



# On the Uncertain Foundation of the Law that Entropy Increases II: The Negentropic Hypothesis

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## Abstract

Part I evinced the fallaciousness of Clausius' argument providing support for the reversible-processes version of the second law, and described in detail the corrected argument introduced by Post-Clausius Thermodynamics to eliminate the failures in reasoning present in the former and provide this way apparently foolproof support for the said law. In this second part we show this corrected argument to be at fault on reason of it subsuming an arbitrary notion without which the validity of the said law comes into question. What we consider to be the rational alternative to the said arbitrary notion is here advanced and an experimental proof suggested to recognize the truthfulness of one or the other. Note: The identifying numbers for sections and figures continue from those of Part I.

**Keywords:** Post-Clausius thermodynamics; The unknown entropy change for the transformation of heat into work; The second law; The negentropic hypothesis; Self-organizing phenomena.

## 5. Against all Logic and Reason

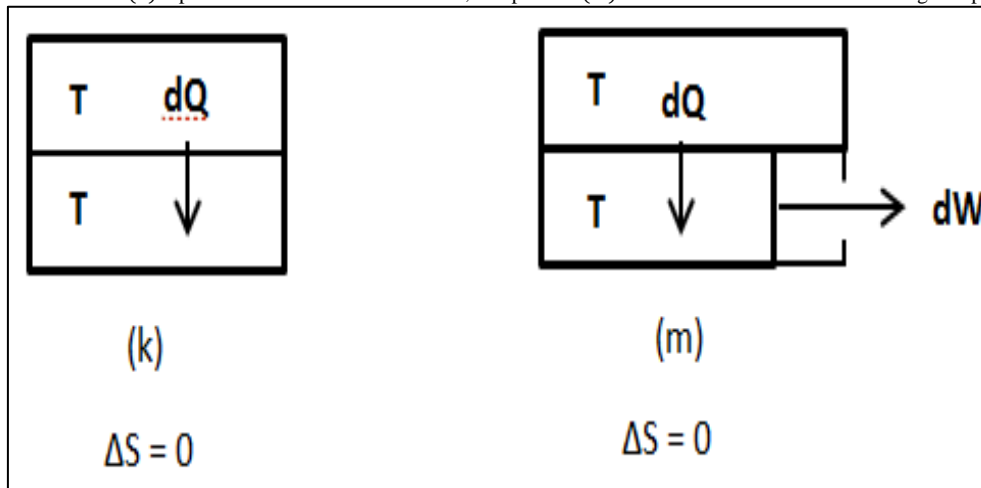
### 5.1. A Comparison Between Two Reversible Processes

Figure 4 depicts two different processes: (*k*) represents a reversible heat transfer, and (*m*) the isothermal and reversible expansion of an ideal gas. In correspondence with their stated reversibility, both of these processes take place, according to *PCT*, at constant total-entropy. Attached to the cylinder of process (*m*), but not shown in the figure, is a mechanical reservoir assumed to be of the weight-in-pulley kind which will respond with a weight's height increase to the production of work by the expansion. No mechanical reservoir is needed in process (*k*) due to the fact that no work is here produced. The inconsequential change taking place in process (*k*) is characteristic of those processes which already in equilibrium are incapable of any work output. It is, in other words, a change that changes nothing, or a Koyré has said "...a change without change..." [1] Process (*m*), on the other hand, is not as process in equilibrium but in its way to such a condition as these are the only processes capable of work output. On this perspective these two processes are as different as the state of rest is from the state of motion.

The reader should note that both processes subsume a heat transfer step. In (*k*) this step constitutes the whole of the process. In (*m*), on the other hand, the transfer of heat represents only the first step of the process. This is said in the understanding that the actual transformation of  $dQ$  into  $dW$  carried on by the expansion of the gas cannot take place without the previous transfer of  $dQ$  from the reservoir to the gas. Only with  $dQ$  in possession of the gas is that the transformation of  $dQ$  into  $dW$  can take place. Using our previously introduced transformation notation we can recognize that the transformation associated to process (*k*) is  $[dQ(T) \rightarrow dQ(T)]$ , while those associated to the occurrence of process (*m*) are  $[dQ(T) \rightarrow dQ(T)]$  plus  $[dQ(T) \rightarrow W]$ .

