thread, is form'd a small Bubble which Bubble ascends up the Thread while the ☿ of the common Baroscope ascends.

The Circumference of the Body is 21 Inches, therefore its Area = 35: the Altitude *ms* = 4, therefore the Body's Solidity $= 140$, each Baſe $x\,m$, $r\,s$, has a Convexity whoſe Altitude is 6.5, therefore the Conoid on each Baſe is nearly $= 11\frac{1}{2}$, therefore d the whole Body is $= (140 + 11\frac{1}{2} + 11\frac{1}{2} =) 163$, and b the entire Altitude of the Body $= (4 + .65 + .65 =) 5.3$. The Inner Circumference of the Tube is 5.014, therefore its Area $n = 2$ the Length of the Tube $= 4.5$, therefore the Tube's Capacity $= 9$, therefore C, the Content of the Body and Tube $= 163 + 9 = 172$ Cubic Inches, that is almoſt $2\frac{1}{2}$ Quarts.

Suppoſe the Air's Preſſure when greateſt $= 30.5$ Inches of ☿ $= (30.5 \times 14 =) 427$ of Water, and $f = 427$, therefore $f\,c = 73444$. Put a for the Depth $o\,u$, of the Air in the Tube when the Body is juſt all immers'd, the Air in the Inſtrument on Immerſion Contracts ſomewhat by



the Cold of the Water; this Contraction I find is nearly as much as would be produc'd by an Addition of 1 Inch to the Atmoſphere's Altitude 427, this in cold Weather, but in warm Weather 'tis probably twice as much: but we will now ſuppoſe it $= 1$, therefore the Depth of the Surface of the Water in the Tube below the Surface of the outer Water is $= b + a$, therefore the Preſſure on that inner Surface is as the Altitude of the Atmoſphere above it $= f + b + 1 + a = F + a$ (putting $F = f + b + 1$.) Then for that the Spa-

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ces into which the Air is contracted, are reciprocal to their respective Pressures, and for that while the Instrument is out of the Water the Pressure f answer'd to the Space C therefore, $F + a : f :: C : \frac{fc}{F + a}$ = Space which the Air takes up in the Instrument under Water; therefore, $\frac{fc}{F + a} - d$ = that Part of the Tube which is possess'd by Air $= an$ (supposing the Tube's Area $2 = n$). Therefore $fc - Fd - ad = Fan + aan$. Therefore $aa + \overline{F + \frac{d}{n}} \times a = \frac{fc - Fd}{n}$. Put $F + \frac{d}{n} = 2g$, therefore $aa + 2ga = \frac{fc - Fd}{n}$ therefore $a = \sqrt{:\frac{fc - Fd}{n} + gg} - g$.

Then suppose the Atmosphere's Gravity less so much as to sink the ☿ $\frac{1}{10}$ Inch = 1.4 of Water, and therefore putting $\varphi = F - 1.4$, and in the last Equation α instead of a, and γ instead of g, You have $\alpha = \sqrt{\frac{fc - \varphi d}{n} + \gamma\gamma} : -\gamma$. Thus I find $\left.\begin{array}{l} a = 2.72 \\ \alpha = 2.94 \end{array}\right\}$ and therefore $\alpha - a = .22$, which $.22 \times n$ gives .44 Cubic Inches, and (supposing a Cube-Inch = 253 Grains) $.44 \times 253 = 111$ Grains-weight of Water that was gotten up into the Tube in the 1st Case more than in the 2d, and therefore the Baroscope requires an Addition of 111 Grains on its Top to sink it with the Level of the Water in the 2d Case more than in the 1st, and this upon the sinking of the ☿ in the common Baroscope only $\frac{1}{10}$ Inch; Now 1 Grain in this new Baroscope is nearly as discernable as $\frac{1}{10}$ Inch in the Common, and therefore this new Baroscope is more exact than the Common 111 Times.

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Put $f = 247$. $c = 172$. $d = 163$. $n = 2$ as above, only change F, put F 437.3, that is, ſuppoſe the Body ſunk in Water 4 Inches lower; In this Caſe $\alpha = 208$, therefore $a - \alpha = .64$ which multiplyed into $\varphi\, n = 1.28$ Cubic-inches, which $\times$ 253 gives 324 Grains, and ſo much the Body's Top $x\, m$ being ſunk 4 Inches under Water, the Body becomes heavier, than while $x\, m$ was at the Surface of the Water. Therefore this 1.28 divided by the aforeſaid Depth 4 gives .32 the Area of the Top Pipe ſuch as would ballance or buoy up the Body at any Depth. Strictly ſpeaking the Pipe ſhould be gradually bigger upward in order to ſuſtain the Inſtrument at any Depth, but as to Senſe 'tis Cylindrical, and its Circumference = 2 005. But for that the leaſt Alteration of the Air would make the Body's Top $x\, m$ in that caſe paſs thro' the 4 Inches (which 4 Inches I ſuppoſe all the Variety of Depth that the Inſtrument has room given it in the Bucket to aſcend or deſcend) therefore the Pipe is made a ſmall matter bigger, (*viz.*) its Circumference is 2.14; whereby the Pipe, according as the Body ſinks more, gives more reſiſtance to the deſcending Body. The Pipes Area is .3643: Therefore the Capacity of the Pipe in 4 Inches Altitude is = 1.457. But as aboveſaid to give juſtly no reſiſtance, its Capacity ſhould be 1.28. Therefore this 1.28 taken from 1.457, leaves .177 the actual reſiſtance in 4 Inches depth, *viz.* (.177 × 253 =) 44 Grains.

