

# Electrostatic process of a spontaneous flow heat pump

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With the help of Catherine Dolet for the translation.

Note the key words which will allow you to find the site's address in case of change  
or in case you forget:

Heat – Pump – Spontaneous - Flow

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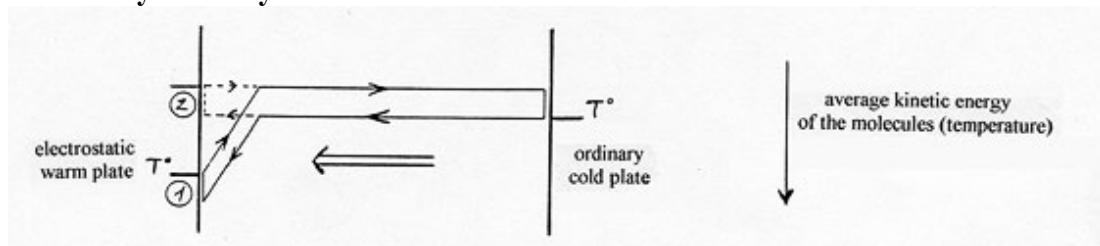
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## SUMMARY

### [Presentation and explanation of the thermodynamic principle \( see page 5\)](#)

It is a new heat-pump process which consists in transferring heat by a gas between two close plates thanks to an electric field created at the surface of the warm plate called “electrostatic” which polarizes and attracts the gas molecules on this plate in order to make them yield energy by thermal accommodation ((1) diagram below). The molecules behave as if they were in contact with a colder plate ((2) diagram below).

### Thermodynamic cycle



[The heat transfer occurs from the ordinary cold plate towards the warm electrostatic plate.](#) (see page 8)

within the limits of a difference of temperature corresponding to the acceleration of the molecules in the attraction field (diagram 5).

[The power of thermal transfer](#) (see page 10)

is determined by the gradient of temperature in the part of the gas which is not submitted to the electric field, that is to say nearly the whole volume of the gas. So we'll adopt the formula giving the heat current by thermal induction in a gas between two plates with two different temperatures, with a modification for the temperature of the electrostatic plate  $T_2'$ .

$$Q = \lambda \frac{T_1 - T_2'}{d + 2g}$$

with  $\lambda$  = thermal conductivity of the gas

$d$  = distance between the plates.

$g = 2.7 \text{ fmp}$  (free mean path of the molecules in the gas).

[Consequently, the rarefaction of the gas doesn't attenuate the power of thermal transfer](#) (see page 10)

compared to a gas being at the atmospheric pressure, as long as the free mean path of the molecules doesn't equal the distance between the plates. With plates distant of 0.1mm, the transfer power is only reduced of 20% for a pressure of  $10^{-2}$  bar, 75% for  $10^{-3}$  bar.

[Explanation of the electrostatic principle.](#) (see page 11)

The attraction of molecules by polarization is known in the phenomenon of electrostriction. It is also at the origin of the formation of rare gas hydrates ( $Ar_n H_2O$ ). In this example, the argon atoms get polarized and are attracted when close from the water molecule dipole.

[The energy of acceleration of a molecule](#) (see page 12)

penetrating in the electric field is given by:

$E_{pol} = \frac{1}{2} \alpha E^2$ . With  $\alpha$  = polarizability of the molecule and  $E$  = electric field.

So it is only the average value of the electric field in contact with the electrostatic plate which determines the acceleration energy of the molecules. A grid gives the acceleration energy of a molecule for a few gas and the corresponding heating.

[Technical description of the electrostatic plate.](#) (see page 13)

In the reference pattern, the electric field is produced in the holes of a grid in contact with the gas. The grid is the positive plate of a condenser and it is kept apart from the cathode by a thin dielectric layer ( diagram 20). The holes dimension is reduced as much as possible to avoid a breakdown in the gas which might occur because of the necessarily very high electric field.

[To get a difference of temperature important enough](#) (see page 15)

between the cold and the warm source, the solution is to proceed by floors, that is to say to superpose the plates like in a millefeuille, the cold plate from a floor becoming the warm plate of the next floor.

[A calculation of the electric power consumed](#) (see page 16)

shows that it is negligible compared to the power of thermal transfer, with allows to expect a very high coefficient of performance ( C.O.P), which cannot be compared to Carnot's.

[Different possible configurations](#) (see page 16)

are examined, the aim being to try to simplify the manufacturing, to reduce the cost, but also to optimize the power and the reliability, especially by trying to eliminate the risk of deterioration of the dielectric linked to the very high electric field.

[The contradiction with Carnot's principle is analyzed.](#) (see page 17)

The absence of necessary work to deliver in the process can be easily explained by the fact that each molecule is accelerated when it arrives on the plate, then slowed down with the same value of energy when it bounces back.  $W_1 - W_2 = 0$ . The electric field doesn't provide the molecules with energy that it cannot recover. The energy is continually given and recovered from the gas molecules when they go to and fro between the plates.