In recognition of the transformations taking place in (*k*) and (*m*) the total entropy changes for these processes adopt, respectively, the following forms:  $\Delta S_{tot}[(k)] = \Delta S_{tot}[dQ(T) \rightarrow dQ(T)]$  and  $\Delta S_{tot}[(m)] = \Delta S_{tot}[dQ(T) \rightarrow dQ(T)] + \Delta S_{tot}[dQ(T) \rightarrow dW]$ .

Figure-4. Process (*k*) represents a reversible heat transfer, and process (*m*) an isothermal and reversible ideal-gas expansion



Now, we know that for a process such as  $(k)$  and on reason of the equal magnitude but opposite sign entropy changes of the reservoirs it is true that  $\Delta S_{tot}[dQ(T) \rightarrow dQ(T)] = -(dQ/T) + (dQ/T) = 0$ , and if so, also true that  $\Delta S_{tot}[(k)] = 0$ . The fact that the heat transfer process taking place in  $(m)$  is identical to that of  $(k)$  allows us to write the total entropy change of the former as  $\Delta S_{tot}[(m)] = 0 + \Delta S_{tot}[dQ(T) \rightarrow dW] = \Delta S_{tot}[dQ(T) \rightarrow dW]$ . The total entropy change for the reversible process depicted in Figure 4(m) is seen this way being uniquely determined by the entropy change of transformation  $[dQ(T) \rightarrow dW]$ .

This last statement, it should be understood, constitutes no more no less than a crossroads in second-law thermodynamics. And it is so on reason of the following facts, (1) that the validity of the second law hinges on the value for the entropy change of this transformation, and (2) that strangely enough this value is not known, and here I mean known with certainty, without a doubt i.e., known as in being *proved* to be equal to a certain value. Point (1) above recognizes that the validity of the second law depends on the value of this transformation being equal to zero. If not zero we would then have that reversible process  $(m)$  would be taking place with a total-entropy change different from zero, this in opposition to the prescription of the said law. If this were to be so we would also have to reject the results/conclusions of *PCT's* analysis carried on in reference to Figure 3. Point (2) recognizes, on its part, that up to this very moment we have no factual knowledge about the total entropy change of transformation  $[dQ(T) \rightarrow W]$ .

If we do not factually know the total-entropy change for  $[dQ(T) \rightarrow W]$  how is it then that we proceeded, when calculating in Section 4 of Part I the values for the transformations according to *PCT*, as if it were zero? In reality in Section 4 we didn't even acknowledge the existence of this transformation, as through all of it we reduced the isothermal and reversible expansions/compressions of the variable body to simple heat transfer processes of the kind shown in  $(k)$ , procedure this no different from that of assigning this transformation a zero entropy change.

The answer to the question posed is simple and indeed surprising: Because Post-Clausius thermodynamics arbitrarily decided it to be so, providing, on the side, an illogical justification for this decision, based, as will be seen below, on the mechanical nature of mechanical reservoirs.

Even if we have centered our attention on transformation  $[dQ(T) \rightarrow W]$  as it occurs in an isothermal and reversible ideal gas expansion, the same considerations apply to its inverse, i.e. to an isothermal and reversible ideal gas compression. For this process, designated here as  $(-m)$ , its total entropy change can be written as  $\Delta S_{tot}[-(m)] = \Delta S_{tot}[W \rightarrow dQ(T)] + \Delta S_{tot}[dQ(T) \rightarrow dQ(T)]$ . The rationale for this equation parallels that provided above for process  $(m)$ : no heat can be transferred from the gas to the reservoir without the transformation of work into heat having previously taken place. For the same reason as in process  $(m)$ , this entropy change reduces to  $\Delta S_{tot}[-(m)] = \Delta S_{tot}[dQ(T) \rightarrow dW]$  and just like it happened with  $\Delta S[dQ(T) \rightarrow W]$ , it is also taken to be equal to zero by *PCT*. The reader might be asking himself why this interest in isothermal and reversible processes of ideal gases? The answer is that that these are the processes, namely *EB*, *CD*, and *AE* determining the total entropy change of the cycle as previously calculated in the argument developed in reference to Figure 3.

