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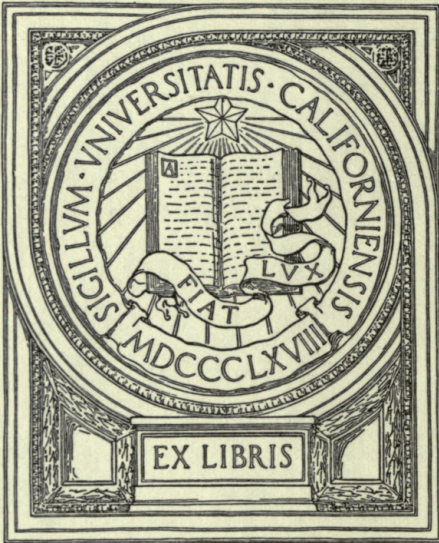
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IN MEMORIAM
George Davidson
1825-1911



Professor of Geography
University of California

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THE FALLACY

OF THE

SECOND LAW OF THERMODYNAMICS

AND THE

Feasibility of Transmuting Terrestrial Heat Into Available Energy

An addendum to essay on
"Means for Transmuting Terrestrial Heat
into Available Energy"

Read July 2, 1902, at the Pittsburg Meeting of the "Physical Section"
of the American Association for the Advancement of Science.

BY
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1902

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PREFACE.

It is hoped that the most exacting critic will appreciate that the writer has herein succeeded in presenting this comparatively unexplored subject in a simple manner free from all questions of quantitative analysis and unknown and doubtful matter.

ABSTRACT.

In order to prove the feasibility of utilizing common omnipresent terrestrial heat as a substitute for fuel, it has been necessary to establish three new and important truths or advancements in the Science of Thermodynamics :—

FIRST:—Refutation, or destruction of the Second Law of Thermodynamics.

SECOND:—Establishment of a new Thermodynamic principle.

THIRD :—Applying this new principle, so as to dispense with the external refrigerating medium which has heretofore been indispensable to the operation of all motive power heat engines.

THE FALLACY

OF THE

Second Law of Thermodynamics

AND THE

Feasibility of Transmuting Terrestrial
Heat Into Available Energy

The Second Law of Thermodynamics was promulgated by Sadi Carnot, in the year 1824. Was mathematically *established* by Professors Clausius and Thompson (Lord Kelvin), independently by each, respectively in the years 1850 and 1851, on the same *peculiar* foundation (on laws which are now obsolete) and at a date when the laws of Boyle, Gay-Lussac, and Watt were considered *sufficiently* accurate and applicable to *all* fluids within *practical* limits of temperature and pressure. And both investigators were *particular* to explain that the mathematical treatment and conclusions therefrom were based upon this *assumption*, which was only approximately correct at best, and applied only to limits of pressure and temperature that were then considered practicable; (Memoirs by Carnot, Clausius, and Thompson) (Translation by Professor Magie, of Princeton University; Harper & Bros., Publishers, New York, 1899).

Subsequently (in the year 1881), Professor Amagat demonstrated that the laws of Boyle and Gay-Lussac are *very far* from being true when the fluid's condition is near the *critical-point*. Also, recent progress in the art of liquefying gases at low temperatures has demonstrated that *practical* limits of temperature and pressure have *increased* to such an extent that the critical-point of many gases is readily attained. Consequently the Boyle and Gay-Lussac law must be abandoned, and Amagat's principle must be substituted. Thus the Thompson and Clausius *assumption* is no longer applicable, and their demonstration is destroyed.

Amagat's demonstration of the impotency of the Boyle and Gay-Lussac law has been universally accepted, but the effect of his demonstration upon the *establishment* of the Second Law of Thermodynamics has not before been observed.