[The applications](#) (see page 21)

are first of all those of the actual heat pump, with an interest highly increased by the high coefficient of performance. Some other specific applications come from this high coefficient of performance, all these inventions coming to graft themselves on the basic process. It would become possible to cool the environment, for instance the water of a stream or a river, to deliver work, for instance electricity ( pages 22 and 23) or to cool sea water to produce both electricity and fresh water ( page 24). It becomes also possible to consider thermoelectric generators which could advantageously replace the actual generators, as well as the generating units and even the batteries for particular use ( page 26).

[Three possibilities of experiment are described.](#) (see page 27)

as well as a preliminary experiment which can be carried out quite easily, to exemplify the variation of temperature in a gas submitted to an acceleration field (pages 35 to 39).

[Some supplementary explanations are introduced](#) for a better assimilation of the thermodynamic principle:

1. [Illustration of the principle with the Joule experiment.](#) (see page 40)
2. [Comparison of the process with a heat pump based on a vacuum diode.](#)  
[The comparison is broadened to the mechanical compression pumps.](#)  
(see page 41)

[Letter to the readers :](#) (see page 43)

An invention on the Internet, why?  
Information about the patents.

[Groups where the PACES is discussed](#) (see french site)

[Foreign equivalent sites](#) (see french site)

## Electrostatic process of a spontaneous flow heat pump.

In a gas submitted to a field of attraction such as gravity, there is a variation of pressure but also of temperature, the gradient of which being parallel to the field of attraction.

So, in the atmosphere, the temperatures cools down as we rise in altitude.

Consequently, if we put two metal plates in thermal contact and in between a thin horizontal layer of gas in which reigns a very dense field of attraction, then a difference of temperature is going to take place between the two plates. The upper plate will yield heat and will get cooler while the lower plate will get warmer by absorbing this heat. The heat will flow spontaneously ( without work) from one plate to the other through the gas by thermal conduction.

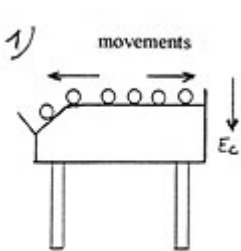
### The thermodynamic principle of the pump.

It consists in transferring heat, through a gas between two plates with different temperatures, from the cold plate towards the warm plate thanks to an electric field created at the surface of the warm plate called “electrostatic” which attracts the gas molecules to make them yield some of their energy by thermal accommodation. By penetrating into the electric field, each molecule is attracted and its kinetic energy increases, which results in an increase of the temperature of the plate in contact with the warm molecules:

The kinetic energy of the molecules  $E_k$  is linked to the temperature  $T$  :

$$E_k = 3/2 KT \text{ ( for a monatomic gas or a rare gas).}$$

A vivid way of imagining this phenomenon is to replace gas molecules by a multitude of billiard balls in motion on a table. This table has a gap on one side (see diagram 1).



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For the imagery to be right, one has to disregard the loss of energy which tends to reduce the motion, such as the slight friction of the balls on the billiard cloth as well as the loss of energy due to the collisions ( the balls get slightly warmer when they collide hence a global loss of kinetic energy after a collision).

One could also note that the average kinetic energy of the balls which hit the left side of the table, at the bottom of the gap, is superior to the average kinetic energy of the balls on the horizontal part of the table.

Each ball that rolls down the gap has its kinetic energy which increases with a value corresponding to the potential energy of the ball falling in the gap. As the average kinetic energy is equivalent to the temperature, the temperature of the balls hitting the left side of the table is superior to the temperature of the balls hitting the right side.

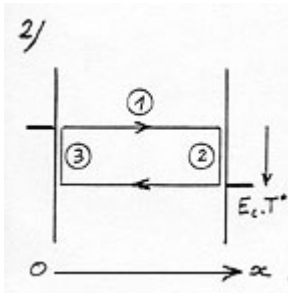
NB: In accordance with this representation, it seemed judicious to me to increase the temperature downwards on all the diagrams. A lower scale on the diagram corresponding to a higher temperature.

The thermal accommodation principle.

Thermal transfer between two ordinary plates with different temperatures.

In order to make the representation simpler, let's imagine two plates close the one from the other with different temperature and some rarefied gas in between so that the molecules can oscillate between the two plates without colliding with other molecules.

Let's first observe one of them when it goes towards the right-hand-side plate (see (1) diagram 2)(The arrowed cycle indicates the direction the molecule follows and its energetic level according to its position on the Ox axis between the plates. A horizontal line shows that the molecule moves with a constant velocity and energy between the plates.)



When it reaches the right hand side plate, which is warmer, the molecule adapts its kinetic energy to the temperature of the plate. It is going to get warmer by bouncing off the surface of the plate with a higher velocity after having drawn energy in the form of heat from the plate (see (2) diagram 2). This phenomenon is known under the name of thermal accommodation (or adaptation).