The arbitrary decision of *PCT* in making  $\Delta S_{tot}[dQ(T) \rightarrow dW] = 0$  went before, and still goes today, unnoticed by most instructors, students, and studios of thermodynamics. Apart from some comments made in passing by a small number of authors, no other reference to the transformation of heat into work appears to be available in thermodynamics books and textbooks. A surprising situation given the fact that it was the need to understand this process what led Carnot to lay the foundations of this discipline which in its latest version blatantly ignores the role its founding notion plays in thermodynamic processes. Thus, when explaining the equation defining the total entropy change for a reversible cycle as the combination of the entropy changes of its heat reservoirs, Pitzer and Brewer tells us that "The work term does not appear...since it involves no entropy..."[2]; apart from this the only other references known to this author are those of Barrow and Bent, both of them using the mechanical nature of the work reservoir to explain or justify the non-appearance of work in their entropy balances. From Barrow:

*We are at liberty, you should recognize, to ascribe any features to this new entropy function that we like, the requirement being that we construct a function that is self-consistent and allows us to form a useful expression of the second law. In this vein we further specify that, for all processes  $dS_{mech\ res} = 0$ ."* [3]

Bent adopts a similar position to that of Barrow. Thus, the entropy balance for the operation of a heat engine working between heat reservoirs of 400 K and 300 K is by him written as follows:  $\Delta S_{tot} = (S_{total})_{final\ state} - (S_{total})_{initial\ state} = \Delta S_{400K\ res} + \Delta S_{300K\ res} + \Delta S_{wt}$ , only to replace, in the next step,  $\Delta S_{wt}$  by zero [4].

Two issues need to be addressed in regard to Barrow and Bent's position: 1) why is it that these author's felt the need to bring the mechanical reservoir into consideration in regard to the total entropy change of a cyclical process when the common position in this issue is that the only bodies changing here are the heat reservoirs? And, 2) Why is Barrow and Bent's position of identifying the entropy change of the heat-to-work transformation with the entropy change of the mechanical reservoir an incorrect position? The answer to the first question *starts* by recognizing that contrary to what we have been taught in the classroom or learned outside of it, at the end of a cycle, defined by the return of the variable body to its initial condition, we have three bodies changing: the hot reservoir, the cold reservoir, and the mechanical reservoir; and *concludes* recognizing that three bodies changing means three entropy changes. Barrow and Bent are correct in writing their entropy balances in terms of three entropy changes; they are, however, wrong in including the entropy change of the mechanical reservoir as the third term.

To understand this let us go back to process  $(m)$  and agree that applying Barrow and Bent's procedure to this process implies replacing the correct expression previously obtained for its total entropy change, namely  $\Delta S_{tot}[(m)] = \Delta S_{tot}[dQ(T) \rightarrow dW]$  for one that reads  $\Delta S_{tot}[(m)] = \Delta S_{mech\ res}$ . Performance of this change, it should be noted, subsumes the outlandish notion that the transformation of heat into work taking place in process  $(m)$

is the responsibility of the mechanical reservoir, when the reality is that this body, by its very definition, is incapable of any exchange of energy in the form of heat. If the mechanical reservoir cannot absorb heat, and if so, neither can it transform heat into work, how is it then the entropy change for the transformation of heat into work is ascribed or attributed to it? The role of the mechanical reservoir in process ( $m$ ) is that of a gauge, a measuring stick of the effect of the transformation of heat into work taking place along the expansion of the gas. Making the mechanical reservoir responsible for  $[dQ(T) \rightarrow dW]$  is like making the speedometer responsible for the motion of the wheels in a vehicle, or like confusing the effect with the cause. It isn't in the mechanical reservoir where the cause of the transformation of heat into work resides but in the concerted action of the heat reservoir in supplying the heat and the expanding gas in actually transforming this heat into work. If so the substitution of  $\Delta S_{tot}[dQ(T) \rightarrow dW]$  by  $\Delta S_{mech\ res}$  is unjustified and until this issue is resolved 1) the constant total-entropy change for process ( $m$ ) should be expressed as  $\Delta S_{tot}[m] = \Delta S_{tot}[dQ(T) \rightarrow dW]$  and 2) the uncertainty arising in the validity of the second law produced by our ignorance of the entropy change of this transformation, remains.

