The new thermodyna...

Jacob Tripler Wainwright
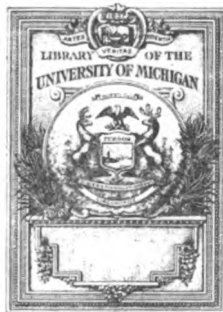
THE NEW THERMODYNAMICS

THE NON-POSTULATED RATIONALE
OF MOTIVE POWER OF HEAT

ALSO

COMPRISING AN INVESTIGATION OF THE PROPOSITION
OF UTILIZING HEAT OF ENVIRONMENT AS
A SUBSTITUTE FOR FUEL

By

JACOB T. WAINWRIGHT

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PREFACE

In the search for Truth, it is far more profitable to diligently study things as we find them, than to dally with *postulated* theories.

Certainly, a treatise on Motive Power of Heat by an Author who does not tolerate postulation will prove to be a distinct novelty, and should also prove to be a boon to all ambitious students of the science.

The particular branch of the science of thermodynamics which treats of the motive power of heat, as it is universally taught at the present time, is not based on known fact regarding the ways of Nature, but upon knowledge of what such ways must be in order to signify avoidance of the *supposed* absurdity which means that heat of environment may be utilized as a source of motive power, although the idea of such utility is not known to conflict with any *established* principle or law of Nature; but, nevertheless, the founders of the science *arbitrarily* adjudged that idea to be absurd and consequently inadmissible. That is to say, the science as taught is not exposition of that which Nature is actually *known* to do in the matter, but is nothing more than exposition of that which Nature is *supposed* to do by reason of *supposed* necessity of avoiding that *supposed* absurdity, and is expressed by the *postulated* generalization which is known as Carnot's principle and is also known as the second law of thermodynamics.

In his original treatise, Carnot *accurately* contended that the principle that "something cannot be created from nothing," as it applied to the then generally accepted but now obsolete conception of the *nature* of heat, necessarily caused the idea of utilizing heat of environment as a source of motive power to be nothing more than a proposal to create something from nothing; that is to say, a direct confliction with the principle which is now known as "conservation of energy." Whereas, the revised or present-day conception of the *nature* of heat necessarily destroyed that contention;

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but nevertheless, *unfortunately*, the idea of utilizing heat from that limitless and all-pervading source yet retains the same old name—"Perpetual Motion of the Second Kind."

The retention of this *misnomer* which implies actual establishment of absurdity is probably the principal cause which has contributed to the remarkable longevity of Carnot's fallacious principle; however, it does not *satisfactorily* explain why, during so many years, the professional teachers of the science have ignored the vast importance of the subject, and failed to recognize a real obligation to scrutinize its entire history. Lack of acumen and expertness in the use of mathematics by the expounders of the science may be safely accepted as the true explanation of this deplorable condition.

A sparse edition of Sadi Carnot's treatise was published in the year 1824, and he suddenly died in the year 1832; whereas, after much time had elapsed, and not until the year 1872 arrived, a later edition was published (Gauthier-Villars, Paris, 1872; translation, John Wiley and Sons, New York, 1890, 1897); comprising also the *initial* publishment of his subsequently made notes and memoranda regarding the significance of the substitution of the then new or present-day conception of the *nature* of heat to replace the obsolete conception upon which he had founded his principle.

Those posthumously published notes and memoranda proved to be an important contribution to the history of the science; not only because therein Carnot accurately described the sole basic principle of Physical Science which was subsequently and independently promulgated by Joule, and Meyer, and is known as the principle of conservation of energy; but also because those notes show that Carnot was *first* to perceive that the revised or present-day conception of the *nature* of heat necessarily invalidated the principle which he had created and already promulgated by manner of publishment in his treatise and is now commonly known as the second law of thermodynamics. In fact, in those notes, Carnot actually repudiated that so-called second law by the following statement:

> "When a hypothesis no longer suffices to explain phenomena, it should be abandoned. This is the case with the hypothesis which regards caloric as matter, as

a subtile fluid. . . . . But it would be difficult to explain why, in the development of motive power by heat, a cold body is necessary; why, in consuming the heat of a warm body, motion cannot be produced."

By reason of this and other statements which are comprised in those notes, Carnot certainly freed himself from responsibility for present-day acceptance of his principle. In fact, he was preparing to publish a revised treatise, and prosecute certain definitely outlined experimentations.

Whereas, about the year 1849, with much adulation and necessarily without knowledge of Carnot's changed stand in the matter, Rudolph Clausius, and William Thomson (Lord Kelvin), who may be considered as chiefly responsible for present-day acceptance of Carnot's principle and the significance which it necessarily entails, resurrected from oblivion Carnot's original treatise; and by reason of the changed conception of the *nature* of heat, they knew and admitted that Carnot's principle no longer constituted a mandate of the principle of conservation of energy, but they regarded it as a *distinct* and independent principle and accepted it as a *true* generalization because the significance which would result from its rejection seemed to them to constitute an absurdity.

By reason of actual perishment of that much-questioned *postulate*, the foundation underlying the entire science has crumbled. Therefore, this brief treatise is purposed as the beginning of the new which will replace the now fallen structure, and to be studied mostly by scholars who already have become versed in the repudiated exposition of the science. In order to avoid prolixity, definitions, explanation of concepts, and well-known deductions which are not affected by the second law question and necessarily hold over and are true by reason of accurate derivation from true definite premise, are not reproduced herein.

From reliable statistics regarding the rapidly increasing rate of consumption of fuel, and geological surveys regarding the world's available store thereof, we know that, at a not far-distant day, that store will become exhausted to a degree which will cause humanity to become sorely distressed unless a *convenient* substitute is discovered and applied; also, it is quite possible that at an early day such substitute might prove to be a realization

of much value. Therefore, immediate encouragement by every possible manner should obtain for sanely conducted and accurate scientific investigation of the ways of Nature which relate to the solution of the problem of utilizing heat of environment as a substitute for fuel.

<div align="right">J. T. W.</div>

MILWAUKEE, 1919

PART 1

GENERAL SURVEY

GENERAL SURVEY

"Something cannot be created from nothing, nor vice versa."

This is the fundamental *axiom* which governs Physical Existence as we find it. Furthermore, necessarily it imposes that: "Conservation of Equivalence" *must* be the *sole* basic principle of *all* branches of Physical Science.

Since heat is a manner of potential motive power that is *transmutable* into work, and vice versa; necessarily, as relates to the science of thermodynamics, "conservation of equivalence" means conservation of the work value of heat. This, in a somewhat more generic sense, is known as the principle of "conservation of energy," because work is *transmutable* also into kinetic energy, and vice versa. Therefore, quite properly, heat is believed to be a manner of motion. All of which necessarily means conservation of the work value of motion.

Thus, it is shown that the true quantitative measure or value of heat is its mechanical equivalent; whereas, temperature is its qualitative measure or measure of its intensiveness; consequently, those two distinct measures are inseparable. Therefore, as relates to any heat carrier or host, the idea of complete elimination of contained heat therefrom necessarily means also complete elimination of temperature.

Unfortunately for the cause of advancement of science, false conception of what constitutes *absurdity* has contributed greatly to the birth and longevity of *postulated* deterrent doctrines.

