



LXVII. On the caloric of gases and vapours

M. Poisson

To cite this article: M. Poisson (1823) LXVII. On the caloric of gases and vapours , Philosophical Magazine Series 1, 62:307, 328-338, DOI: [10.1080/14786442308644417](https://doi.org/10.1080/14786442308644417)

To link to this article: <http://dx.doi.org/10.1080/14786442308644417>



Published online: 29 Jul 2009.



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LXVII. *On the Caloric of Gases and Vapours*, by M. POISSON; from the *Annales de Chimie*, tome xxiii. p. 337: with Observations by JOHN HERAPATH, Esq.

To the Editors of the *Philosophical Magazine and Journal*.
Gentlemen,

THINKING M. Poisson's paper, which you had the goodness to put into my hands, would not be unacceptable to your English readers, I have taken the trouble to translate it from the French, and have added some notes and observations which appeared necessary either to elucidate it or to set its merits in a proper light.

From this paper and those of M. Laplace it is plain with what ardour the subject of gases and heat is pursued on the continent. Would our English philosophers but lend their aid in the securer course of deciding some of the more important and disputed points by experiments, it is manifest we should speedily come to decisive conclusions respecting the nature and laws of heat. In hopes that some of them will shortly take up the complete experimental investigation of so important a question,

I am, gentlemen,

Yours truly,

Cranford, October 15, 1823.

J. HERAPATH.

On the Caloric of Gases and Vapours; by M. POISSON*.

§ I. Let ρ be the density of a gas, θ its temperature in centigrade degrees, and p its elastic force, or its pressure on a unity of surface; then shall we have

$$p = a \rho (1 + \alpha \theta) \quad (1)$$

α and a being two coefficients of which the first is the same for every gas, and equal to .00375, and the other should be given for each particular gas. The total quantity of caloric contained in a given weight of gas, a gramme† for instance, we have no method known of computing; but we may consider the excess of this quantity above that which a gramme of the gas contains under a pressure and temperature arbitrarily chosen. Denoting this excess by q , it will become a function

* This paper sets out with a formula drawn from the hypothesis, that the increments of expansion under a constant pressure are proportional to the increments of heat. Other hypothetical views are afterwards introduced to account for particular phænomena, the success of which will best appear in the course of the paper. It may however here be observed, that though this paper does not profess to descend deeply into physical principles, it is nevertheless completely hypothetical; but I shall not stop to point out all the hypothetical parts; I shall merely call the attention of the reader to the more material points.—J. H.

† 15.44579 English grains Troy.

of p , ρ , and θ ; or, because those variables are connected by the preceding equation, simply a function of p and ρ . Thus we shall have $q = f(p, \rho)$; f being a function whose form it will be required to determine.

The specific heat of this gramme of gas is the quantity which must be communicated to it to raise its temperature θ one degree; and it will be very nearly $\frac{d q}{d \theta}$. But we may consider this specific heat under two different points of view,—first, in allowing the gas to dilate under an invariable pressure,—and secondly, in keeping the volume constant whilst the temperature and pressure augment together. Hence we shall have in virtue of the first equation

$$\frac{d q}{d \theta} = - \frac{\alpha \rho}{1 + \alpha \theta}, \quad \frac{d p}{d \theta} = \frac{\alpha p}{1 + \alpha \theta}$$

It results, therefore, if we put c for the specific caloric when the pressure is constant, and c_v when the volume is constant, that

$$\left. \begin{aligned} c &= - \frac{d q}{d \theta} \cdot \frac{\alpha \rho}{1 + \alpha \theta}, \\ c_v &= \frac{d q}{d p} \cdot \frac{\alpha p}{1 + \alpha \theta} \end{aligned} \right\} \quad (2)$$

which, if we put $\frac{c}{c_v} = k$, give

$$\rho \frac{d q}{d \theta} + k p \frac{d q}{d p} = 0. \quad (3)$$

It is evident, *a priori*, that this ratio k ought always to exceed unity; for the heat must necessarily be greater to raise the temperature a certain quantity when the gas dilates, than when the density is invariable. Experiment however is the only way of obtaining the value of k , and of discovering to us in what manner it depends on p and ρ . Following the experiments of MM. Gay-Lussac and Welter, cited in the *Mécanique Céleste*, book 12. p. 97, this quantity is sensibly constant for the same gas; and for dry atmospheric air its value is $k = 1.375$. Now supposing k independent of p and ρ , the integral of equation (3) is

$$q = f\left(\frac{p}{\rho^{\frac{1}{k}}}\right); * \quad (4)$$

* This is a very simple case of the intégration of partial differentials. Eliminating $\frac{d q}{d \theta}$ in the course of integration instead of $\frac{d q}{d p}$ would have given

$$q = f\left(\frac{p}{\rho}\right),$$

which is rather closer to the subject and somewhat more easily obtained than M. Poisson's, though in other respects virtually the same.—J. H.