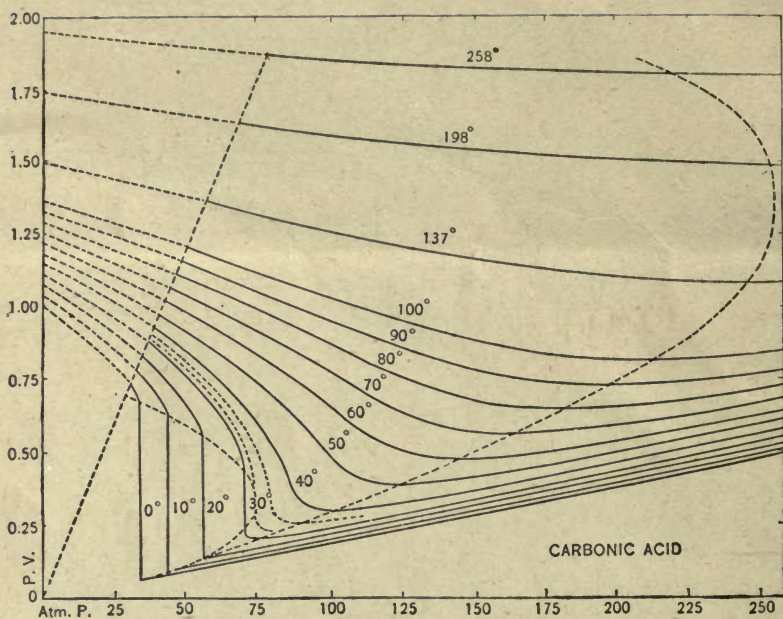


Fig. 6.

Figure 6 is an exact reproduction of a diagram of isothermals relating to carbon-dioxide, made by Amagat (*Annales de Chimie et de Physique*, 6e Série, t. xxix. 1893) (Translation by Professor Barus, of Brown University; Harper & Bros. publishers, New York, 1899) and is the result of actual research. 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 *pv*.

The lowest isothermal shown by Amagat corresponds to the temperature of zero (274 degrees absolute) on the Centigrade-thermometer. Above the critical-pressure, and within the limits of his diagram, this isothermal is practically a straight line which, if prolonged, passes through the origin of ordinates. This shows that, within these limits of pressure, this particular isothermal has *constant volume* for all degrees of pressure. Consequently, at or near this particular *finite* temperature, and within these limits of pressure, this particular fluid (carbon-dioxide) becomes *absolutely* incompressible or inert, as regards the influence of pressure alone. Thus, this *important* phenomenon is placed beyond dispute.

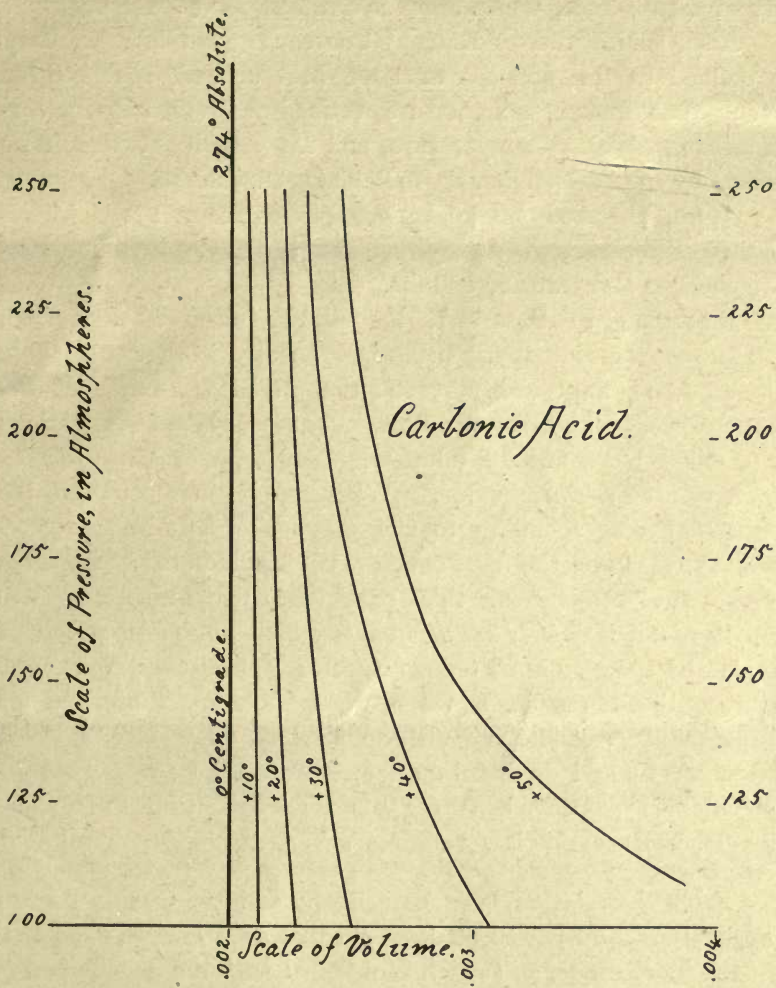


Fig. 7.