Since *true* absurdity may be defined as confliction with *known fact;* necessarily, when confliction cannot be proved, it becomes presumed absurdity and nothing more than a mere matter of personal opinion devoid of substantial foundation. Therefore, invocation of *unproved* absurdity should have no place in science. Nevertheless, such pernicious practice underlies the entire science of thermodynamics as it is universally taught at the present time.

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In the year 1824, Sadi Carnot originated the *postulated* so-called "second law of thermodynamics" by formulating it as the require ment which Nature must comply with in order to defeat realization of the *presumedly absurd* proposition which means utilizing heat of environment as a source of motive power. This proposition is now known by the *misnomer*, "The Perpetual Motion of the Second Kind."

Carnot *accurately* explained that realization of that kind of so-called perpetual motion means the effect of combined action of two distinct heat engines, one acting as a heat pump driven by the other acting as a heat motor; furthermore, that the motor must be operated by a working substance that is more efficient as a medium for converting heat into work than the working substance which is used in the pump to produce a reversed effect.

He was skeptical regarding the then prevalent belief that heat (caloric) is an indestructible corporeal something, but, nevertheless, he founded his treatise upon that conception of the *nature* of heat, and he *accurately* explained that it necessarily imposes that realization of second-kind perpetual motion simply means creation of something from nothing and consequently relegates the idea of such realization to the limbo of chimeras. However, with the exception of that particular deduction and its significance, his entire treatise is free from involvement of the question of the true *nature* of heat.

Whereas, Rudolph Clausius, and others who subsequently became responsible for the present-day state of the science admitted that the *revised* conception of the *nature* of heat necessarily imposes that second-kind perpetual motion does *not* conflict with the principle of conservation of energy, nor with any other *known* fact. Nevertheless, they arbitrarily adjudged the idea of its realization to be *absurd* and, therefore, inadmissible; that is, they based their adjudgment of absurdity upon nothing more substantial than mere personal opinion devoid of proof.

Carnot's formulation of the aforementioned requirement that Nature must comply with in order to defeat realization of that presumed absurdity has never been improved upon, simply because it is accurate, concise, and does not involve the question of the true *nature* of heat. He expressed it thus:

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"The motive power of heat is *independent* of the agents employed to realize it; its quantity is fixed *solely* by the temperatures of the bodies between which is effected, finally, the transfer of the caloric."

In present-day parlance of the science, and in accord with Carnot's explanation of that declaration, it may be stated thus:

"The work that is obtainable from a given quantity of heat by means of a cycle that operates adiabatically between two temperatures is *independent* of the working medium, and is dependent *solely* upon those temperatures."

That is to say, dependent not only upon the amount or extent of cyclic temperature-drop but also upon the degree of temperature whereat such drop obtains; because Carnot stated that the work value of such a cycle corresponding to a given measure of temperature-drop and the transference of a given measure of heat from an external source of supply is not constant but depends upon the degree of temperature whereat such transference is effected.

The work value of such a cycle which operates between a unit measure of temperature-drop, and represents an *aggregate* dropment of a unit measure of heat through a unit measure of temperature, is known as the "efficiency rate"; because, when these units of measure are arbitrarily made sufficiently minute, the Calculus imposes that the work value of that cycle represents the *rate* at which temperature-drop *converts* a unit measure of heat into work *at the particular state of the working medium* which represents the mean or middle state of the working medium's physical domain which is comprised within that cycle. Necessarily, this mean state obtains at a point which is located on the line which represents the mean or middle temperature of the cycle, and midway thereon with respect to transference of heat between the adiabatic lines which represent the limits of the cycle.

Carnot's principle which is known as the second law of thermodynamics necessarily imposes that the "efficiency rate" must be independent of the working medium and must functionate as a *sole* function of its corresponding temperature; that is to say, it imposes that for *all* kinds and states of working media, a common value for the "efficiency rate" must obtain *anywhere* on a line or

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route of constant temperature at a common degree or measure of temperature. In fact, Carnot accurately perceived that this mathematically expressed condition respecting this rate is the particular exaction which Nature must comply with in order to defeat the supposedly absurd second-kind perpetual motion proposition; and he stated that he knew that this rate is a decreasing function of its corresponding temperature, but that by reason of lack of *sufficient* knowledge regarding the physical properties of *any* one substance he was unable to arrive at an exact formulation of its functional relation to temperature. The "efficiency rate" as thus defined by Carnot is sometimes called "Carnot's Function."

Whereas, subsequently, Clausius took hold of this matter; and by selecting a so-called "perfect-gas" which is a substance that may be accepted as a negligible departure from a real existing thing, and by co-ordinating the principle of conservation of energy with the physical properties of a perfect-gas, he was enabled by manner of mathematical deduction to accurately arrive at a simple evaluate of its "efficiency rate"; furthermore, this evaluate proved to be independent of everything except temperature. To this limited extent, that is, as it applies *only* to perfect-gases, Clausius thus actually verified Carnot's principle; however, as applies to other kinds of substances, he *balked* at a further and more general investigation of this matter and *unwarrantably* accepted Carnot's principle by accepting this mandate of a perfect-gas as representing *all* kinds and states of substances. This *unwarranted* acceptance constitutes the false premise upon which he reared his mathematics of motive power of heat.

A perfect-gas may be defined as a gas that possesses the following peculiar characteristics:

1. Amenableness to Boyle's law.

2. Amenableness to Gay Lussac's supplement to Boyle's law.

3. Maintenance of constant *rate* of change of contained heat, reckoned with respect to corresponding variation of temperature, and for all change of temperature routes.

4. Amenableness to Dalton's law of common coefficient of expansion.

It will be perceived that co-ordination of these four characteristics necessarily imposes that amenableness thereto means also:

Common "coefficient of pressure," common "coefficient of $(p \times v)$," and common "coefficient of contained heat," all reckoned with respect to corresponding variation of temperature; and, furthermore, that these four distinct coefficients functionate as equivalents, that is, all four have a common measure or value at a common degree of temperature.

From these peculiar characteristics, Clausius *accurately* deduced that, *so far as relates to a perfect-gas*, the "efficiency rate" is evaluated by the "coefficient of expansion," and that in turn the "coefficient of expansion" is evaluated by the reciprocal of the corresponding temperature as measured in the absolute sense by a perfect-gas thermometer.

Temperature, as thus measured, necessarily means measured relatively with respect to the degree of cold whereat *all* perfect-gas thermometers would simultaneously become devoid of contained heat *if* they maintained the so-called perfect-gas state *all of the way to that end*. Whereas, we know that such maintenance to that end is not upheld by Nature. Nevertheless, Clausius *presumed* that Nature does maintain that state to that end.

In addition to this *presumption* which is distinctly his own *postulate*, Clausius invoked also the *postulated* Carnot principle, in order to uphold his contention that the aforementioned simple evaluate of the "efficiency rate" *always* holds true not only for all perfect-gases, but also for all thermodynamic working media.

Upon arrival at this stage of his deductive procedure, he presumed or postulated somewhat further, and to the effect that *all* substances are capable of functionating as thermodynamic working media. This further postulation is essential to uphold his further contention that:

"*All* substances have a common definitely located *absolute* zero of temperature."