More precisely, when a molecule at a temperature  $T_i$  hits a surface at a temperature  $T_s$ , there is exchange of energy and the molecule is re-emitted at an intermediate temperature  $T_r$ . A coefficient of accommodation is thus determined, which is the ratio of the average amount of energy effectively exchanged to the energy which could be exchanged if the re-emitted particles reached a perfect thermal equilibrium with the wall.

$$a = \frac{T_r - T_i}{T_s - T_i}$$

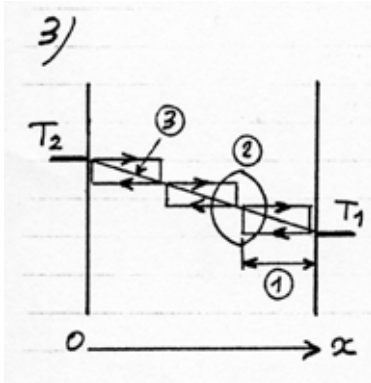
“a” is usually included between 0.4 and 0.85.

The coefficient “a” mainly depends on the nature of the gas. It is high with a gas with a high molecular mass (which is the case with this invention. Ref: Techniques de l'ingénieur B4020).

The opposite effect will occur when in contact with the left plate which is colder as the molecule will bounce off at lower velocity after having yielded energy in the shape of heat to the plate (see (3), diagram 2). This exchange multiplied by the many “round-trips”, since the average velocity of a gas molecule is about 400 to 500 m/s, added to the high density of the molecules contained in a gas, has the effect of progressively leveling the temperature of the two plates.

Influence of the gaseous pressure on the power of heat transfer.

With a pressure (or density) corresponding to an average mean free path superior to the distance between the plates, i.e. a rarefied gas, a slight variation of pressure will produce a variation in the number of those “energy carriers” that are the molecules and consequently a variation of the power of heat transfer.



For a pressure corresponding to an average mean free path (mfp) inferior to the distance between the plates, i.e. a high density gas, some collisions will occur in the gas and this all the more as the density is high ( the mean free path in an argon gas at the atmospheric pressure is 50 nanometers ( $10^{-9}m$ ) or 0.05 micron).

As can be seen on the diagram opposite, those collisions shorten the molecular thermodynamic cycles (1) but they also tend to level the average energy of the molecules after the rebound (2) which diminishes the difference of average kinetic energy on a given

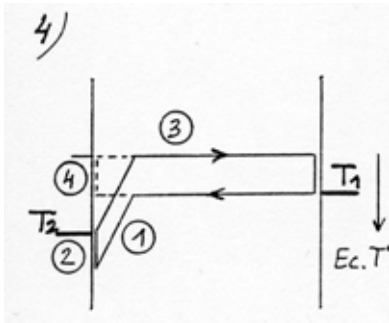
plane between  $O$  and  $x$  in the two moving directions of the molecules. The frequency of the energy exchanged against the walls always increases proportionally to the pressure. But this increase in the frequency is compensated by a decrease of the energy exchanged with each collision. If we take up the imagery of the “energy carriers” again, the number of carriers continually increases with the pressure, but when the free mean path is shorter than the distance between the plates, this increase is compensated by a diminution of their charge, hence a constant discharge of energy. The power of heat transfer doesn’t fluctuate with the pressure anymore, what confirms the following formula:

$$Q = \lambda \frac{T_1 - T_2}{d + 2g}$$

$\lambda$  = Thermal conductivity of the gas ;  $T_1 - T_2$  = temperature of the plates;  $d$  = distance between the two plates;  $g = 2.7$  mfp (mean free path) for the heavy gas.

We can see in this example that the temperature in the gas would vary according to the position on the axis  $Ox$  between the plates, according to a gradient or a thermal slope ((3) diagram 3). The symbolical representation of three cycles mainly means that the temperature of the gas, as in a rarefied gas, is linked to the moving direction of the molecules. But it would be more accurate to represent the temperature according to the moving direction and to draw two lines parallel to the thermal slope because the collisions occur at every level on the axis  $Ox$ . The division into three juxtaposed cycles, suggests that in a high density gas, everything takes place as if there were walls or extremely thin films set parallel to the plates, the mean free path corresponding to the distance between those walls.

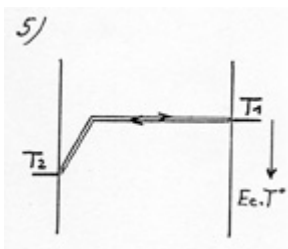
Introduction of an attraction field



To make the demonstration simpler, we'll use the rarefied gas again. Let's suppose that the molecule when coming close to the left plate, called electrostatic, penetrates into an electric attraction field. This will be transcribed on the thermo-energetic graph with a gap ((1) diagram opposite) similar to the billiard table represented before.

This attraction field increases the kinetic energy of the molecule and is going to bring it to a temperature superior to the plate's (with the limits of a difference of temperature between the plates corresponding to the potential energy of the attraction field). By thermal accommodation (or adaptation), it is going to yield energy when in contact with the plate (2) and set off again at a lower velocity. To set off again, the molecule has to "go up" the attraction field and lose as much kinetic energy as it had previously gained by "falling down". The final result stands in a cooling down of the molecule (3), although originally, before penetrating into the attraction field, it was colder than the plate it was about to meet. This cooling down will be identical to the one it would have undergone on an ordinary plate with an identical difference of temperature between the molecule and the plate at the moment of the contact (4).