Let me note here that it was very convenient indeed for *PCT* to locate the origin of  $[dQ(T) \rightarrow dW]$  in the mechanical reservoir as this body, evolving by definition at constant total entropy, provides the required  $\Delta S_{tot}[dQ(T) \rightarrow dW] = 0$  to make process ( $m$ ) comply with the prescriptions of the second law.

Another way of looking at this issue starts recognizing that the only *zero* essentially linked to the entropy is the one inherently associated to entropy's nature as a point function. A zero total-entropy change is mandatory for the return of the universe of any thermodynamic process to its initial condition. This 'return to initial condition' must be met by each and every one of the bodies in any way involved in the process being considered. If we take a look at the effects of an optimally efficient cyclical process at the conclusion on one cycle in its operation we will realize that the universe of this process has not returned to its initial condition as we have three bodies –the heat and mechanical reservoirs- in conditions different from the ones they initially had, and on reason of this our first reaction will be to deny a zero-total entropy change to such a process. But then we learn that in these optimally efficient cycles the entropy changes of the heat reservoirs are compensated, i.e., they are of the same magnitude but opposite sign in such a way that their combined entropy change is zero. This consideration changes not, however, our initial rejection of a zero-total entropy change for this cycle, the reason being that we still have a body –the mechanical reservoir- in a condition different from the one it initially had. With the heat reservoirs out of the picture, we now realize that there is no other body with which the mechanical reservoir could compensate its entropy change and if so the only way possible for this optimally efficient cycle to have a zero-total entropy change requires the entropy change of the mechanical reservoir to be zero. This is the point at which *PCT* comes in, as Barrow's and Bent's arguments evince, to tell us that on reason of its mechanical nature the entropy change of the *MR* is zero and if so the total-entropy change of an optimally efficient cycle is zero which means that the second law in its reversible processes version, is indeed correct. But this explanation is still unable of changing our initial position on reason of the fact that the always zero total-entropy change of the mechanical reservoir is a consequence of the way such a body has been defined and is in no way related to the total-entropy change of the actual conversion of heat into work; an impossible process if restricted to the sole participation of the mechanical reservoir. In other words, the transformation of heat into work as it takes place in a cyclical process or as it occurs in process ( $m$ ) requires, in addition of the presence of the depository/gauge represented by the mechanical reservoir the participation, actually the concerted participation of the heat reservoir and the gas which we have summarized in the expression  $[dQ(T) \rightarrow W]$ . Let us note, in passing, that of all the bodies involved in a reversible cyclical process the only one complying with the return to its initial condition is the variable body. This mere fact makes it both logical as well as rigorous, this said in attention to Clausius' definition of the entropy transcribed in Section 2.2, to posit that it is to this body that equation  $-Q_h/T_h + Q_c/T_h = 0$  actually corresponds.

To those of us who like to believe, with McGlashan, that "Thermodynamics is an experimental science, and not a branch of metaphysics" [5] Preface), as well as to think, as Truesdell does, that thermodynamics can be understood through our experience [6], positions these based on our certainty that the laws of thermodynamics are supposed to be a reflection of nature's behavior and not a receptacle of our preconceived ideas on how we think nature should behave, makes a lot of sense to consider work as an energy form of a superior quality than heat. For Smith and Van Ness the small efficiencies achievable in the conversion of heat into work in cyclical processes compared with the almost quantitative conversion possible for one form of work into another, or of work into heat, indicate the existence of "...an intrinsic difference between heat and work..." with heat "...a less versatile or more degraded form of energy than work..." or, equivalently, with "work...energy of a higher quality than heat" [7] If, as Jantsch has suggested "Entropy is a measure for the quality of the energy in the system" [8], then the entropy change would also be a measure of the change of quality experienced when heat is transformed into work, or produced out of it. A similar message can be found in the following quote from Weber and Meissner: "The entropy change of the system plus surroundings may be viewed as a quantitative measure, or index, of the degradation of energy as work to energy as heat, as a consequence of the irreversible elements in the process under study" [9]

