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Rolf Freitag, 2005-11-21, First Edition

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For the evaluation have been taken into account:
DE 19715754 C1,
Brenig, Wilhelm: Statistische Theorie der Wärme, 3. Aufl. 1992, Pages. 10,11,63-67;
Elementare Materie, Vakuum und Felder. Die Struktur des Vakuums und der Bausteine der Natur. P. A. Dirac, E. Schrödinger, D. H. Greenberger, u. a. Spektrum der Wissenschaft: Verständliche Forschung, 2. Aufl., 1988, S. 73;
Hurlbut, F. C.: Studies of Molecular Scattering at the Solid Surface., In: Journal of Applied Physics, Vol. 28, Nr. 8, 1957, page 844-845;

Description: **Technique for producing temperature differences in gasses by potential fields**

Main Claim: Technique for producing temperature differences in gases, characterized by
- that the gas in the container is so thin that the average mean free path of the gas molecules is not longer than the height of the gas container in the potential field and
- that the ceiling and the floor of the container a so formed that the radiation characteristic of the molecules, which fly from the floor to the ceiling, is not cosine-shaped to the plumb line.

Description

State of the art

[0001] It is known that, due to the second law of thermodynamics, the generation of temperature differences at thermal equilibrium is not possible (Brenig, Wilhelm, Statistische Theorie der Wärme, 3. Aufl. 1992, S. 67). Therefore temperature differences at thermal equilibrium can only be achieved in systems in which the additive separability energy of the subsystems and the logarithms of the distribution functions of the subsystems, thus

the necessary and sufficient assumption of the second law, is not fulfilled (Brenig, Wilhelm, Statistische Theorie der Wärme, 3. Aufl. 1992, S.10,11,63f.).
[0002] An example is the photon gas of the zero point radiation in the gravitational field. For example the earth would have, at thermal equilibrium with a cosmological radiation of exact 0 K, a temperature of $4 \cdot 10^{-40} K$ (Dirac, P. A., Schrödinger , E. u. a., Elementare Materie, Vakuum und Felder, 2. Aufl. 1988, S. 73).

Conceptual formulation

[0003] The underlying problem of this invention is to produce temperature differences in not additive separability systems with gases. These temperature differences can be used technically for heating, cooling or power generation.
[0004] This problem is solved by the tokens of the claim.
[0005] For simplicity in the following as potential field only the homogeneous acceleration field of constant acceleration g is considered, because other cases, e. g. an electron gas in an inhomogeneous E-field, the calculation is analogous. In case of thin monoatomic gases, where the influence of the side walls on the temperature of floor and ceiling are negligible (e. g. without walls and infinite large floor and ceiling) it is incidental that the equilibrium temperature of the thermal isolated ceiling at height h above the floor at height 0 is, by integration above the phase space of the gas stream in height h:

$$T(gh) = \frac{m \cdot \overline{v^2}}{4 \cdot k} = \frac{m}{4 \cdot k} \int_0^{\pi/2} \int_0^{2\cdot\pi} \int_0^{\infty} v^2 \cdot \varphi_\theta(v, gh)_N \cdot \sin(\theta) \cdot dv d\varphi d\theta \tag{1}$$

with

$$\varphi_\theta(v, gh)_N := \frac{v_0 \cdot \varphi_\theta(v, gh)}{\int_0^{\pi/2} \int_0^{2\cdot\pi} \int_0^{\infty} v_0 \cdot \varphi_\theta(v, gh) \cdot \sin(\theta) dv d\varphi d\theta} \tag{2}$$

and $v_0 = \sqrt{v^2 + 2 \cdot g \cdot h}$. For an isotropic reflecting floor, then

$$\varphi_\theta(v, gh) = \frac{4}{\sqrt{\pi}} \left(\frac{m}{2 \cdot k \cdot T}\right)^{\frac{3}{2}} \cdot (v^2 + 2 \cdot g \cdot h) \cdot e^{-\frac{(v^2+2\cdot g\cdot h)\cdot m}{2\cdot k\cdot T}} \cdot \Theta\left(v - \sqrt{2 \cdot g \cdot h} \cdot \tan(\theta)\right) \cdot \frac{v}{\sqrt{v^2 + 2 \cdot g \cdot h}} \tag{3}$$

it is incidental that the temperature of the ceiling at height h is:

$$\frac{T}{4} \cdot \frac{3 \cdot \sqrt{m \cdot g \cdot h \cdot k \cdot T \cdot \pi} \cdot erfc\left(\sqrt{\frac{m\cdot g\cdot h}{k\cdot T}}\right) e^{\frac{m\cdot g\cdot h}{k\cdot T}} - 8 \cdot k \cdot T - 2 \cdot m \cdot g \cdot h}{\sqrt{m \cdot g \cdot h \cdot k \cdot T \cdot \pi} \cdot erfc\left(\sqrt{\frac{m\cdot g\cdot h}{k\cdot T}}\right) e^{\frac{m\cdot g\cdot h}{k\cdot T}} - 2 \cdot k \cdot T} - \frac{2 \cdot m \cdot g \cdot h}{4 \cdot k} \tag{4}$$