That is to say, by reason of obtainment of a common "efficiency rate" at *any* common degree of temperature, *all* substances simultaneously become devoid of temperature and consequently also devoid of contained heat upon arrival at a certain *fixed* degree of cold which he named "Absolute Zero of Temperature," and that its location reckoned relatively with respect to a given

temperature is fixed by the corresponding "coefficient of expansion" which obtains for *any* perfect-gas at that given temperature.

Upon this deduction which was thus derived from those *three* distinct *postulates*, he based his well-known concept which he named entropy and flagrantly promulgated it as a true *generalization* upon which was reared much sensational significance that proved to be a pernicious deterrent to the advancement of science, and also upon which was reared much of the science of thermodynamics as it is universally taught at the present time.

Since the Clausius evaluate of the "efficiency rate" does not hold true for all substances, nor for all states of any one substance, necessarily it results that his concept which he named entropy does not hold true as the unchangeable measure of adiabatic difference. Consequently, the various kinds of entropy charts, et cetera, are accurate only so far as they relate to extreme degree of rarefaction (this matter is explained hereinafter).

Clausius accurately perceived that all perfect-gas thermometers should be identical with respect to the location thereon of their so-called absolute zero reckoned relatively with respect to some fixed degree of temperature such as that of melting ice at a fixed degree of pressure, and that this requirement imposes that all so-called perfect-gases must be amenable to the Dalton law of common "coefficient of expansion."

Carnot knew that irreversibleness causes inefficiency in the process of converting heat into work, and that consequently it operates as a contributing agent to defeat realization of perpetual motion of the second kind. He also perceived that it must be treated as a *controllable* condition, and in that way he carefully provided for it in his formulated principle by restricting the scope of the principle to the limitations of a reversible cycle.

The *postulated* Carnot principle has been invoked by various subsequent writers to enable arrival at various deductions which they have promulgated as particular ways of expressing the so-called second law of thermodynamics. Also, various writers have arrived at various deductions founded on irreversibleness, and have promulgated them under the same guise. In this way, the basic idea as formulated by Carnot has been somewhat obscured.

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Thus, it is shown that the *generic* conception of the so-called second law of thermodynamics is simply mere denial of possibility of creating perpetual motion of the second kind, not only in the practical sense, but also theoretically; and also it is shown that Carnot's formulation is simply a concise statement of what that denial demands from Nature.

All of which shows that, by reason of acceptance of the premise that heat is an *indestructible* corporeal infiltrating entity, Carnot *accurately* contended that he was justified in ignoring the distinctive characteristics of working media, and that he *warrantably* reared his principle upon that premise; whereas, subsequent destruction or rejection of that premise necessarily destroyed his contention and relegated his principle to the limbo of *postulates*. Moreover, they who accepted his principle and are responsible for the present-day deplorable state of the science simply accepted that *postulate* because its rejection seemed to them to be absurd, and they based their adjudgment of absurdity upon nothing more substantial than mere personal opinion devoid of proof; that is to say, they failed to comprehend the true meaning of absurdity.

Furthermore, they believed that the so-called second *basic* law of thermodynamics is distinct and *independent* of the other basic principle which is known as "conservation of energy." Whereas, although these two principles do not directly conflict with each other, nevertheless, they are incongruent because the principle of conservation of energy enables an accurate revelation of the *limitations* of Carnot's principle; that is to say, revelation of exactly *how far* Nature upholds that doctrine; that is to say, enables destruction of the contention that Carnot's principle is a true generalization; that is to say, destruction of the contention that Carnot's principle holds true for *all* kinds and states of working media. In fact, the applicableness of Carnot's principle proves to be *very much* restricted (this matter is explained hereinafter).

As an interesting item of history of science, it may be mentioned here that the late Henri Poincaré, throughout his writings, frequently expressed dissatisfaction with the "second law," and in one instance thus:

> "The second law of thermodynamics does not seem to be compatible with the first law."

It seems that the manner by which he arrived at this conclusion has never been disclosed.

Moreover, as a mere philosopheme, it may be safely stated that every *true* law or principle of physical science necessarily is relatively specific to, and dependent to *some* extent upon, a more generic conception. That is to say, there cannot be a plurality of *basic* laws.

Therefore, the Author has purposed this brief treatise not only as an accurate exposition of the *true* rationale of the motive power of heat, but incidentally also to show precisely how the *postulated* Carnot principle *conflicts* not only with certain facts that are revealed by the principle of conservation of energy, but conflicts also with experimentally revealed facts.

It may be stated here that the proof of that confliction is arrived at herein simply by accurately deriving from the principle of conservation of energy the true evaluate of the "efficiency rate," *generic* so far as it applies to all thermodynamic media and reckoned with respect to temperature variation for reversible cyclic conversion of heat into work, and comparing this evaluate with that which Clausius accurately derived from the *postulated* Carnot principle. The comparison shows that the Clausius evaluate is fallacious as a generalization, but does hold true for all working media that are identified with certain definite characteristics and that those characteristics obtain only at the extreme limits of rarefaction; that is to say, obtain only whereat the so-called perfect-gas state obtains.

Unfortunately for the cause of advancement of the science of thermodynamics, it is common practice for teachers of the science to cite to inquisitive pupils various published tables and charts of the physical properties of the several elastic fluids which are usually used in thermodynamical operations, they are cited for the purpose of proving by manner of quantitative analysis the futility of questioning the so-called second law. Whereas, it seems that comparatively few teachers of the science are aware of the questionable origin of some of the published tabulated values which must be used in that manner of settlement of the question. It is a fact that, by reason of inconvenience, such questionable values were not derived by manner of actual experimentation but were derived by manner of co-ordination of tabulated values of other

concepts with the so-called second law; that is to say, they guilelessly invoke and apply that so-called law to the purpose of upholding itself. Certainly, this is a unique condition that confronts inquisitive students in search of truth.

Also, unfortunately, with regard to this question of validity it is a common assertion which has been handed down through several generations of teachers that, by reason of *numerous* verifications, the so-called second law must be accepted as true. Whereas, verifications, by manner other than that which has just been described, or with working media or procedures other than those which are identified with extreme limits of the physical domain, are rare and unreliable.

Also, it may be mentioned that, unfortunately, by reason of Carnot's sudden and untimely death, he failed to publish his doubts and changed views regarding the validity of the principle which he had created. His changed conception of the matter resulted from his rejection of the old, and acceptance of the present-day conception of the *nature* of heat. His original manuscripts are preserved in the archives of the French Academy of Science, and verbatim extract therefrom comprising this information was published at a comparatively recent date.

PART 2

MATHEMATICAL

SYMBOLS

m = Mass.

H = The external store of heat.

$h = \dfrac{H}{m}$.

I = The internal store of heat, also called "contained heat."

$i = \dfrac{I}{m}$.

E = The internal store of non-vibratory motional energy.

p = As it applies to a solid substance, means expansive push or pressure, or contractive pull, as the case may be. As it applies to a fluid substance, it means pressure per unit of surface.

V = As it applies to a solid substance, means occupied lineal space which p tends to diminish, or enlarge, as the case may be. As it applies to a fluid substance, it means occupied volume.

$v = \dfrac{V}{m}$.

t = Temperature.

W = External work, $= \int p \times dV$.

$(W.c.)$ = External work produced by a cycle.

$(W.r.c.)$ = External work produced by a reversible cycle.