The connection between entropy production and quality loss or degradation of energy has been part of our commonsensical approach to thermodynamics for quite some time. Writing in 1904 Swinburne defines entropy as "a quantity which when multiplied by the lowest available temperature, gives the incurred (energy) waste" [10]. The previous notions allows us to understand that in the transformation whose occurrence marks the separation, the distinction between processes ( $k$ ) and ( $m$ ), namely  $[dQ(T) \rightarrow dW]$ , a change in quality is taking place as the higher quality energy form we call work is being produced out of the lower quality form called heat, and to such a change there must correspond, if our ideas about entropy are correct, an entropy change, or more precisely, a negative entropy change. If we associate energy degrading with positive entropy changes then we must associate negative entropy changes with energy upgrading. In accord with this notion then  $\Delta S[dQ(T) \rightarrow dW] < 0$ . The previous

argument takes care of the sign. To determine its magnitude we need to go back to Clausius and recognize, with him, that the entropy change of such a process can only depend on the amount of heat transformed into work and beyond this it can only depend on its temperature, i.e.  $\Delta S[dQ(T) \rightarrow dW] = -dQ/T = -dW/T$ . In being this so then the total entropy change for process ( $m$ ) becomes:

$$\Delta S_{tot}[(m)] = \Delta S[dQ(T) \rightarrow dQ(T)] + \Delta S[dQ(T) \rightarrow dW] = 0 - dQ/T = -dQ/T = -dW/T.$$

And, consequently, for process ( $-m$ ):

$$\Delta S_{tot}[(-m)] = \Delta S_{tot}[W \rightarrow dQ(T)] + \Delta S_{tot}[dQ(T) \rightarrow dQ(T)] = dQ/T + 0 = dQ/T$$

The previous considerations will be now summarized in what will be henceforth referred to as:

**The Negentropic Hypothesis:** *The total entropy changes for the reversible transformation of an amount of heat  $Q$  of temperature  $T$  into the equivalent amount of work  $W$ , or vice versa, are  $-Q/T$  and  $Q/T$ , respectively.*

The knowledge coming out of this hypothesis will be collectively referred to as ‘the negentropic formulation of the Second Law’ or simply ‘the negentropic formulation’. Obviously, the acceptance or rejection of the negentropic hypothesis will come via the contrast of its predictions with experiment. After all, as Planck’s has so clearly stated: “Experiment is the only means of knowledge at our disposal. Everything else is poetry, imagination.” ([https://www.goodreads.com/author/quotes/107032.Max\\_Planck](https://www.goodreads.com/author/quotes/107032.Max_Planck))

On the one side the negentropic hypothesis recognizes the reversible transformation of work into heat, say that taking place through an isothermal and reversible ideal gas compression, as an entropy producing process and in this sense it is put in the same category as that energy degrading process represented by irreversible, say frictional transformation of work into heat, and on the other it recognizes the energy upgrading process represented by the transformation of heat into work as a negentropic process. It was the understanding of the opposite effects of these two kinds of processes what led Clausius to assign them opposite signs. His use of this idea came however short on reason of his mistaken conceptualization as to the how this process takes place.

Energy’s quality, it needs to be pointed out, is an anthropomorphic concept. Its highest level is assigned to that energy form we call work, and this is done on reason or in reference to its availability, ease and versatility of use to sustain our humanity, to increase the productivity of our efforts, and propel, in general, what we humans call progress. Carnot defined work as follows: “We use here the expression motive power to express the useful effect that a motor is capable of producing.” Carnot [11], and here he means, of course, useful to us. It seems to me that there is no better way for the reader to get the proper dimension of the difference in quality between heat and work than asking him/her to compare the things he/she can do with a bonfire with those he/she can do with electricity.