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f being

f being an arbitrary function. From this we obtain

$$p = \rho^k \phi q,$$

and because of equation (1)

$$1 + \alpha \theta = \frac{1}{a} g^{k-1} \phi q;$$

ϕ being another function. The quantity q remaining the same, if p , g , and θ become p' , g' , and θ' , we shall have

$$p' = g'^k \phi q, \quad 1 + \alpha \theta' = \frac{1}{a} g'^{k-1} \phi q.$$

Eliminating ϕq and observing that $\frac{1}{a} = 266^\circ \cdot 67$ there result

$$\left. \begin{aligned} p' &= p \left(\frac{g'}{g} \right)^k \\ \theta' &= (266^\circ \cdot 67 + \theta) \cdot \left(\frac{g'}{g} \right)^{k-1} - 266^\circ \cdot 67 \end{aligned} \right\} \quad (5)$$

These equations (5) comprehend the laws of elasticity and temperature of gases, compressed or dilated without changing their quantity of caloric; such as would take place if the gases were contained in vessels impervious to caloric*; or when the compression is so rapid, as in the phenomenon of sound, that we may suppose the loss of heat quite insensible. In ignition (*Dans le briquet à air*) for example with air, if the volume is suddenly reduced to a fifth, or if we have $g' = 5 g$, we find by the preceding value of k

$$\theta' - \theta = 221^\circ + \cdot 83 \theta;$$

in which it is plain that the augmentation of temperature will be the greater the higher the original temperature θ . For when $\theta = 0$ we have $\theta' = 221^\circ$, a temperature which philosophers think sufficient to ignite tinder (*Vamadou*) in compressed air.

Eliminating g in equation (4), by means of equation (1), we have

$$q = f \{ a p^{\frac{1}{k}-1} (1 + \alpha \theta) \}$$

In order to determine the arbitrary function f , we have need of a new hypothesis. M. Laplace's hypothesis in the 12th book of the *Mécanique Céleste* consists in assuming that the increments of caloric follow the same ratio as those of the temperature, which requires that the function f should be of the first degree with respect to the variable it contains; from which it results that, since $\alpha = \frac{1}{266 \cdot 67}$,

$$q = A + B (266 \cdot 67 + \theta) p^{\frac{1}{k}-1}; \quad (6)$$

A and B being two arbitrary constants. Whence the specific heats are

$$c = B p^{\frac{1}{k}-1}, \quad c' = \frac{1}{k} B p^{\frac{1}{k}-1}$$

They do not therefore depend on the temperature θ , but are

* Such cases I think could never under any circumstances whatever be subjected to experimental examination.—J. H.

known

known for all pressures, when one of them has been determined for one determinate pressure. Following MM. Laplace and Berard, we have $c = \cdot 2669$ for air under a pressure of $m \cdot 76$, the specific heat of an equal weight of water being unity. Calling therefore P the pressure corresponding to the barometric height $m \cdot 76$, we get

$$\cdot 2669 = B P^{\frac{1}{k}-1};$$

from which we conclude generally

$$c = (\cdot 2669) \left(\frac{P}{p} \right)^{1-\frac{1}{k}};$$

and the value of c , is deduced from that of c by dividing the latter by k . Since the quantity k exceeds unity, the specific heat of a gramme of air, and generally of any gas whatever, will augment as the elastic force p diminishes.

If we denote by m the quantity of caloric lost by a gramme of air, when its temperature is diminished n degrees, we shall have the pressure p remaining constant,

$$m = n (\cdot 2669) \left(\frac{P}{p} \right)^{1-\frac{1}{k}}$$

For an equal volume, the temperature being invariable, the weight will be $\frac{p'}{p}$ grammes, when the pressure becomes p' . Calling therefore m' the loss of caloric of this other volume for the same diminution of temperature, we get

$$m' = \frac{n p'}{p} (\cdot 2669) \left(\frac{P}{p'} \right)^{1-\frac{1}{k}};$$

from which we conclude

$$\frac{m'}{m} = \left(\frac{p'}{p} \right)^{\frac{1}{k}}, *$$

for the ratio of the quantities of caloric lost by the same volume of air under different pressures.