Δ = Signifies variation.

d = Signifies differential variation.

In the mathematical formulations, the Author has adopted the modernized Euler bracket and subscript system for *specifically* indicating *constancy* of the subscribed entities; and thereby eliminates all ambiguity, particularly as relates to that branch of the Calculus which treats of partial differential coefficients.

In the parlance of the Differential Calculus, "differential coefficient" means the *rate* of variation of the dependent variable,

reckoned with respect to the corresponding variation of the independent variable. Whereas, throughout this treatise and in accord with common practice, the sole word "coefficient" is used to denote that which may be described as; the differential coefficient, ratioed by the corresponding measure or value of the dependent variable; that is to say, it represents only so much of the differential coefficient as obtains per unit of the dependent variable's corresponding measure or value, and it is called the coefficient of that which the dependent variable denotes. This use of the word applies to the concepts which are called "coefficient of expansion," "coefficient of pressure," "coefficient of $(p \times v)$," "coefficient of contained heat," and the like.

Herein, it is understood that all entities and procedures are reckoned in the algebraic sense; that is to say, reckoned as having positive, or negative nature, as the case may be. This applies to the meaning of the words, work, pressure, accretion, et cetera.

THERMOMETRY AND ORIGIN OF THE SCIENCE

Devoid of conception of conservation of anything, the science of thermodynamics began as a study of the physical properties of the non-saturated or so-called superheated state of elastic fluids; and temperature was reckoned in the relative sense, and measured as proportionate to its expansive effect upon a thermometric gas (air) maintained at constant pressure.

As pertains to gases only, the earliest formulation of functional correlation originated from Boyle. His conception of the matter is known as Boyle's law and may be expressed in a mathematical way thus:

$$(p \times v)_t = \text{a constant}, \dots\dots\dots\dots\dots (a)$$

It will be perceived that this means that $(p \times v)$ functionates as a *sole* function of t with all significance which this feature implies, but that the functional relation is not completely defined. However, subsequently, Gay Lussac supposedly defined the functional relation in the complete sense, and the full or ultimate significance of his conception of the matter is known as the Boyle–Gay Lussac law, and as applies to a *thermometric* gas may be expressed thus:

$$\text{Constant rate} = \frac{d(p \times v)}{dt}$$
$$= \frac{\Delta(p \times v)}{\Delta t}$$
$$= \frac{(p \times v) \doteq 0}{t}, \dots\dots\dots\dots\dots (b)$$

This does not mean that this constant rate has a common measure or value for all Boyle–Gay Lussac gases, nor does it mean that the constant value which does obtain is such as to signify a common value for temperature as reckoned in the so-called absolute sense. Consequently it results that mere amenableness to the Boyle–Gay Lussac law by various thermometric gases is *not sufficient* to determine whether they effect identical measurement of temperature when reckoned in the absolute sense; that is to say, not sufficient to determine whether, at a certain fixed degree

of cold, *all* such gases simultaneously become devoid of measure or value for the concept which is expressed by $(p \times v)$, and consequently also devoid of temperature and contained heat. However, subsequently, Dalton by his principle of common coefficient of expansion defined the functional relation which remedies this deficiency; and the full or ultimate significance of his principle is known as the Boyle–Gay Lussac–Dalton law, and as applied to thermometric gases, may be expressed thus:

> **All perfect-gas thermometers are amenable to the Boyle–Gay Lussac law and at common temperature have a common "coefficient of expansion" (reckoned with respect to variation to temperature).**

By reason of co-ordination with the Boyle–Gay Lussac law, such "coefficient of expansion" may be mathematically expressed and progressively evaluated thus:

Common "coefficient of expansion" for *all* perfect-gases

$$
\begin{cases}
= \left(\dfrac{dv}{dt}\right)_{p} \Big/ v = \left(p \times \left(\dfrac{dv}{dt}\right)_{p}\right) \Big/ (p \times v) \\[2ex]
= \left(\dfrac{d(p \times v)}{dt}\right) \Big/ (p \times v)
\end{cases}
$$

$$
= \left(\dfrac{\Delta(p \times v)}{\Delta t}\right) \Big/ (p \times v)
$$

$$
= \left(\dfrac{(p \times v)}{t}\right) \Big/ (p \times v) = \frac{1}{t}, \ \dots\dots\ (c)
$$

Although by a somewhat different manner of procedure, Clausius was first to arrive at the final evaluate of this equation (c), and also first to perceive its significance; that is to say, perceive that, for all thermometric gases that are amenable to the Boyle–Gay Lussac–Dalton law, a common location on their respective scales of temperature obtains for the so-called absolute zero; that is, the degree of cold whereat *all* of such thermometric gases would simultaneously become devoid of temperature and contained heat *if* they maintained amenableness to that law *all of the way to that end.*

In addition to the erroneous and preposterous *assumption* that Nature actually maintains such amenableness all of the way to

that end, Clausius invoked Carnot's principle to uphold his contention that that zero on a Boyle–Gay Lussac–Dalton gas thermometer necessarily must also represent the degree of cold whereat *all* thermodynamic working media simultaneously become devoid of contained heat; because he knew that the coefficient of expansion of a Boyle–Gay Lussac–Dalton gas evaluates the reciprocal of its corresponding so-called absolute measure of temperature, *and also evaluates its "efficiency rate,"* and that Carnot's principle means, and distinctly states, that a common "efficiency rate" must obtain for *all* thermodynamic working media at common temperature. Upon arrival at this stage of his deduction, it became necessary to assume that all substances can functionate as thermodynamic working media, in order to further contend that that zero represents also the degree of cold whereat *all* matter simultaneously becomes devoid of temperature and contained heat.

Upon that same premise, William Thomson (Lord Kelvin) based his contention that that so-called absolute scale of temperature is independent of all substances and consequently might with propriety be called the "thermodynamic scale"; whereas, it really is, and should be called, the "imaginary perfect-gas scale."

As a proper sequence to all of this Clausius and Thomson contention regarding an absolute scale of temperature, Andrews, Amagat, and others have experimentally established the fact that neither the Boyle, nor the Gay Lussac law, is a true *generalization* for gaseous fluids; that is to say, they do not hold true for all states in which a gas may exist.

Thus, it is shown that the exactions from Nature which are imposed by these contentions of Clausius and Thomson are not forthcoming, and that consequently the location of their so-called absolute zero of temperature is not an ordinance of Nature, but is merely an *imaginary* condition and means the degree of cold whereat a *perfect-gas* would become devoid of contained heat and cease to occupy space *if* its so-called perfect state *would exist all of the way to that end*. Whereas, we know as an indisputable fact that that state vanishes with progression into low temperature.

Moreover, it is quite probable that contained heat remains *ever present* to some extent in *all real* substances, regardless of the degree of cold which may obtain. This assertion is upheld by

present-day knowledge obtained by manner of experimentation, and to the effect that the value or measure of the concept which is known as "specific heat," as it applies to solid matter, *diminishes very rapidly* with progression into low temperature.

However, Clausius' so-called absolute scale of temperature serves a useful purpose as a means for simplifying mathematical formulations relating to the substances which with negligible error may be considered as perfect-gases. Moreover, as a *standard* thermometric medium, a Boyle–Gay Lussac–Dalton gas is an ideal substance so long as it maintains amenableness to that law.