## 5.2. The Law that Entropy Increases: A Law with Restricted Domain of Application

In *PCT* arbitrarily making zero the entropy change for reversible heat-work interconversions it restricted the domain of application of the law of increasing entropy to irreversible processes, i.e. those with a null work output. This is the realm where the law of increasing entropy reigns supreme as the only processes here taking place are those necessarily complying with the said arbitrary condition represented as  $\Delta S[dQ(T) \rightarrow dW] = 0$ . Until the issue of the total entropy change for the transformation of heat into work is solved, the second law, as currently understood, will be no more than a generalization valid for irreversible ( $W = 0$ ) processes. If the said value is proved to be, as here postulated, lesser than zero, then the law of increasing entropy will acquire the status of the special case of a larger generalization –the true second law- taking account the entropic as well as negentropic effects of energy-degrading and energy upgrading processes, respectively.

Let us then write, in attention to the ‘three bodies changed’ reality of one cycle in the operation of a reversible engine such as the one represented in Figure 3, the following equation for its total entropy change:  $\Delta S_{tot}[Rev. cycle] = -(Q_h/T_h) + (Q_c/T_c) + \Delta S_{tot}[Q(T_h) \rightarrow W]$ . The bracket in the last term of this equation represents, as should be recalled from Section 4, the work-effect of the cycle represented in Figure 3(h), produced there by isothermal and reversible expansion *EA*. The work  $W$  produced by this process is the one responsible for the equivalent increase in the potential energy of the mechanical reservoir. Use of the negentropic hypothesis allows us to write the previous equation as follows:  $\Delta S_{tot}[Rev. cycle] = -(Q_h/T_h) + (Q_c/T_c) - W/T_h$ .

The fact that the said three bodies are left in a changed condition in any engine’s operation, reversible or not, allows us to recognize the previous equation as the general expression for the total-entropy change of any heat-engine, and, with the proper signs included, of any refrigerator, reversible or not.

The previous equation makes clear that the concatenated operations of a reversible engine and a reversible refrigerator, working both between the same heat reservoirs, leads to a combined total-entropy change of zero, as it corresponds to a universe returning to its precise initial condition. As previously noted, a combined total entropy change of zero for a body returning to its initial condition is the only property coming to the entropy on reason of its point function condition. The zero total-entropy change purportedly ruling along any reversible path is a property artificially foisted upon those processes via the arbitrary decision of *PCT* of making zero the total-entropy change of reversible heat-work interconversions in order to uphold the validity of what some believe to be the supreme law of nature.

The equation for the total-entropy change of heat-engines written above subsumes the notion that allows us to make sense not only of energy-degrading processes but also of the order-building processes taking place in our universe. To unveil it let us start recognizing that in an engine working at the reversible efficiency ( $\eta_{rev} = (T_h - T_c)/T_h$ ) the entropy changes of the heat reservoirs are compensated, i.e.  $-(Q_h/T_h) + (Q_c/T_c) = 0$ , and that on reason of this the previous equation reduces to  $\Delta S_{tot}[Rev. cycle] = -W/T_h < 0$ . Thus, at the conclusion of one cycle in the operation of a reversible engine the entropy of its universe has experienced a decrease proportional to its

work output. Let us also recognize that in an engine operating between the same heat reservoirs as the previous one but with an efficiency of zero no work will at all be outputted. Here the whole of the heat coming out of the hot reservoir reaches the cold one with all its work-producing potential untapped. This process, none other than the irreversible heat transfer of  $Q_h$  from  $T_h$  to  $T_c$ , takes place, as we know, with a total-entropy change of  $\Delta S_{tot}[Q_h(T_h) \rightarrow Q_h(T_c)]_{irr} = Q_h(T_h - T_c)/(T_c T_h) > 0$ . The fact that the operation taking place at the inefficient limit is entropic while that of the efficient limit is negentropic allows us to conclude that there must exist one operation of intermediate efficiency  $0 < \eta < \eta_{rev}$  with a total-entropy change of zero. To locate this operation all we have to do is put equal to zero the general equation for the total-entropy change of the cycle and solve for its efficiency. When we do this we get  $-(Q_h/T_h) + (Q_c/T_c) - (W/T_h) = 0$ . The substitution of  $Q_c = Q_h - W$  followed by the isolation of  $W/Q_h$  leads us to  $\eta_{umbral} = (T_h - T_c)/(T_h + T_c)$ . Recognition that the quotient  $W/Q_h$  represents the efficiency of the operation in question explains its substitution by  $\eta_{umbral}$ . The *umbral* qualifier ascribed to this efficiency stems from the fact that it separates entropic from negentropic operations. Any operation taking place with an efficiency smaller than  $\eta_{umbral}$  is entropic, i.e. it takes place with a positive total-entropy change. Those with efficiency larger than the umbral efficiency take place, on the other hand, with negative total-entropy changes. The condition  $0 \leq \eta < \eta_{umbral}$  encompasses all those operations in which the entropic effect of energy dissipation surpasses the negentropic effect of the transformation of heat into work. In all those operations in which the condition  $\eta_{umbral} \leq \eta \leq \eta_{rev}$  is met, the opposite is true. If we recognize the transformation of heat into work as an indispensable condition for progress, evolution, or development then its wasteful dissipation should be associated with regress, descent, or decline. The breaking or transition point from chaos to order or vice versa is the one represented by the zero total-entropy-change umbral efficiency. This way, when transiting along the path of increasing efficiencies, order will first appear at the umbral efficiency and, conversely, chaos will appear at that same point when crossed coming from the region of higher efficiencies. According to these considerations the appearance or disappearance of order, and here I am using order as a synonym for negentropy, will take place at that condition represented by a zero-total entropy change.