§ II. The formulæ (6) and (7) are extracted from the 12th book of the *Mécanique Céleste*. M. Laplace has also extended the former to aqueous vapour. For this purpose he supposes, first, that when a gramme of vapour is formed, and neither augmented by more vapour nor diminished by condensation, the ratio of its specific caloric under a constant pressure to its specific caloric under a constant volume is invariable; secondly, that the quantity of caloric necessary to elevate the tempera-

* M. Poisson's formula (7) must be regarded as a mere theoretical conclusion unsupported and even unsanctioned as to numbers by experiments. It is directly at variance with what I have shown, Phil. Mag. vol. lxii. p. 138, follows from M. Laplace's views. What makes it more curious, it is Laplace's own conclusion. Such is the unfortunate inconsistency which follows from the doctrine of caloric even in the hands of such men as Laplace and Poisson.—J. H.

ture any number of degrees, is proportional to this number, the pressure being constant. This being admitted, if we call C the caloric required to reduce a gramme of water at zero into vapour at 100° and with an elasticity of $^m.76$; Q the caloric necessary to vaporise this same gramme of water and give it a temperature θ , under any pressure p ; γ the same specific caloric of the aqueous vapour under the pressure $^m.76$; and finally, if we substitute in equation (6) the barometric altitude h for the pressure p , which it measures, this formula will give $Q=C$ when $h=^m.76$ and $\theta=100^\circ$, and $\frac{dQ}{d\theta}=\gamma$ when $h=^m.76$. Determining then in consequence the two arbitrary constants which it contains, it becomes

$$Q=C+\gamma\left\{(266.67+\theta)\left(\frac{^m.76}{h}\right)^{\frac{k-1}{k}}-366.67\right\} \quad (8)$$

It would be desirable that the accuracy of this formula should be verified by experiment, and the constants C , γ , and k determined with precision.

If we put unity for the specific heat of a gramme of water, or for the quantity of heat necessary to raise its temperature 1° , we shall have $C=650$ very nearly, by taking the mean of the values found for this quantity by different philosophers. Following MM. Laroche and Berard, we shall likewise have $\gamma=.847$. Indeed they have not given this value of γ with much confidence; but there is reason to believe it is not far from truth, and we shall therefore adopt it until it be modified by other observations. With respect to the value of k we know of no direct observations by which it can be determined; but an important remark which many philosophers, and particularly MM. Clement and Désormes, have made will enable us to approximate to it.

According to this remark, when a space is saturated with vapour, the quantity of caloric contained in each gramme is sensibly the same whatever be the temperature; so that if for θ in the value of Q we put successively different temperatures, and substitute at the same time for h the corresponding maximum tensions of the vapour, Q will be constant or nearly the same in each case. When $\theta=100^\circ$, the maximum tension, $h=^m.76$, which numbers substituted for θ and h in the value of Q render the coefficient of γ nearly $=0$. Consequently denoting by H instead of h the maximum tension of any temperature θ , this coefficient of γ must still be nearly $=0$, whatever be the value of θ . Hence the following approximate equation:

$$(266.67+\theta)\left(\frac{^m.76}{H}\right)^{\frac{k-1}{k}}-366.67=0; \quad (9)$$

from

from which we may determine k by giving to θ any value for which the corresponding one of H has been settled by observation. For example, by the table of M. Biot's *Traité de Physique*, tome 1, p. 531, deduced from the experiments of M. Dalton, $H = {}^m\!0\cdot88742$ when $\theta = 50^\circ$; and therefore the preceding equation gives

$$\frac{k-1}{k} = \cdot0683 \text{ and } k = 1\cdot073.$$

By employing values of H corresponding to other values of θ comprised between 0° and 100° , the value of k will scarcely differ from the preceding by a hundredth at most, or a two hundredth at least. We shall therefore retain this value of k , to which joining the preceding values of C and γ our formula (8) becomes

$$Q = 650 + (\cdot847) \left\{ (266\cdot67 + \theta) \left(\frac{{}^m\!76}{h} \right)^{\cdot0683} - {}_{-366\cdot67} \right\}. \quad (10)$$