Thus, the absolute temperature question is disposed of.

THERMODYNAMIC MEDIUM AND THERMO-DYNAMIC STATE

With the purpose of precisely defining the limitations to generalization which govern the mathematical deductions that are presented hereinafter it may be stated that, as relates solely to the motive power of heat, and in contradistinction to the dynamics of all other kinds of vibratory and mysterious motions, such as sound, light, chemism, electricity, magnetism, et cetera, a *thermodynamic* medium or substance may be defined as and is herein understood to be a substance that functionates as a medium for effecting intermutation of nothing other than heat, external work, and internal or contained non-vibratory motional energy; that is to say, heat is the *only* manner of vibratory or mysterious motional energy which is involved. With negligible error this characteristic holds true for all elastic fluids, and for nearly all other substances that may be utilized as working media for operating heat engines.

Whereas, the thermodynamic state of a substance may be defined as so much of its actual state as is represented by the particular variable elemental components of state which functionally co-operate to make it a thermodynamic medium.

From experience we have learned the simple fact that the following correlation obtains for the functional components of thermodynamic state:

$$\left[\frac{I}{m}, \text{ and } \frac{V}{m},\right] \text{ are functions of } [t, \text{ and } p,],\dots\dots\dots(1)$$

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That is:

$$[i, \text{ and } v,] \text{ are functions of } [t, \text{ and } p,], \ldots \ldots \ldots \ldots (2)$$

This manner of formulation is intended not only to designate the four distinct functional variable components of thermodynamic state, but also to express that they are related in the peculiar manner which means that *any* two of them when not related as *sole* functions of each other may functionate as independent variables which determine the remaining two which functionate as dependent variables.

In a functional system wherein a *plurality* of *dependent* functional variables obtain; necessarily, so long as such dependent variables functionate in that particular capacity, they are dependent *only* upon the group of independent functional variables. This necessarily means that the group of independent functional variables added to *only one* dependent variable are *sufficient* to constitute a *complete* group of interdependent variable components of the system.

Therefore, any two of the four functional variable components of thermodynamic state, when not related as *sole* functions of each other, are sufficient to determine that state.

It will be perceived that expansive pressure is the intensity of the expansive influence of contained heat, that it is a factor in the measurement of external work, and that it can be measured directly and in the absolute sense. However, as relates to certain ways of operating solid matter as a working medium, pressure must be reckoned as a negative or pulling force and likewise can be measured directly and in the absolute sense.

Whereas, temperature is the intensity of the communicative proclivity of contained heat, and cannot be measured directly because such proclivity is a manifestation of preponderance, and consequently it is measured indirectly and in a relative way by manner of its corresponding arbitrarily standardized effect upon an arbitrarily standardized substance, and reckoned relatively with respect to an arbitrarily standardized fixed state of that substance. Moreover, temperature is not involved in the measurement of external work, and consequently it is foreign to the principle of conservation of energy.

CHANGE OF STATE OF A THERMODYNAMIC
MEDIUM

Therefore, necessarily, the principle of conservation of energy imposes the following generalization for change of state of a thermodynamic medium:

$$-\Delta H - \Delta I = \Delta E + W = \Delta E + \int p \times dV, \ldots \ldots \ldots (3)$$

Equation (3) means that, for that kind of substance, expansive change of state creates two distinct effects which, together, result as the equivalent of corresponding vanished heat. That is, a portion of such transmuted heat applies to the creation of external work, and the remainder applies to the creation of internal non-vibratory motional energy. Necessarily, expansive change of state obtains only when the internal pressure preponderates over the external pressure.

As relates to expansive change of state of an elastic fluid, by reason of so-called frictional resistance which is also called viscous shear, such internal motion ultimately subsides with corresponding reconversion into heat; but this subsidence of motion obtains at *less* degree of pressure than that at which the motion was created, therefore the procedure simply effects vanishment of some heat at a degree of pressure and restores it at a *lesser* pressure, and necessarily means dissipation or sacrifice of some pressure-drop opportunity to transmute heat into external work. The quantity of heat which thus vanishes and is subsequently restored at lesser pressure quite properly might be called "*freely* degraded heat" or "*freely* degraded energy."

Moreover, as relates to an elastic fluid, when the external pressure preponderates over the internal pressure, contractive change of state obtains with corresponding conversion of a portion of the externally applied work into heat, and corresponding conversion of the remainder into non-vibratory motional energy within the fluid by reason of contractive movement. Such internal motion ultimately subsides with corresponding reconversion into heat, but this subsidence of motion obtains at a *greater* degree of pressure than that at which the motion was created; therefore, the procedure ultimately converts *all* of the externally applied

work into heat, but some of such heat is created at a *greater* degree of internal pressure than that which obtained when its corresponding external work equivalent was expended in creating the fluid motion. Quite properly, the heat which is thus created by manner of fluid friction might be called "*freely* up-graded heat" or "*freely* up-graded energy."

Procedure which is actuated by pressure preponderance necessarily is irreversible so long as such preponderance does not reverse; whereas, procedure which results as functional readjustment of respective measures of unlike components of state necessarily is reversible. Therefore, the irreversible activity of change of state represents the impelling cause, and the reversible activity represents the functional readjustment between unlike components of state to maintain the functional correlation which is *fixed* by Nature. This explains why irreversibleness *always* obtains for change of state, and that the degree of actuative preponderance is an increasing function of the speed of the procedure.

Therefore, as relates to an elastic fluid, it will be perceived that, for volumetric change of state, sacrifice or dissipation of some pressure-drop opportunity is controllable, and that such loss of opportunity is *compensated* by corresponding contribution to the *speed* of the procedure.

Whereas, temperature is the intensity of a distinct manner of proclivity and does not functionate as an impellant in volumetric change of state. However, preponderance of a host's temperature with respect to that of another host represents the actuating force which *transfers* or imparts heat from one to the other, and the degree of such temperature preponderance is an increasing function of the speed of this particular procedure; therefore, such procedure is irreversible so long as the preponderance does not reverse, and the speed of the procedure is the compensate for corresponding sacrifice or loss of some *pressure-drop value* of temperature during transition of the heat to its new abode.

All of which merely exemplifies the generalization which means that speed of conversional procedure is the compensate for corresponding sacrifice of conversional opportunity as reckoned in the quantitative sense.

REVERSIBLE CHANGE OF STATE OF A THERMO-DYNAMIC MEDIUM

Although in the strict sense, reversible change of state of a thermodynamic medium is an impossible procedure, nevertheless, as the reversible portion of the activity of change of state, it may be treated as a distinct procedure by applying the following criterion which necessarily means elimination of the procedure of converting heat into irreversible activity:

$$\Delta E = 0, \dots\dots\dots\dots\dots\dots\dots\dots (4)$$

By equating this value in equation (3), there results:

$$W = \int p \times dV = -\Delta H - \Delta I, \dots\dots\dots\dots (5)$$

IRREVERSIBLE CHANGE OF STATE OF A THERMO-DYNAMIC MEDIUM

By like manner, irreversible change of state of a thermodynamic medium may be treated as a distinct procedure by applying the following criterion which necessarily means elimination of the procedure of converting heat into external work, or vice versa:

$$W = \int p \times dV = 0, \dots\dots\dots\dots\dots (6)$$

By equating this value in equation (3), there results:

$$\Delta E = -\Delta H - \Delta I, \dots\dots\dots\dots\dots (7)$$

When this condition obtains for expansional change of state of an elastic fluid, it is called "free expansion"; that is, as relates to a thermodynamic medium of this kind, the vanished heat applies to the sole purpose of creating non-vibratory motional energy within the host.