[0006] (With a cosine like emitting floor it would be only T.) As indicated by own first-principles simulations, the ceiling temperature decreases with decreasing mean free path length, but qualitative there is no change.
[0007] For instance with Xenon and a floor temperature of 293 K the ceiling temperature would be up to 310 K (with an average temperature gradient of roundly 0.02 K/m at g=9.81 m/s^2). By cascading such systems, e. g. for powering a turbine, at the highest ceiling several more 100 K can be achieved (see Fig. 1).
[0008] Because the internal thermal resistor of a chamber of such a system, due to R. Heise, Elementare Einführung in die Kinetische Gastheorie, Leipzig 1963, S. 101, is

$$R_{th} = \frac{\Delta T}{P_{th}} = \frac{1}{3 \cdot A \cdot n \cdot k} \sqrt{\frac{4 \cdot m \cdot \pi}{k \cdot (T + T_D)}} \tag{5}$$

and therefore high, it is advisable to maximize the density. One possibility is e. g. minimizing the height h, where for compensation g has to be increased, e. g. with a gas centrifuge. This also increases the gradient.
[0009] As can be seen at the integral over the phase space (1) it doesn't matter if the floor emits isotropic or if the ceiling is formed so that, in consequence of their geometry, the from the floor not isotropic emitted atoms only that part gets received, which has been emitted isotropic. This is the case e. g. for a sphere above a flat, cosine-like emitting floor, because in this case the (atom-)ray-density is direction independent and because the to the floor projected sphere is always the same, the floor emits to the sphere also in this case isotropic.
[0010] An example of such a floor are harsh surfaces (Journal of Applied Physics, Volume 28, Nr. 8, 1957, P. 844 ff.) because the cosine characteristic is only in consequence of the geometry.
[0011] In phonon as in photon gases the outcome of the relativistic calculation is also a temperature gradient (Dirac, P. A., Schrödinger , E. u. a., Elementare Materie, Vakuum und Felder, 2. Aufl. 1988, S. 73), but it is so small that it can't be used technical even in near future.

Example

[0012] Examples of the invention with monatomic gases are shown in Fig. 1 and 2 and are explained in the following.
[0013] In Fig. 1, a side view cross section, the knudsen gas chambers are stacked on top of each other and lateral thermal isolated (2). The chambers are separated by thermal conductive plates or foils (3). The density of the gas atoms (4) is so low, that the mean free path is longer than the height of a gas chamber and the chamber width is much bigger than the chamber height to have negligible side effects. Because the temperature gradient is the same in the chambers in first approximation and in the sphecial case of isotrop emitting partition walls the temperature difference between the ceiling (1) and the floor (5) is

$N\cdot$((formula 4)-T) (N=number of chambers) at a very low heat flow.

[0014] In Fig. 2, a side view cross section, a sphere (1) is hanging under a ceiling, suspended on a nylon wire. The gas (4) has a mean free path longer than the height of the sphere above the floor (5). The isolation of the chamber, which is much bigger than the sphere, is mirroring reflecting and thermal isolating. So the isolation has no influence to the temperature inside the chamber. At thermal equilibrium the sphere temperature is due to formula 4 higher than the floor temperature. The thermal radiation, which decreases the temperature difference, can be reduced e. g. by gilding all surfaces in the chamber, so that it can be neglected. With a closed cycle cooling system the increased temperature of the sphere can be used outside the chamber.

Patent claims

1. Method for producing temperature differences in gases, characterized in
   - that the gas in the container is so thin that the average mean free path of the gas molecules is not longer than the height of the gas container in the potential field and
   - that the ceiling and the floor of the container a so formed that the radiation characteristic of the molecules, which fly from the floor to the ceiling, is not cosine-shaped to the plumb line.

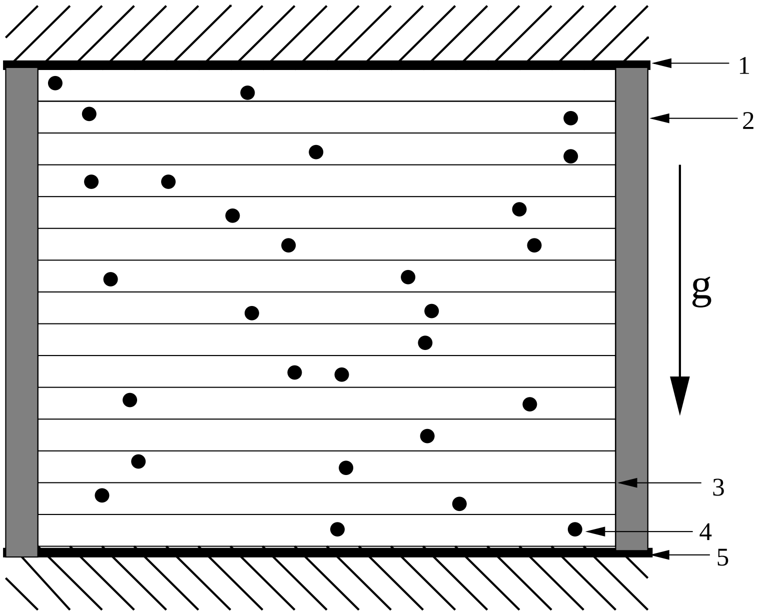

Fig. 1

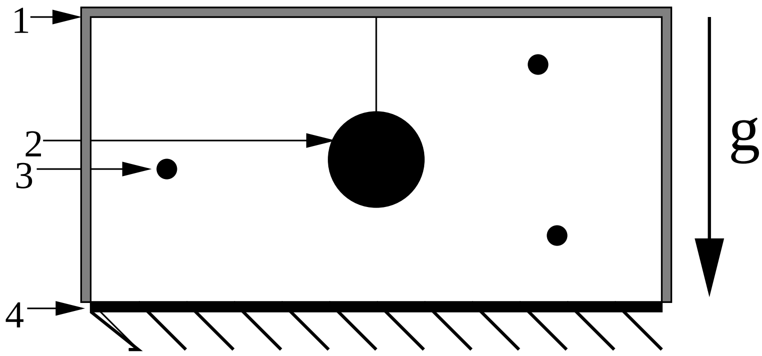

Fig. 2