The application of this formula to temperatures far distant from 100° shows us that the quantity Q varies but very little in the case of saturation or when $H = h$. For $\theta = 0^\circ$, we have

$H = 5\cdot059$; whence $Q = 658$. For $\theta = -19^\circ\cdot59$ M. Gay-

Lussac has found $H = {}^{mm}\!1\cdot3718$; whence $Q = 662$. When $\theta = 140^\circ$ many philosophers agree in giving to H nearly four times its value at 100° , or four times ${}^m\!76$; whence we get $Q = 653$. Again, M. Christian makes H nearly twice the last value or eight times ${}^m\!76$ when $\theta = 170^\circ$; from which Q comes out 661. These values of Q , as we perceive, differ but very little among themselves, though they have ranged over a temperature of nearly 200° , and a tension of vapours from almost nothing to eight atmospheres*. This result shows that k in the case of aqueous vapour is but very little greater than unity; but we cannot, as we have shown above, suppose it precisely equal to unity. We should not forget that Q is not sensibly constant unless when the tension or vapour is a maximum. When

* The evidence in favour of his formula which M. Poisson here adduces in the supposed constancy of Q is illusive. It all results from the high value which Q happens to have. Where would have been the evidence had Q happened to have a much less value? for instance, a value of about 3 or 4 or even 10!! Did probability belong to the views producing this theorem, the coefficient of γ being once nearly = 0 should deviate but very little from it. Its different values even under the range of temperature M. Poisson mentions, have ratios from nothing to infinity. A greater proof of the propriety and justice of my objections cannot be adduced than in the very erroneous values of the tension H immediately following. Nothing, it appears to me, can be a stronger argument of the insufficiency of a theory, than the same formula in one instance coming up nearly to observations, and in another instance closely connected running almost in direct opposition to them.—J. H.

the space is not completely saturated, Q , as given by equation (10), will vary more with the variations of h and θ . The specific heat of vapour depends simply on h ; for denoting this heat by c we have

$$c = .847 \left(\frac{m \cdot 76}{h} \right)^{.0683}$$

Dividing this by k or 1.073, we have the specific heat under a constant volume.

By means of the value of k we draw from equation (9)

$$H = .76 \left(\frac{266 \cdot 67 + \theta}{366 \cdot 67} \right)^{14 \cdot 65}$$

If this equation was correct, that is, if Q was rigorously constant in the case of saturation, this formula would express in this same case the tension of the vapour in terms of the temperature; but though Q varies so little, the preceding value of H wanders in high pressures far too much from observations. Thus when $\theta = 170^\circ$ H comes out 13 atmospheres instead of 8; nor does the formula represent observations but imperfectly in temperatures beneath 100° .*

Whether the vapour be at a maximum or not, equation (1), which is equally applicable to vapours and gases, will always give the density ρ of the vapour when the temperature θ and tension h are known. Therefore calling D the density of the vapour at 100° and under the pressure of $m \cdot 76$, we obtain

$$\rho = \frac{D h \cdot 366 \cdot 67}{.76 \cdot 266 \cdot 67 + \theta}$$

The weight of a litre† of dry air at the temperature of 100° and pressure of $m \cdot 76$ is equal to $8 \cdot 945$; and the weight of a litre of vapour $\frac{1}{2}$ of it or $8 \cdot 59$. Consequently the weight of a volume v of vapour at the temperature θ and tension h will be

$$\frac{v h \cdot 187 \cdot 833}{m \cdot 76 \cdot 266 \cdot 67 + \theta} :$$

the unity volume being the litre. Then calling V the quan-

* In the Annals of Philosophy for December 1821, I have given a theorem which represents experiments within about 2 inches of pressure from 32° to 312° of Fahrenheit, and comprehending a tension from 1.5th inch to 167 inches, or upwards of 5 atmospheres. It indeed seems to agree with the observations much better than they agree with each other. In fact, I am inclined to doubt the correctness of Dr. Ure's experiments in the higher temperatures. From the manner in which he made them, I think the vapour of the mercury must have had considerable influence in augmenting the apparent tensions. Probably Mr. P. Taylor's, in the Phil. Mag., vol. ix. page 452, are nearer the truth, though his not describing the manner of his operating * prevents us from using them with that confidence to which they are very likely entitled.—J. H.

† 61.028 cubic inches, or 2.113 pints.