However, by use of the device which is known as the turbine engine, translational fluid motion created in this way may to a very considerable extent be converted into external work, and the heat and other kinds of vibratory motions which are created by fluid friction and other manners during the procedure, and the

kinetic energy or work value of the non-vibratory motions which the fluid retains after passing through the turbine, represents inefficiency of the procedure as a process for converting heat into work. However, since these defects are controllable to a very considerable extent, conversion of heat into external work by this manner of procedure has proved to be comparatively efficient when the turbine engine is properly constructed and operated under favorable conditions.

VAGARIES OF TEMPERATURE

Since free expansion means elimination of external resistance to expansive change of state, creation of motion of a thermodynamic fluid by manner of free expansion, but without aid of work or energy to or from an external source and subsequent reconversion of that motion into internally contained heat but at lessened pressure and with consequent change of temperature, is a convenient procedure by which to experimentally determine the vagaries of temperature corresponding to unchanged measure of contained heat because it is a simple exemplification of the principle of conservation of energy. The temperature change which results from such procedure is the phenomenon which is known as the "Joule effect"; although at an earlier date he had promulgated as a principle that was widely published that, for all thermodynamic fluids, such temperature change is nil.

As relates to thermodynamic media, the concept which is known as "internal work" and is also called "disgregation work" may be defined as the accretion of contained heat corresponding to expansional change of state at constant temperature. Necessarily, such accretion must be reckoned in the positive or negative sense as the case may be. Moreover, this concept applies in a componental way for change of state on any expansional route, because a succession of minute changes alternately at constant volume and constant temperature may represent change of state along such route. Necessarily, "internal work" is merely a consequence of the "Joule effect," and vice versa; that is to say, one is a consequence of the other.

Whereas, as relates to thermodynamic media, "latent heat" is the concept which may be defined as the heat equivalent of the

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algebraic sum of "external work" and "internal work" corresponding to change of state at constant temperature.

The concept which is known as the "inversion line" relates only to thermodynamic fluids and originated from Amagat and means the locus of the points whereat lines of constant $(p \times v)$, and constant t, become identical; that is to say, the locus of the points whereat Boyle's law holds true, it does not necessarily mean that also Gay Lussac's supplement to Boyle's law holds true for *all* locations thereon. However, it is quite probable that transition along that line toward the extreme limits of rarefaction means gradual approach to the state whereat that supplement does hold true. Moreover, it is quite probable that, at the extreme limits of rarefaction, also Dalton's law of common coefficient of expansion holds true.

Amagat's "inversion line" does not necessarily represent the locus of the points whereat the "Joule effect" reverses its nature in the positive-negative sense. Necessarily, the locus of the points whereat that reversal obtains represents also whereat so-called "internal or disgregation work" reverses its nature in the positive-negative sense; that is to say, the locus of the points whereat lines of constant I, and of constant t become identical. Moreover, transition along this line toward the extreme limits of rarefaction necessarily means gradual approach to the perfect-gas state and consequently whereat the Joule proclivity becomes extinct, that is to say, arrival at the region in the physical domain whereat the proclivity to create "internal work" and its consequence which is manifest as the "Joule effect" becomes extinct.

Certainly, an experimental investigation of these unsettled matters regarding the vagaries of temperature will prove to be an interesting contribution to the science.

CYCLIC PROCEDURE OF A THERMODYNAMIC MEDIUM

Since, at the end or closure of a cycle, the working fluid returns to its initial state, necessarily, the following criterion must apply to all cycles:

$$\int_{v'}^{v'} dI = O ,\dots\dots\dots\dots\dots\dots(8)$$

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in which V' symbolizes the initial value or measure of V which obtains in the cyclical changing of state. Usually, it is convenient to arbitrarily make the minimum measure the intial measure.

Equation (8) necessarily imposes the principle that, as relates to a thermodynamic medium:

> "At the conclusion of *any* cycle for converting heat into work, the 'contained heat' is conserved, and the work is created at the expense of transferred heat only."

By equating the equation (8) criterion in equation (3), there results:

$$\Delta E + (W.c.) = \Delta E + \int_{V'}^{V'} p \times dV = -\Delta H , \ldots \ldots \ldots (9)$$

in which V' symbolizes the minimum measure of V which obtains in the cyclical changing of state.

REVERSIBLE CYCLIC PROCEDURE OF A THERMO-DYNAMIC MEDIUM

Whereas, by equating in equation (9) the criterion which is expressed by equation (4), there results:

$$(W.r.c.) = \int_{V'}^{V'} p \times dV = \int_{V'}^{V''} (\Delta p)_V \times dV = -\Delta H , \ldots \ldots (10)$$

in which—

$(\Delta p)_V$ symbolizes variation of p at constant V, and to the extent which is comprised within the work area of the cycle at the corresponding measure or value of V;

V' symbolizes the minimum measure of V;

V'' symbolizes the maximum measure of V.

By differentiating with respect to V, equation (10) becomes:

$$d(W.r.c.) = (\Delta p)_V \times dV , \ldots \ldots \ldots \ldots (12)$$

By again differentiating, but with respect to p, equation (12) becomes:

$$d^2 (W.r.c.) = d (\Delta p)_V \times dV , \ldots \ldots \ldots \ldots (13)$$

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CONVERSIONAL EFFICIENCY OF A THERMODYNAMIC MEDIUM

As relates to the motive power of heat, conversional efficiency of a thermodynamic medium pertains to conversion only of heat into external work, or vice versa; and dissipation or sacrifice of such efficiency means *diversion* to another purpose of a *portion* of the functionally imposed *opportunity* to effect such conversion.

As relates to change of state of a thermodynamic medium that converts heat into external work, or vice versa, such dissipation or sacrifice means diversion of some functionally imposed *pressure-drop opportunity* to a purpose other than that of effecting such conversion. From what precedes, it will be perceived that the *only* purpose to which such diversion can obtain is to produce irreversibleness and corresponding speed of procedure.

As relates to a thermodynamic medium, since the degree or intensity of irreversibleness is *controllable,* and is also the sole cause of inefficiency in the process of conversion, necessarily the maximum degree of conversional efficiency ·which is theoretically possible obtains *only* for *reversible* change of state, and is determined by certain physical properties of the working medium. Moreover, such properties are permanent, are *fixed* by Nature, and *are not necessarily identical for all kinds and states* of such working media.