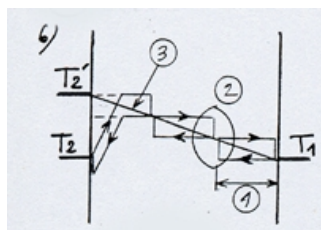
NB: It is now necessary to note that the potential energy of the attraction field only being equivalent to a small fraction of the average kinetic energy of the molecules ( a few dozens of degrees at the most, compared to the ambient temperature which is about 300 Kelvins), it is very unlikely for them to get trapped and they don't need to recover thermal energy on the plate to get out of the attraction field which of course would annihilate the expected effect. This can be compared to a car driving over a pothole. It is only slightly slowed down and doesn't need the power of its engine to get out of it.



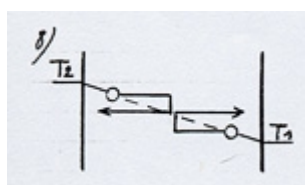
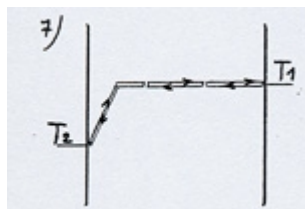
The energetic exchange described before tends to warm up the electrostatic plate and to cool the ordinary plate until the difference of temperature between the plates reaches a value corresponding to the potential energy of the attraction field. The thermodynamic equilibrium is reached when the average energy of the molecule in contact with each plate corresponds to the respective temperature of the plates (see diagram opposite). In this case there is globally no more heat transfer. This situation corresponds to the configuration "billiard table" on which the balls bounce off the walls while preserving their kinetic energy.

With a stronger pressure (or a gas with a higher density) the fundamental principle remains the same, except that the molecules, once out of the attraction field and cooled, take up energy again by means of intermolecular collisions rather than on the cold plate. Out of the attraction field the energetic exchange process remains identical to the one between two

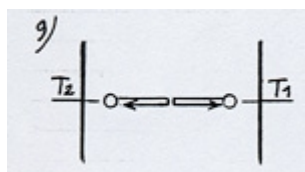




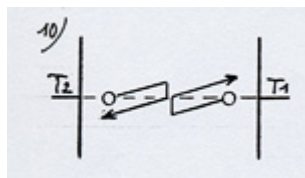
ordinary plates with a temperature varying on the axis Ox according to a gradient or a thermal slope (see (3) on the diagram opposite) which besides determines the power of thermal transfer. So, when the thermal slope in this area is flat, the thermodynamic equilibrium is reached and the transfer power is cancelled (diagram 7). According to this diagram, the gas reigning in the attraction field ( against the electrostatic plate) would be in thermodynamic equilibrium in spite of the variation of temperature and in spite of the intermolecular collisions in this area. To be convinced of this, it is necessary to examine the conditions in which is equilibrium is established. As we have seen on the diagrams 3 and 6 the collisions tend to equalize the average energy of the two directions of motion of the molecules. If one consider, at a given time, the whole lot of molecules being on a plane parallel to the plates, included between O and x, the molecules moving leftward have an average energy higher than those moving rightward. But this difference tends to cancel itself for the molecules which have just collided (diagram 8).



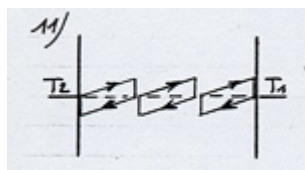
The thermodynamic equilibrium is reached when the molecules have an identical average energy in both directions of motion, that is to say when there is no more global exchange of energy in the collisions. In that case, the whole gas is at a uniform temperature, the average energy of the molecules is the same everywhere (diagram 9).



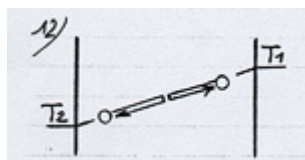
If we now introduce an attraction field, the molecules move with a variable energy and not constant anymore as in the preceding cases ( which is represented by the sloping arrows). In the case which is represented diagram 10, where the temperature is uniform in the gas, the molecules gain or lose energy on their way and consequently, they meet a different energy, hence a global exchange of energy in the collisions. The gas isn't in thermodynamic equilibrium.



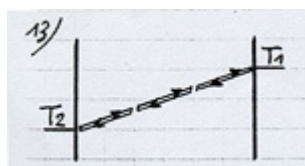
To take up the example of the diagram 3, the thermal exchange between the two plates would happen as is represented on the diagram 11.



The thermodynamic equilibrium is reached when the molecules moving on each side have an identical average energy when the shock occurs. In that case there isn't any global exchange of energy in the collisions anymore, although the temperature isn't uniform in the gas (diagram 12).