* We regret that Mr. P. Taylor's absence from home, and pressing engagements, have as yet prevented his communicating through our pages an account of his apparatus. Several of the most eminent men of science both of our own and other countries have examined it.—EDIT.

tity of heat necessary to form this quantity of vapour, the water being first at zero temperature, V will be the product of this number of grammes and the quantity Q , given by (10); so that we shall have

$$V = \frac{h \cdot v \cdot 187 \cdot 33}{76 \cdot 266 \cdot 67 + \theta} Q.$$

The unity to which V has respect is the quantity of heat necessary to elevate the temperature of a gramme of water one degree, which, as we know, is 75 times that requisite to liquefy a gramme of ice at zero. Consequently, if we assume this last quantity to be the unity of heat, we must multiply the above value for V by 75.

In steam engines, in which this fluid is employed in a state of saturation, Q does not sensibly vary: the ratio of V to h , or of the quantity of heat usefully employed in pressure on the piston, is then, all other things being alike, reciprocally as $266 \cdot 67 + \theta$. The higher the temperature θ , therefore, of the vapour, the less will be this ratio; and consequently the expanse of heat will increase less rapidly than the force produced. But the economy which thus results in favour of high pressure engines is far inferior to that which experience seems to indicate; and it is in a less waste of heat, or in other circumstances relative to their construction, that we must look for an explanation of the advantage which they present.

§ III. Let us suppose that we have two different gases of the same temperature θ and elasticity p ; and whose volumes are v and v' . Were they now put one on the other in a closed vessel of the capacity $v + v'$, it is plain they could preserve an equilibrium, because the temperature is the same and the mutual pressures are equal; but this equilibrium would not be stable. Experience proves that these gases would gradually penetrate each other until they are completely intermixed. It further shows that during this operation heat is neither evolved nor absorbed; so that after a certain time the mixture is perfectly homogeneous; the two gases holding the same proportion in every part, and the temperature and pressure being θ and p . From these facts, established by observation, we may deduce another equally well verified by experience.

If two gases mixed together at the temperature θ fill a volume v ; and if p, p' denote the pressures they would separately exert, separately occupying the same volume v , at the same temperature θ , the pressure of the mixture will be $p + p'$. In effect, let us suppose that the two gases at first are distinct, and let $p' > p$; then dilating the gas under the pressure p' until p' changes to p , its volume will become

$$\frac{v p'}{p},$$

provided

provided the same temperature θ has been preserved. Placing the two gases now one on the other, their united volume is

$$v + \frac{v p'}{p} \text{ or } \frac{v}{p} (p + p').$$

These gases, according to what we have said above, will equally intermix without changing their temperature or common pressure p . Now by Marriotte's law, which is as true of mixed as of simple gases, if we compress the mixture without changing its temperature until its volume

$$\frac{v}{p} (p + p')$$

becomes v , its pressure p will become $p + p'$, the same as we had to prove. Equally good would the principle hold with three or more gases, or with a mixture of gases and vapour; in all cases the united pressure will be equal to the sum of all the pressures which the gases or vapours would singly exert, when separately occupying the same volume v at the same temperature θ . It may be seen in the 12th book of the *Mécanique Céleste* how M. Laplace has deduced this principle from the hypotheses he has made on the caloric and radiation of the gases; we simply propose to exhibit its connexion with another fact which we first announced.

Let n and n' be the number of grammes of two different gases mixed together at the temperature θ under a pressure p and filling a volume v ; and let c , c' denote the specific heats of a gramme of these gases under an invariable pressure p , and c'' the specific heat of a gramme of the mixture under the same pressure. Then will

$$(n + n') c'' = n c + n' c' \quad (11)$$

For if we suppose the two gases instead of being mixed merely superposed, so that under the temperature θ and pressure p of the mixture they occupy separate portions u and u' of the total volume v ; then, by what we have said above, the quantity of heat will be the same in the two gases thus placed as in the perfect mixture of them. This equality will moreover subsist if we augment by one degree the temperatures of the mixture and of the gases. Now to make this augmentation we must communicate a new quantity $(n + n') c''$ of heat to the mixture, and the quantities $n c$, $n' c'$ to the two gases. The first therefore must be equal to the sum of the other two, which is equation (11)—an equation that may be easily extended to the mixture of any number whatever of gases and vapours. It will give the specific heat of any mixture when that of each of the component gases or vapours is known; and reciprocally we may employ it to find the specific heat of either of the component gases when those of the others and of the mixture are known.

known. Thus MM. Laroche and Berard having determined the specific heat of air mixed with vapour at the temperature 39° and pressure $m\cdot76$, and moreover knowing the number of grammes of dry air and vapour contained in the mixture, as well as the specific heat of dry air under the same pressure $m\cdot76$, have been able to draw from it the specific heat of vapour at the whole pressure $m\cdot76$, and not at the particular tension of the vapour, a case which they have left undecided, *Annales de Chimie*, tome 85, p. 132. This specific heat of vapour is the value of γ , which we have used in the preceding article*.