The fact that, magic and metaphysics aside, work is the only chaos ordering and structure building agent allows us to understand why post-Clausius thermodynamics has been incapable of providing a rational model for those systems called self-organizing (pattern-forming) which in essence represents energy-upgrading machines. There is no way that the one-legged golem represented by the law of increasing entropy who recognizes energy degrading but not energy upgrading, can produce a theory of self-organizing processes when it has previously decided that energy upgrading processes –the ones responsible for order, structure, and self-organization in this universe of ours- are immaterial or invisible to the second law.

With the negentropic hypothesis as guide a model for that energy-upgrading engine called Bénard Convection has been developed. The judgement of validity for the model and for the notion on which it stands is, fortunately, not to come from the opinion, even if the opinion is supposed to be a learned opinion- of thermodynamicists; after all, we already know that “Much learning doesn’t teach understanding” (Heraclitus, Wikiquote) and particularly because “Thermodynamics is too important to be left to the thermodynamicists” [12]s, but from the ultimate and incontestable verdict of experience, i.e. from the comparison of its predictions with the actual behavior of nature. Such a test can definitely be used to disqualify the notion assigning a zero total-entropy change for reversible heat/work inter-conversions, and if so also to give the law of increasing entropy its proper place, not as the supreme law of nature as Eddington [13] posits, but as a special case of a general law that takes into account the entropic and negentropic contributions of energy degrading and energy upgrading processes, respectively. The model and the results of the comparison of its predictions with relevant experimental data are the matter of a future paper this author intends to publish in the near future in this same venue.

Even if my ideas on these issues were fully developed way before the time I had the opportunity of reading his work, I have to acknowledge that as far as I know it was Teilhard de Chardin the first one to recognize that a complete description of nature’s evolution cannot be achieved without the inclusion of energy upgrading processes:

*For a century and a half the science of physics, preoccupied with analytical researches, was dominated by the idea of the dissipation of energy and the disintegration of matter. Being now called upon by biology to consider the effects of synthesis, it is beginning to perceive that, parallel with the phenomenon of corpuscular disintegration, the Universe historically displays a second process as generalised and fundamental as the first: I mean that of the gradual concentration of its physicochemical elements in nuclei of increasing complexity...The outflow of Entropy equaled and offset by the rising tide of Noogenesis! [14]*

The proper perspective to the previous quote requires recognition of the fact that the entropy can only be opposed, equaled, or offset by its opposite (its dialectical opposite, to be precise): the negentropy.