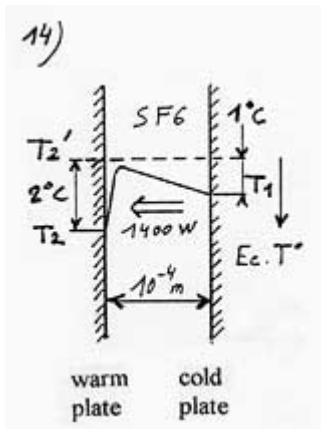
We have a natural example of a gas in thermodynamic equilibrium although its temperature isn't uniform; this gas is the atmosphere in which the temperature and the pressure decrease when we rise in altitude: about 6°C per 1000 m. It is the attraction field of gravity which is at the origin of this variation of temperature and pressure. The masses of air compress and get warmer when they go down or release their pressure and cool down when they go up. The principle of this invention consists in creating a very powerful gravitational field in order to get a sufficient difference of temperature on a very short distance and one can consider that the warm electrostatic plate is the low altitude plate while the cold ordinary plate is the high altitude plate.



Power of thermal transfer

To calculate the power of thermal transfer (heat current) we will use the formula used with two ordinary plates with an adaptation for the temperature of the electrostatic plate. It isn't the real temperature of the electrostatic plate that one must consider but the temperature beyond the attraction field ( $T_2'$ . See diagram 6), which with  $T_1$ , defines the gradient of temperature in the gaseous space which is out of the attraction field.  $T_2'$  is equal to the real temperature of the plate ( $T_2$ ), to which one subtracts the difference of temperature corresponding to the potential energy of the attraction field.

$$Q = \lambda \frac{T_1 - T_2'}{d + 2g}$$



Let's imagine the case of two plates separated of 0.1mm ( $10^{-4}$  m) and an attraction field equivalent to  $2^\circ\text{C}$  ( the example is voluntarily modest to better show the potentiality of this process). In thermal equilibrium, that is to say when the thermal slope is flat, out of the attraction field ( $T_1 - T_2' = 0$ ), the electrostatic plate would be warmer than the ordinary plate of  $2^\circ\text{C}$ . By reducing this gap of  $1^\circ\text{C}$ , one redresses the thermal slope of  $1^\circ\text{C}$  so,  $T_1 - T_2' = 1^\circ\text{C}$

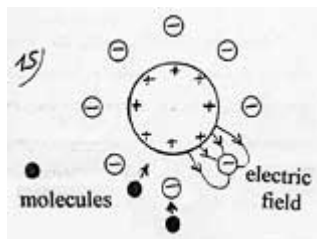
If the gas used is some SF6, the thermal conductivity of which is  $\lambda = 0.14$  w/m.K and if we disregard  $2g$  if  $g$  is small compared to  $d$ , the heat current per square meter would be:

$$Q = \frac{0.14 \times 1^\circ\text{C}}{10^{-4} \text{ m}} = 1400 \text{ Watts,}$$

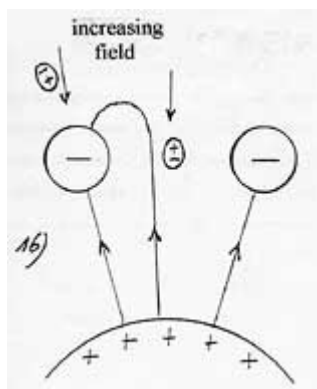
from the cold plate towards the warm plate.

With a distance between the plates of 0.01 mm (10 microns) wich is conceivable, and an attraction field equivalent to  $20^\circ\text{C}$ , we could get  $140 \text{ KW/m}^2$  !

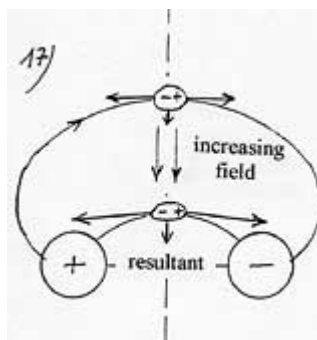
**Electrostatic principle**



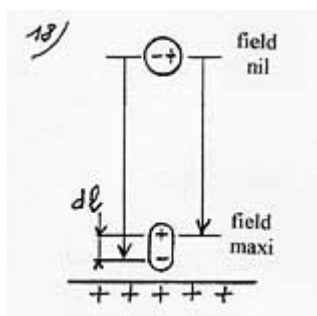
Let's imagine a positively charged metallic bar inside a metal cage connected to the earth, that is to say a Faraday cage. The later neutralizes the electric field out of the cage thanks to the negative charge it carries by influence. If a gas molecule is far from the cage, it doesn't perceive any electric field and nothing happens. But if it gets close enough from the cage, the screen effect disappears and the molecule gets polarized under the effect of the electric field residing between the bar and the cage (see diagram opposite).



In the case it penetrates between two bars of the cage, the electrons of the molecule are attracted and its nucleus repelled. But as the electrons are closer from the bar and consequently in a more intense field than in the nucleus, the attraction of the nucleus wins over the repulsion of the electrons. There again, the molecule is attracted. If we take up again the case of a molecule moving on the symmetry axis of a dipole, that is to say perpendicularly to the electric field ( diagram 17), the nucleus of the molecule is attracted towards the negatively charged bar and the electrons towards the positively charged bar, each one of these forces being led tangentially to the field line. As this line is curved the two opposite attraction forces are thus not parallel. Hence a resultant of forces led towards the increasing field.