Our equation (11) will still hold, if for the specific heats c, c', c'' , under a constant pressure we substitute the specific heats corresponding under a constant volume. For instance, calling these latter c_0, c'_0, c''_0 we shall have

$$(n+n')c''_0 = n c_0 + n' c'_0.$$

Let k, k', k'' be the several ratios of c to c_0 , c' to c'_0 , c'' to c''_0 , so that $c = k c_0$, $c' = k' c'_0$, $c'' = k'' c''_0$, then from equation (11) and the preceding we conclude

$$k'' = \frac{n k c_0 + n' k' c'_0}{n c''_0 + n' c'_0};$$

or if the ratios k, k' are unequal, the quantities c, c'_0 will, according to what we have said in § I., be different powers of the pressure p ; from which it results that the ratio k'' will not be independent of p . Thus the ratio of the two specific heats for a constant pressure and volume of the same simple gas being supposed invariable, but different in different gases, cannot be invariable in a mixture of two of more simple gases, or simple gases and vapours. If this ratio has appeared constant in the experiments on atmospheric air of different pressures, it is because the values of the specific heats for the two component gases oxygen and azote are sensibly the same†.

* I cannot satisfy myself of the degree of confidence to be attached to the experiments of MM. Laroche and Berard. Calculations from the influence of currents of air do not impress me with the idea that such methods are susceptible of much accuracy. Besides, it certainly seems to be adverse to the theory of caloric itself, that so rarefied and expanded a body as vapour should have a less specific heat than its generating water; which is the case in the above philosopher's results. Crawford's method is much more simple and direct, and brings out results more favourable to caloric.—J. H.

† M. Poisson seems here to think the atmosphere a mere mechanical mixture of oxygen and azote. Were this the case, the proportion of these elements would scarcely be so uniformly the same in all parts of the atmosphere as philosophers tell us it is. But Mr. Harrop's experiments, namely, that nitrogen confined over water absorbs from it just as much and no more oxygen than is sufficient to make atmospheric air, appear to put it beyond a doubt that the atmosphere is a chemical compound, though perhaps but a weak one.—J. H.

Supposing this ratio constant for vapour as well as for dry air, its value is very different in the two fluids, and cannot therefore be constant in moist air, particularly if the vapour in the air be considerable. Hence the formulæ we have given in § I., being founded on the invariability of the ratio in question, will not apply at the same time to simple gases and mixtures of gases and vapours.

Addition to the preceding Memoir by M. POISSON.

During the printing of this memoir M. Clement has communicated to me the result of a new experiment on the temperature of vapour under a very high pressure. According to this experiment, the pressure of aqueous vapour, in the state of saturation at the temperature of 215° centigrade, is 35 atmospheres. From these data equation (10) gives

$$Q = 659;$$

so that the invariability of the quantity Q appears still to hold good very nearly under this high temperature. Nevertheless, we cannot suppose that the caloric Q is rigorously invariable; for, were this the case, our equation (9) would bring out 54 atmospheres for the *maximum* pressure of vapour at 215°, whereas experiment gives only 35 atmospheres.

LXVIII. *Quadrature of the Circle; and Proportion of the Diameter to the Circumference; containing some Observations on its Perimeter and Area, tending to demonstrate the utter Impossibility of ever obtaining a perfect Solution of these delusive Problems: together with the true and ONLY Cause of the constant Failure of all Attempts to effect it. To which is added, a simple and easy Process of estimating the most useful Properties of the Sphere &c. in Mensuration. By Mr. JOHN SNART.**

To the Editors of the Philosophical Magazine and Journal.

CONSIDERING the sterling talents and very high capabilities of many of the speculators on these mathematical desiderata, it is truly astonishing that none of them ever appear to have penetrated the *true cause* of their continual disappointment; but, as if they were fully persuaded of the entire practicability of the thing, they have all confidently persevered to obtain a still nearer and nearer approximation,

* Communicated by the Author.

(which