But this reſiſtance will not be the ſame in all weathers, in order therefore to calculate what it will be when the ☿ of the common Baroſcope is very low: For example, but 28 Inches high = 392 of Water; f muſt be ſuppos'd = 392, therefore $F = f + b + 1 = 398.3$, and the reſt as before; *viz.* $d = 163$, $f\, c = 67424$. $F\, d = 649229$. Thence by the aforeſaid Equation $\left.\begin{array}{l} a = 2.59 \\ \alpha = 2.84 \end{array}\right\}$ Therefore

$\alpha - a = .25$, which [illegible] gives .50 Cubic Inches, which × 253 = 126 Grains. So that this Baroſcope when the ☿ is loweſt, is more exact than the common 126 Times, ſuppoſing the Body immers'd afreſh when the ☿ is ſo low.

Next while the ☿ is ſo very low, ſuppoſe the Top of the Body depreſs'd 4 Inches under Water; therefore $\varphi = F + 4 = 402.3$, the reſt are as before, *viz.* f c = 67424, then α will be 1.9: but before, while the Top of the Body was at the Surface, α was 2.59. Therefore the Difference 69 × Tube's Area 2, gives 1.38 Cube-inches, which × 253 gives 349 Grains, and ſo much the Baroſcope is heavier when the Top *xm* is 4 Inches under Water, or which comes to the ſame, ſuppoſing that ☿ at 28, and *xm* at the Surface; this Baroſcope by the ☿'s aſcending $\frac{4}{34}$ Inch will become heavier 349 Grains. The Pipe's Capacity in 4 Inches Altitude was 1.457, from which take the aboveſaid 1.38, the reſidue = .077, which × 253 gives 19 Grains in 4 Inches; ſo that the Pipe will ſuſtain the Baroſcope, and alſo 44 when the ☿ is $30\frac{1}{2}$ high, and but 19 Grains when the ☿ is 28 high. The fewer Grains difference there are in its ſinking, thro' 4 Inches, the more nice the Baroſcope will be.

There where the Thread cuts the Surface of the Water, is form'd a Bubble, therefore this Bubble while the Inſtrument ſinks in Water 4 Inches, which is all the room that I give it, the Bubble moves on the 2 Diagonal Threads 20 Inches, it follows therefore that 120 Grains difference would make the Bubble walk over 120 Inches, if the Threads were ſo long, but as it has been above calculated, about 120 Grains difference of Weight of the Inſtrument is produc'd by ſo much of the Alteration of the Air, as would make the ☿ of the common Baroſcope $\frac{1}{10}$ Inch: therefore when the ☿ aſcends $\frac{1}{10}$ Inch, the Bubble of this new Baroſcope aſcends 120 Inches; therefore this new Baroſcope is more exact than the Common Baroſcope by about 1200 times.

Observations made with this new Baroscope.

1. While the ☿ of the common Baroscope is often known to be stationary 24 hours together, the Bubble of the new Baroscope is rarely found to stand still 1 minute.

2. Suppose the Air's Gravity encreasing, and accordingly the Bubble ascending, during the Time that it ascends 20 Inches, it will have many short descents, of the Quantity of $\frac{1}{2}$ Inch, 1, 2, 3, or more Inches, each of which being over it will ascend again. These retrocessions are frequent, and of all Varieties in quantity and duration, so that there is no judging of the general course of the Bubble by bare inspection, though you see it moving but by waiting a little time.

3. A small Blast of Wind will make the Bubble descend; a Blast that can't be heard in a Chamber of the Town, will sensibly force the Bubble downward. The Blasts of Wind sensible abroad cause many of the abovesaid Retrocessions, or Accelerations in the general Course; as I found by carrying my Baroscope to a Place where the Wind was Perceptible.

4. Clouds make the Bubble descend. A small Cloud approaching to the Zenith works more than a great Cloud near the Horizon. In Cloudy weather the Bubble descending, a break of the Clouds (or clear Place) approaching to the Zenith, has made the Bubble to ascend; and after that break had pass'd beyond the Zenith a considerable Space, the bubble again descended.

5. All Clouds (except one) hitherto by me observ'd, have made the Bubble to descend. But the other day the Wind being *North*, and the Course of the bubble descend-

descending. I saw to the Windward a Large thick Cloud near the Horizon, and the bubble still descended, but as this Cloud drew near the Zenith it turn'd the way of the bubble making it to ascend, and the bubble continued ascending till the Cloud was all pass'd, after which it resumed its former descent. It was a Cloud that yielded a cold shower of small Hail.

Printed for *Sam. Smith* and *Benj. Walford*, Printers to the Royal Society, at the *Princes Arms* in St *Paul's* Church-yard, 1704.