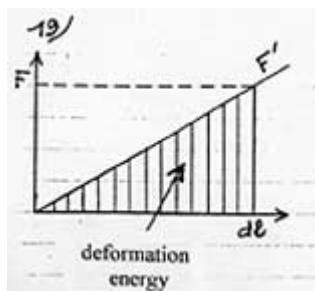


The penetration of a molecule into an electric field has always the effect of attracting it towards the increasing field and this having nothing to do with the motion nor the direction of the field. This phenomenon of attraction by electrostatic polarization of a gas is known under the name of Debye's force, which is for instance at the origin of the formation of rare gas hydrates ( $Ar_n H_2O$ ) with production of heat resulting from the energy of attraction between molecules.



Parameters of the energy of attraction

When a polarizable molecule, such as SF<sub>6</sub>, penetrates into an electric field, it produces a dipole which induces a difference in absolute value of electric potential energy acquired by both charges, positive and negative. This difference of potential energy is the result of the difference dl between the charges (diagram opposite) caused by the electrostatic force F which separates them at this place.



Yet, some of this energy is used to deform the molecule in the same way as energy is needed to set a spring in motion. As the force of deformation  $F'$  varies linearly with  $dl$  (diagram 19), the average force of deformation is thus  $1/2F'$ , and the energy of deformation  $1/2F'.dl$ . Consequently, the remaining energy of  $1/2F'.dl$  is the attraction energy of the molecule on the plate. The polarizability of the molecule is

$$\propto = Q.dl/E \text{ (en Cm/Vm}^{-1}\text{)} \text{ So } Q.dl = \propto.E$$

On the other hand the electrostatic force which separates the charges

$$F = Q.E$$

$$\text{so } F.dl = Q.E.dl = \propto.E^2$$

$$\text{Energy of attraction} = \frac{1}{2} F.dl = \frac{1}{2} \propto .E^2$$

This formula can be found in different books by different authors.

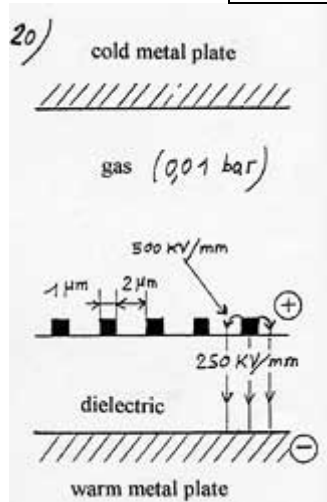
To put it differently the energy of attraction of a polarizable molecule only depends on the value of the electric field at the surface of the plate and this independently of the length of attraction  $L$ , that is to say the thickness of the zone of variable field to cross and also independently of the value of the gradient of the electric field. Indeed, for a same electric field of surface, if one doubles the thickness of the zone of variable field, one doubles the length of attraction  $L$  but at the same time, one reduces of a half the gradient of the electric field and hence, the gravity. Consequently, the attraction work remains identical.

The grid below gives the attraction energy (or attraction work) and the correspondance in heating degrees for a few examples of gas molecules penetrating in a field of  $5 \times 10^8$  V/m ( 500 KV/mm) assessing they come from a zone where the field is nil.

The heating of  $1^\circ\text{C}$  is equal to about  $2.10^{-23}$  Joule per molecule of monatomic gas, that is to say  $3/2K$ , with  $K=1.38 \times 10^{-23}$  Joule. For a polyatomic molecule such as SF6, the translation energy of the molecule now represents the half of its total energy, the other half being rotation-on-itself energy. To estimate correctly the heating of such a molecule, considering that only the translation energy increases when the molecule penetrates the electric field, one would have to divide by two the heating that one would have if it was a monatomic molecule (which only possesses the translation energy).

Gas	Polarizability In Cm/Vm <sup>-1</sup>	Attraction energy with $5 \times 10^8$ V/m	Degrees of heating
Argon	$1.85 \times 10^{-40}$	$2 \times 10^{-23}$ Joules	1 Kelvin
Krypton	$2.96 \times 10^{-40}$	$3.2 \times 10^{-23}$ Joules	1.6 K
Xenon	$4.66 \times 10^{-40}$	$5 \times 10^{-23}$ Joules	2.5 K
SF6	$7.4 \times 10^{-40}$	$8 \times 10^{-23}$ Joules	4/2 K

**Technical description of the electrostatic plate. Reference pattern**



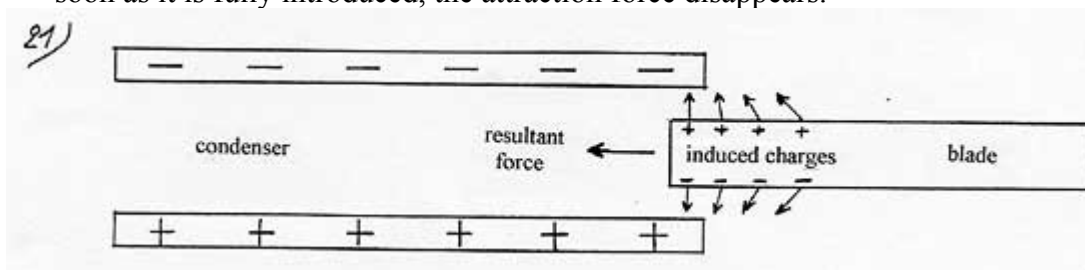
It is a condenser whose plate, charged negatively is made of the metal plate on which is laid a thin dielectric and the grid, in contact with the gas which constitutes the positively charged armature. This grid could be made by engraving holes in a vacuum-packed metal layer, laid on the insulating material. The grid plays the role of the Faraday cage mentioned before in "Electrostatic principle". It allows to generate a high field at the surface of the plate, more precisely in the holes of the grid as well as an insignificant residual field in the whole remaining gaseous space.