EFFICIENCY OF A REVERSIBLE CYCLE OF A THERMO-DYNAMIC MEDIUM

In the generic sense so far as relates to thermodynamic media, and with the error which the Calculus imposes as negligible when the involved *units* of measurement are arbitrarily made minute, the "efficiency rate" of reversible cyclic conversion of heat into work, as it obtains at a given state of such working substance, and as reckoned with respect to variation of some one particular functional component of thermodynamic state, may be defined as the work created by a reversible cycle comprised between two distinct sets of lines or change of state routes; the lines of one set being similar with respect to constancy of that particular functional component of the working medium's thermodynamic state, and separated to correspond to a unit measure of difference;

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and the lines of the other set being adiabatic, and separated to an extent which corresponds to *transference* of a unit measure of heat on the line or route which is similar to and situated midway between the other two or first mentioned lines. That is to say, the *rate* at which reversible cyclic variation of that particular functional component of the working medium's thermodynamic state creates cyclic work from a unit measure of heat transferred on that intermediate line or route of constancy of that particular component of state, and corresponding to the point or state which is on that line and located midway thereon with respect to transference of heat between these two adiabatic lines.

For the purpose of *generic* formulation of that rate, that is, as it applies without distinction to *any* one of the several functional components of thermodynamic state, and to all thermodynamic media, the letter x may be used to symbolize without distinction *any* one of such components of state. Thereby, the "efficiency rate" in its most generic sense, so far as applies to working substances of that kind, is mathematically expressed thus:

$$\text{"Efficiency rate"} = \frac{d^2\,(W.r.c.)}{dx \times (dH)_x}, \dots\dots\dots\dots\dots\dots (14)$$

By equating in equation (14) the evaluate of equation (13), there results:

$$\text{"Efficiency rate"} = \frac{d^2(W.r.c.)}{dx \times (dH)_x}$$

$$= \frac{d(\Delta p)_V \times dV}{dx \times (dH)_x}$$

$$= \left(\frac{d(\Delta p)}{dx}\right)_V \times \left(\frac{dV}{dH}\right)_x, \dots\dots\dots\dots (15)$$

Since equation (15) evaluates the "efficiency rate" in that degree of generic sense, necessarily the several specific componential cases which apply to all thermodynamic media may be evaluated simply by substituting for x in that equation the particular component of state which applies to the specific case.

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Thereby, it results that for *any* thermodynamic medium:

$$\frac{d^2(W.r.c.)}{dp \times (dH)_p} = \frac{d(\Delta p)_V \times dV}{dp \times (p \times dV + dI)_p} = 1 \Big/ \left(p + \left(\frac{dI}{dV}\right)_p\right), \dots\dots\dots(16)$$

$$\frac{d^2(W.r.c)}{dt \times (dH)_t} = \frac{d(\Delta p)_V \times dV}{dt \times (p \times dV + dI)_t} = \left(\frac{dp}{dt}\right)_V \Big/ \left(p + \left(\frac{dI}{dV}\right)_t\right), \dots\dots(17)$$

$$\frac{d^2(W.r.c.)}{dI \times (dH)_I} = \frac{d(\Delta p)_V \times dV}{dI \times (p \times dV + dI)_I} = \left(\frac{dp}{dI}\right)_V \Big/ p, \dots\dots\dots\dots(18)$$

$$\frac{d^2(W.r.c)}{dV \times (dH)_V} = \frac{d(\Delta p)_V \times dV}{dV \times (p \times dV + dI)_V} = \left(\frac{dp}{dI}\right)_V, \dots\dots\dots\dots\dots(19)$$

It must be kept in mind that equations (16) to (19) inclusive respectively represent distinct componential cases, and that they hold true for *all* thermodynamic working media. Furthermore, they should prove to be interesting, particularly equation (17) because it enables a simple and *unquestionable* exposition of *precisely how* Carnot's principle which is known as the second law of thermodynamics *conflicts* with *known* ways of Nature.

CONFLICTION OF THE DEFUNCT SECOND LAW OF THERMODYNAMICS WITH KNOWN WAYS OF NATURE

It has been shown that the equations (16) to (19) inclusive are directly imposed by the principle of conservation of energy, and it will be perceived that the final evaluate of equation (17) is *not* independent of the physical properties of the working medium, nor is it a *sole* function of temperature. Whereas, it was hereinbefore explained that the *postulated* Carnot principle means and distinctly states that the final evaluate of equation (17) *must be independent* of the working medium, and also *must be a sole function* of temperature.

In fact, as depicted in the symbolic nomenclature which is adopted herein, Carnot mathematically expressed and evaluated the "efficiency rate" thus:

$$\frac{d(W.r.c)}{dt} \times \left(\frac{1}{\Delta H}\right)_t = \text{Function of } t,$$

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Furthermore, Clausius progressed Carnot's evaluate to a *definite* conclusion thus:

$$\frac{d(W.r.c.)}{dt} \times \left(\frac{1}{\Delta H}\right)_t = \text{Function of } t = \frac{1}{T},$$

in which T symbolizes temperature as reckoned in the so-called absolute sense on the "perfect-gas" scale of temperature.

As relates to the various *finite* states of an elastic thermo-dynamic fluid, it is a *well-known* indisputable fact that Amagat and others have experimentally established that:

$$\left[\left(\frac{dp}{dt}\right)_V \Big/ p\right]_t = \left\{ Increasing \text{ function of pressure, } \ldots\ldots(20) \right.$$

This fact is *very* plainly discernable on Amagat's well-known and widely published graphic chart of the physical properties of carbonic acid (CO_2). Moreover, Amagat's "principle of corresponding state" has been experimentally verified with respect to quite a number of fluids, and is believed to be a true generalization that means that that carbonic acid chart is a simple exposition of Nature's ways as they obtain with more or less perspicuity for *all* elastic thermodynamic fluids. That chart is reproduced hereinafter in the Appendix.

Also, it is *well known* that the phenomenon which was hereinbefore described and is known as the "Joule effect" has enabled establishment of the indisputable fact that:

$$\left(\frac{dI}{dV}\right)_t = Decreasing \text{ function of pressure}, \ldots\ldots\ldots(21)$$

It may be mentioned that, as a decreasing function of pressure, this concept which is thus evaluated in equation (21) equates to nil and *reverses its nature* in the positive-negative sense at a degree of pressure that is finite and represents whereat the "Joule effect" likewise reverses its nature.

These particular characteristics that are expressed respectively by equations (20) and (21), when equated and co-ordinated in the final evaluate of equation (17), necessarily cause that equation to impose that, as it applies to locations on a given temperature line,

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that final evaluate is *not* independent of the location or position on that line, but is a function of the pressure which corresponds to the location. Whereas, the *postulated* Carnot principle necessarily means that the evaluate of equation (17) *must* have a *constant* measure or value for *all* locations on a given temperature line, and that also it *must* have a *common* value for *all* thermodynamic working media when they are at a common temperature.

Thus, by simple indisputable manner of qualitative analysis it is proved that the *postulated* Carnot principle is fallacious so far as relates to the finite or accessible regions of the physical domain of an elastic thermodynamic fluid.

Now, the question arises: How about the extremely remote regions of the physical domain of an elastic thermodynamic fluid?

It will be perceived that by equating the concept $\left(\dfrac{dI}{dV}\right)_t$ to nil in equation (17), necessarily there results the evaluate of the "efficiency rate" which applies *only* to the particular states of a thermodynamic medium which are identified by that particular characteristic, whereas, necessarily that particular characteristic obtains only whereat the "Joule effect" becomes nil. Moreover, hereinbefore it was explained that within finite limits of rarefaction, extinction of the "Joule effect" obtains *only* at the line or change of state route which is known as the locus of the points whereat that effect becomes nil by reason of reversal of its nature in the positive-negative sense.