This phenomenon does not result as an erratic change in the condition of the fluid, but is the result of a series of gradual and well known changes. For the purpose of showing this matter in a more familiar way, I have constructed the diagram of isothermals shown by Figure 7, from matter shown in Figure 6. In Figure 7, the ordinates represent the pressures in atmospheres, while the abscissas represent the corresponding volumes.

The Second Law of Thermodynamics has been defined in many different ways; all of which are merely mathematical deductions from the fundamental law which defines, "Difference of

Entropy between any two Isodiabatics" as a particular thermal property of a substance, which *remains constant for all temperatures*.

Also, "Difference of Entropy between two Isodiabatics" may be defined as the quantity of latent-heat or heat absorbed (or given up) at constant temperature, ratioed or divided by the corresponding absolute-temperature, and comprised between limits defined by the two particular isodiabatics considered.

Again, thermodynamic changes or lines are said to be isodiabatic to each other, when they are identical as regards temperature changes and transfer of heat.

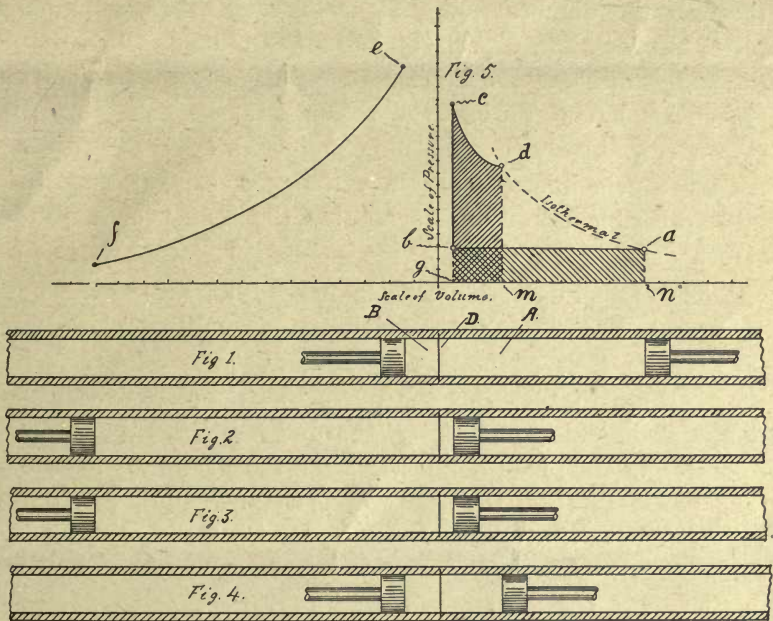
Referring to Figure 7, it will be observed that such "Difference of Entropy," measured on any isothermal whose temperature is appreciably greater than 274 degrees of absolute-temperature, will consist of a finite quantity of latent heat ratioed or divided by a finite absolute-temperature, and consequently there results a *finite* value. Whereas, if measured on the isothermal corresponding to 274 degrees of absolute-temperature; by reason of the *incompressible* or inert condition acquired by the fluid at or near this particular temperature, it will consist of an *infinitely small* quantity of latent-heat ratioed or divided by the *very finite* temperature of 274 degrees, and consequently there results a value which is *zero*. Thus, in a simple manner; free from all questions of quantitative analysis, and unknown and doubtful matter; the Second Law of Thermodynamics is disproved, as regards its application to carbon-dioxide, because this law requires one finite value for all temperatures.

From the relation between Entropy and the Second Law of Thermodynamics, it will be observed that such law does not permit the inert condition (which is identical with the disappearance of that property by which latent-heat can be developed), until the fluid has been cooled to an extent corresponding to *zero* of absolute-temperature. Whereas, Amagat, by his research work on other gases, has conclusively demonstrated that the properties of carbon-dioxide are typical for all fluids. Consequently, all gases become inert at some *finite* absolute-temperature, and therefore the Second Law of Thermodynamics is fallacious for *all* fluids.

After having disposed of the Second Law of Thermodynamics, my next object is to establish the principle that it is possible, in a *perfect* thermodynamic engine, to change or transform the pressure condition or tension of the working fluid; without trans-

ferring heat to, or from an external medium; without transferring dynamic energy to, or from an external source; and without resulting a changed temperature.

My principle indirectly conflicts with the Second Law of Thermodynamics, as will appear hereinafter.