Why don't we apply the electric field to the whole gaseous space?

It would avoid the grid. But it is the gradient of the electric field in the space which induces the attraction of the gas molecules. It is between the area where the field is insignificant and the area where the field is high (in the holes of the grid) that they are attracted. In such a zone of variable field, the positive and negative electric charges of the molecular dipole don't exactly undergo the same electrostatic force (attraction or repulsion) since they are not located at the same place. And it is this difference of force between the attraction of a charge and the repulsion of the opposite charge which induces a resultant of force which is strictly speaking the attraction force of the molecule. This force always exerts itself towards the field gradient, that is to say towards the high field and not according to the direction of the electric field.

If we put a gas into a uniform electric field, between a cathode and an anode, the gas molecule wouldn't undergo any attraction force. Yet, each molecule would behave as a dipole because of the electric field which keep the opposite charges apart, but the electric field being uniform, the repulsion force of a charge would compensate exactly the attraction force of the opposite charge.

Here is a very enlightening experiment about this phenomenon. If we introduce a blade into a charged condenser, the blade is attracted into the condenser. The attraction energy comes from the polarization of the blade, that is to say from the induced charge on each surface of the blade when penetrating into the condenser. Those charges exert an attraction in relation to the positive and negative terminal of the condenser such as can be seen on the diagram below. The attraction force of the blade in the condenser is a resultant of all the forces and it persists as long as the blade isn't totally introduced into the condenser. As soon as it is fully introduced, the attraction force disappears.



The principle is the same for a single particle. Such a particle would be attracted when penetrating into the condenser but not afterwards anymore. The attraction force is obvious in the case of the blade because of the very high number of molecules it contains.

#### Dimension of the grid

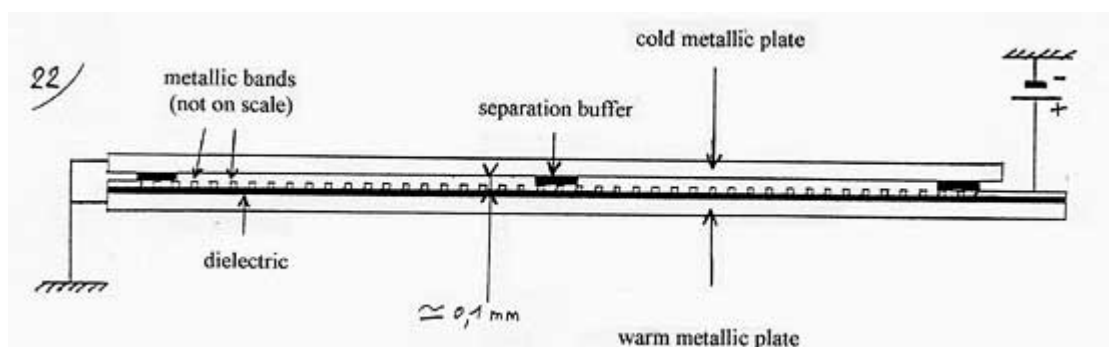
To avoid all risks of a gas breakdown within the zone of high field, that is to say in the holes of the grid, we must reduce to the minimum the size of those holes as well as the thickness of the grid. In the same way, we can only reduce the thickness of the dielectric in proportion to the holes of the grid. Yet, the thinner the dielectric is, the higher its resistance at breakdown (dielectric rigidity) is. The dielectric rigidity of a 5-micron layer of parylene would be satisfying to apply to the required electric field (250 KV/mm). But one may consider that those dimensions mustn't be exceeded.

#### The gas pressure

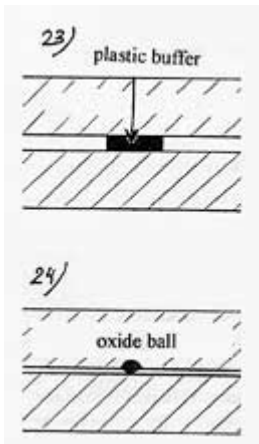
One must see to it that the free mean path of an electron in the gas (without ionization) nearly corresponds to the distance between the plates in order to avoid the multiplication of the electrons which can be emitted by the dielectric surface which could produce a breakdown in the gas. In the case of a distance between the plates of 0.1 mm we would need a minimum vacuum of about 0.01 bar.