## 6. Final Comments on the Negentropic Hypothesis

To me Angrist and Hepler’s quote “*Thermodynamics is too important to be left to the thermodynamicists*” is but a reflection of the fact that thermodynamicists are not actually trained to look at reality through the critical eyes of their reason, but through the prejudiced eyes of the *magister dixit*s that aprioristically define for them what is true and what is not; what is possible and what is not. Case at hand Planck’s decree that anthropomorphism must be removed from physical science and Eddington’s dogma stating:

*The law that entropy increases holds, I think, the supreme position among the laws of Nature. If someone points out to you that your pet theory of the universe is in disagreement with Maxwell’s equations –then so much the worse for Maxwell’s equations. If it is found to be contradicted by*

*observation –well, these experimentalists do bungle things sometimes. But if your theory is found to be against the second law of thermodynamics I can give you no hope; there is nothing for it but to collapse in deepest humiliation [13].*

Every time I read Eddington's quote I cannot help but follow it in my mind with the terse words of Saint Augustine "Roma locuta est; causa finita est." (The Pope has spoken, the case is closed) ([http://en.wikiquote.org/wiki/Augustine\\_of\\_Hippo](http://en.wikiquote.org/wiki/Augustine_of_Hippo)), and I do this because Eddington's quote is nothing short of a religious dogma; one the pillars of the Church of Increasing Entropy (replace 'deepest humiliation' with the 'fire of Hell' and the simile is complete).

The honest attitude of thermodynamicists in this regard is to get rid of dogmas, decrees, and magister dixits in favor of the light of their reason. This is the path of science, or as Heraclitus has said: "Now that we can travel anywhere, we need no longer take the poets and myth-makers for sure witnesses about disputed facts" (Heraclitus, Fragments, 2001, Penguin Classics, p. 11)

It is difficult to tie the stature of Eddington as a scientist with his previous quote which might very well be the epitome of an anti-scientific statement in the sense that it is directed to impede, to hinder, or obstaculize our reason from freely inquiring, questioning, and doubting the said law. Inquiring within the body of knowledge constituting the foundations of this law –the essential trait of scientific work- is forbidden, on Eddington's decree, for us simple mortals. Almost 2500 years of human inquiry propelled, knowingly or unknowingly, by that attitude perfectly captured in Heraclitus words "Applicants for wisdom do what I have done: inquire within" is found in second-law-thermodynamics replaced by Eddington's prohibition to do so! (Heraclitus, Fragments, 2001, Penguin Classics, p. 80) As far as my knowledge on this issue goes, no other scientist took such an extreme position. Not even Planck, another prominent scientist who yields to the temptation of trying to impose his idiosyncrasies into physical science, went that far. Actually, Planck left open the possibility that the 'supreme law of nature' might not be so:

*Presumably the time will come when the principle of the increase of the entropy will be presented without any connection with experiment. Some metaphysicians may even put it forward as being a priori valid. In the mean time, no more effective weapon can be used by both champions and opponents of the second law than indefatigable endeavor to follow the real purport of this law to the utmost consequences, taking the latter one by one to the highest court of appeal –experience. Whatever the decision may be, lasting gain will accrue to us from such a proceeding, since thereby we serve the chief end of natural science –the enlargement of our stock of knowledge [15].*

This is precisely what I intend to do.

The previous considerations provide a frame of reference for the various reactions that the advancement of my *negentropic hypothesis*, which introduced at the end of Section 5.1 assigns a negative total entropy change of  $-dQ/T$  for the transformation of the amount of heat  $dQ$  of temperature  $T$  into an equivalent amount of work  $dW$ , might produce in thermodynamicists of Eddington's School. Some will react indignantly to my doubting of the law of increasing entropy, some others will just have a good laugh at my position, and still others will find a myriad of arguments to contradict me. Let me state in this regard that, if proved right, the negentropic hypothesis will bring along a radically different way to look at thermodynamic processes and at the meaning of a total-entropy change. As I stated above, the law of increasing entropy will see its validity restricted to the irreversible domain where no heat-to-work transformations take at all place. Contrary to what some idealistic minds –in the Hegelian sense- might think, the negentropic hypothesis doesn't claim that nature works in ways different than those perceived through our experience and our reason; its claim is that the current thermodynamic description of natural phenomena is incomplete and that the achievement of a complete description, one that includes both: entropy production due to energy degrading processes as well as entropy reduction due to energy upgrading process, will bring forward a new way of looking at nature. The battle between the old view and the one promoted by the negentropic hypothesis is not, however, a battle of words and opinions but a battle between facts. And facts are what I intend to produce when the negentropic hypothesis is contrasted with experiment.

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