This evolution of the "efficiency rate" may be expressed thus:

$$\frac{d^2(W.r.c.)}{dt \times (dH)_t} = \left(\frac{dp}{dt}\right)_V \bigg/ \left(p + \left(\frac{dI}{dV}\right)_t\right)$$

$$= \left(\frac{dp}{dt}\right)_V \bigg/ (p+O), \ldots\ldots\ldots\ldots (22)$$

The final evaluate of this equation (22) necessarily means that for the particular states of an elastic thermodynamic fluid whereat the "Joule effect" becomes nil, the "efficiency rate" is evaluated by the fluid's corresponding "coefficient of pressure."

Hereinbefore, it was explained that transition along this reversion line of the "Joule effect" toward the state of extreme rare-

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faction corresponds with gradual extinction of ability or proclivity to create that phenomenon, and corresponds also with gradual extinction of variableness of the value or measure of the concept $\left(\dfrac{dp}{dt}\right)_V$ as it applies to a given measure of volume, and corresponds also to gradual acquirement of extreme rarefaction and is the state whereat the "coefficient of pressure" equates to a measure or value that is common to all elastic thermodynamic fluids in that state when at a common degree of temperature.

Therefore, by equating $\left(\dfrac{dp}{dt}\right)_V$ to a constant in equation (22), necessarily there results the evaluate of the "efficiency rate" which applies *only* to the particular class of elastic thermodynamic fluids which is identified by this particular characteristic in addition to the characteristic that $\left(\dfrac{dI}{dV}\right)_t$ equates to nil. That is to say, there results the evaluate of the "efficiency rate" which applies *only* to *all* thermodynamic gases that are in the state of extreme rarefaction. This further evolution of the "efficiency rate" may be expressed thus:

$$\frac{d^2(W.r.c.)}{dt \times (dH)_t} = \left(\frac{dp}{dt}\right)_V \Big/ (p+O) = \left(\frac{\Delta p}{\Delta t}\right)_V \Big/ (p+O)$$

$$= \frac{p \pm O}{T} \Big/ (p+O) = \frac{1}{T}, \dots\dots\dots\dots (23)$$

in which T symbolizes temperature as reckoned in the so-called absolute sense on the "perfect-gas" scale of temperature.

Since the final evaluate of this equation (23) is a *sole* function of temperature, and is common to all working media that are comprised in the particular class to which it appertains, necessarily it means that *all* thermodynamic gases at an extreme degree of rarefaction are the *only* working media that are amenable to the postulated Carnot principle.

Thus, it is shown that, by equating in equation (17) certain criterions that are known to apply only to the state of extreme rarefaction, equation (23) is derived directly from equation (17) which is a mandate of the principle of conservation of energy.

Moreover, the final evaluate of equation (23) is *precisely* the same as that which Clausius *accurately* derived from the hereinbefore described laws which are peculiar to all so-called "perfect-gases." Consequently, a mutual verification of accuracy of deduction is effected.

Upon arrival at a *true* evaluate of the "efficiency rate" which is known to obtain with negligible error for a certain *actual* working medium, Clausius then *accurately* contended that the postulated Carnot principle necessarily imposes that that evaluate must also hold true for *all actual* working media. Whereas, it has just been shown exactly *how far Nature upholds* that evaluate.

It may be remarked that the most interesting feature of this manner of effecting a refutation of the second law of thermodynamics is that it involves *only* a *qualitative* analysis of functional correlation, and that consequently the deductive procedure is indisputable by reason of freedom from the necessity of considering questions regarding accuracy of experimentations because quite naturally such questions would arise and be involved in a quantitative analysis.

Also, it may be mentioned here that, after having accepted the *postulated* Carnot principle as a true generalization, and without knowledge of Clausius' researches, William Thomson (Lord Kelvin) attempted to *measure* the "efficiency rate" at various degrees of temperature and thereby enable arrival at an *empirical* formulation of its functional relation to temperature. For this purpose, he invoked the experimentations of Regnault and others pertaining to the thermal properties of saturated steam. Subsesequently, he learned of Clausius' pronouncements, and quite naturally his results failed to agree with Clausius' simple deduction. However, he attributed the discrepancy to inaccuracies that were incidental to the experimentations, and he accepted Clausius' evaluate because he knew that it was *accurately* derived from the functional characteristics of a particular substance (perfect-gas) which is believed to exist in an extremely approximate sense. Like Clausius, he did not attempt nor intend to question the validity of the *postulated* Carnot principle, but was interested only in arriving at a definite fixed *universal* schedule of "efficiency rate" values corresponding to a scale of temperature *solely*.

Thus, it is shown that Clausius excelled Thomson in mathematical acumen, because his method of analysis involved only a *qualitative* consideration of accepted principles; whereas, Thomson attempted to arrive at the same end by manner of disputable values or measures derived from experimentations. Consequently, he was unable to question the Clausius pronouncements, and was convinced that necessarily he was compelled to accept them.

CONCLUSION

Moreover, it is shown *how* the *postulated* Carnot principle *plainly* conflicts not only with certain facts that are revealed by the principle of conservation of energy but also with experimentally revealed facts, and exposes the preposterousness of the exactions which that now defunct dogma imposed on Nature.

APPENDIX

This is an exact reproduction of a diagram of isothermals relating to carbon dioxide, made by Amagat and is the result of actual experimentation. (See *Annales de Chimie et de Physique*, b* Serie, t. xxix. 1893. Translation by Professor Barus of Brown University; Harper and Bros. Publishers, New York, 1899.)
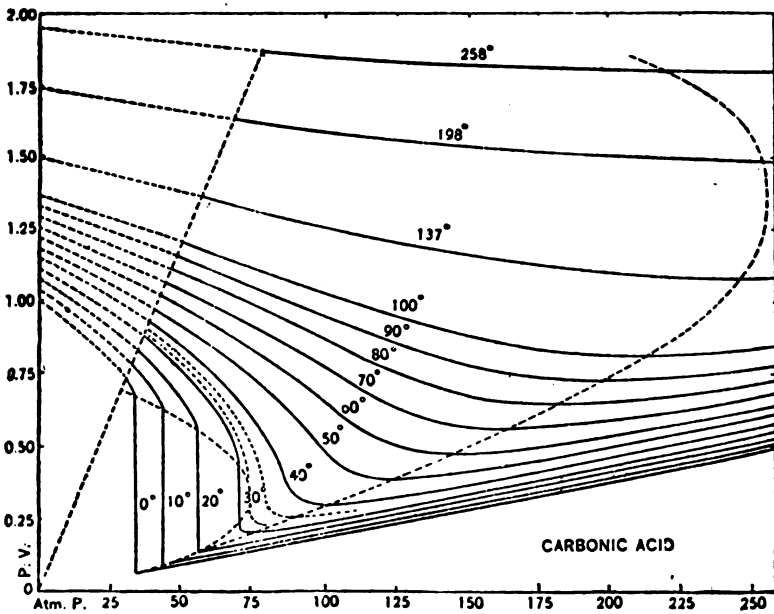
The abscissas represent the pressures in atmospheres; while the ordinates represent the corresponding values of the product resulting from multiplying the pressure by the corresponding volume, otherwise designated as $(p \times v)$.