Figures 1, 2, 3, and 4 show successive operations of an *ideal* type of transforming engine.

A and B are insulated cylinders; each closed by its respective piston; and separated, one from the other by the diaphragm D capable of a perfect conduction of heat.

The cylinder A contains the gas to be treated or transformed as regards its tension, the gas in the cylinder B is merely a working fluid. By reason of the diaphragm D, these separated gases always have a common temperature.

Figure 5 is a Clapeyron diagram showing the successive operations in the respective cylinders.

Figure 1 shows the beginning of the operation. Starting with the gas in the cylinder A, in the condition at *a* on the diagram; and with the gas in the cylinder B, in the condition shown at *e*; each gas having the same temperature but differing as regards pressure and density.

The first operation consists in densifying the gas in cylinder A, through a falling range of temperature; and at constant pressure somewhat above, or at the critical pressure; until the *inert* condition is reached. At the same time, the gas in cylinder B is expanded at a sufficient rate to maintain the above mentioned constant pressure in cylinder A by reason of a transfer of heat through the diaphragm D. Figure 2 shows the position of the pistons at the close of this operation, and the points *b* and *f* on the diagram show the respective condition of these separated gases after having thus passed through the series of conditions shown respectively by the lines *a-b* and *e-f*. By reason of Amagat's principle, the gas in cylinder A has now acquired an incompressible condition, as regards the influence of pressure alone.

The second operation consists in applying an increased pressure on the fluid in cylinder A, while the condition of the gas in the cylinder B is maintained without change. Figure 3 shows the unchanged position of the pistons at the close of this operation, and the points *c* and *f* on the diagram show the respective condition of the separated gases after the gas in cylinder A has thus passed through the series of conditions shown by the line *b-c*, while the condition of the gas in cylinder B remains unchanged.

The third operation consists in densifying the gas in the cylinder B, through a series of conditions *exactly* the reverse of that by which it was expanded; at the same time, the gas in cylinder A is expanded through a range of increasing temperatures and a series of pressures suited to maintain the gas in cylinder B through its return series of conditions, or in other words, expanded on the line *c-d* which is isodiabatic to the line *a-b*. Figure 4 shows the position of the pistons at the close of this operation, and the points *d* and *e* on the diagram show the respective condition of the separated gases after having thus passed through the series of conditions shown respectively by the lines *c-d* and *f-e*.

These three operations cause the transformation of the gas in cylinder A, from the condition of tension shown at *a*, to the increased tension shown at *d*; also cause both gases to return to their initial condition as regards temperature. Whereas, the gas in cylinder B is caused to depart from and return to its initial

condition in all respects; depart and return through one range or path of conditions; and consequently without a transfer of heat through the diaphragm D, in an aggregate sense, or in other words, the heat transferred from cylinder A is returned to it again.

Since this change has been effected by a return to the initial condition of temperature, and *without* an aggregate transfer of heat through the diaphragm D; it necessarily results that, in an aggregate sense, neither heat nor dynamic energy has been transferred to, or from *either* cylinder.

The isothermal $a-d$ can be chosen at sufficient temperature to insure that, within the limits of the diagram, it is *practically* governed by the law of Boyle and Gay-Lussac. In such case, the return of the treated gas to its initial temperature means a return to its initial condition as regards conserved energy; and consequently, in order not to conflict with the First law of Thermodynamics, the area $a-b-g-n$ which represents the external work accompanying the compression, must be equal to the area $c-d-m-g$ which represents the external work accompanying the expansion; from which it results that, the point d must be at a higher pressure than the point a .

After having demonstrated the truth of my principle, my next object is to show how such principle can be applied as a means for dispensing with a refrigerating medium, in the operation of a perfect heat engine.

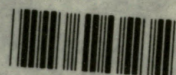
Again referring to Figures 1 to 5 inclusive; a modification of the apparatus may readily be conceived, by which the transformed fluid at the condition corresponding with the point d , may be transferred to another cylinder capable of effecting an isothermal-expansion from the condition at d to the condition at a by means of heat received from an external source, and then returning the fluid to the transforming engine to there be transformed to its initial condition at d in the manner just described.

Such operation constitutes a cycle which may be successively repeated. And it will be observed that; such cycle absorbs heat from an external source, at a constant temperature; converts *all* of this heat into available dynamic energy; and does not discharge any heat to an external source.

Thus, is presented the long sought feasibility of converting Terrestrial Heat into Available Energy.

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