#### Value of the electric field and potential

The average value of the electric field on the surface is going to determine the molecules energy of attraction and the heating of the plate. This field is higher in the holes of the grid on the dielectric surface and much less on the horizontal metallic surface of the grid. According to some computer-made calculations, the average value of the electric field on the surface with a plastic dielectric whose  $E_r = 2$ , would be about twice the electric field existing in the dielectric. A field of 250 KV / mm in the dielectric is thus necessary if we want to reach an average field of 500 KV /mm on the surface. With a dielectric thickness of 5 microns, the electric potential would rise to 1.25 KV. For an identical electric field, the necessary potential is all the more lower because the dielectric is thin.



Separation buffers

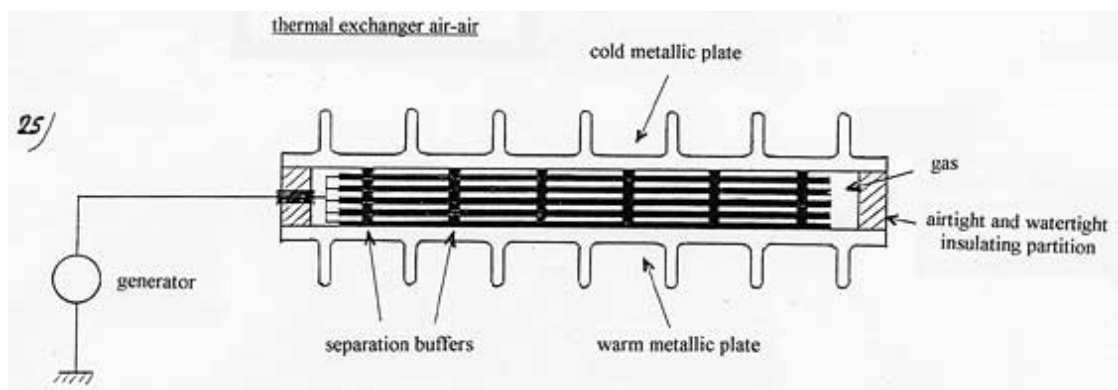


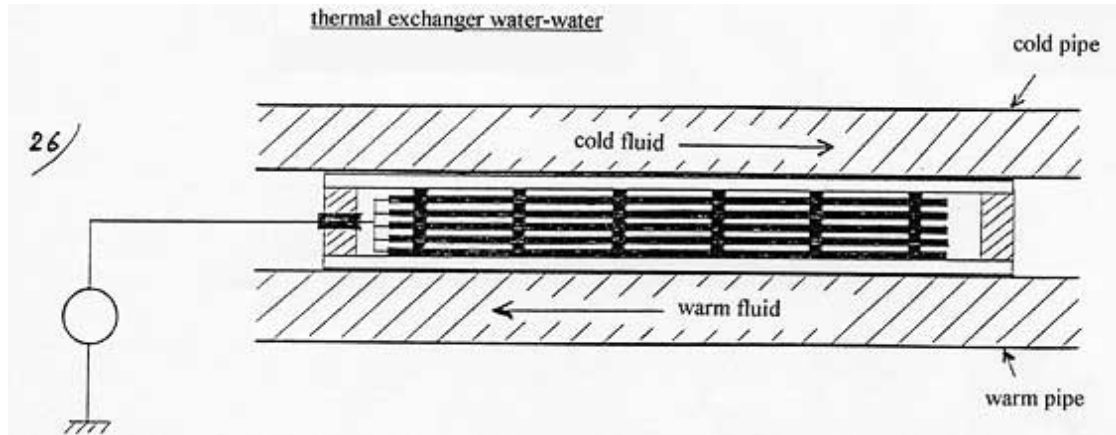
Spread over the whole surface of the plates, they maintain regular spaces between them. They are as very few and as narrow as possible in order to limit the return of heat the return of heat in the normal direction : warm plate => cold plate.

A way to make them would consist in putting, on the inferior side of each plate (at the opposite of the graved side), an adhesive plastic layer with a thickness equal to the required separation then, in milling this layer away except for what we want to keep for the buffers. Another possibility allowing to reduce the distance of separation and then to rise the power of thermal transfer would consist in making oxide micro-balls on the surface of the metal, by ionic implantation for instance.

**General configuration**

A plate being a few degrees warmer than the opposite one, the heating must be multiplied to get a difference of temperature big enough between the cold source and the warm source. The solution consists in proceeding by stages, that is to say to superpose the plates, the cold plate of a stage becoming the warm plate of the following stage. If we take up again the example described in diagram 14, the power of thermal transfer of 1400 watts we had between two plates would be recovered but now between the cold source an the warm source, with the required difference of temperature.





### Consumed electrical power

It is the power consumed by the generator to maintain the tension in the condensers because a very weak current goes through the dielectric and would discharge the condensers if they were maintained to a constant tension. The current depends on the resistance of the dielectric. With a high resistance material such as parylene ( $10^{17} \Omega \text{ cm}$  at the required field) we have, for an electric field of  $10^7 \text{ V/cm}$ , a current of  $10^{-10} \text{ A/cm}^2$  or  $10^{-6} \text{ A/m}^2$ . With a tension of about 1000 volts we get a consumed power of about  $10^{-3} \text{ watt/m}^2$ , or 0.01 watt for a mellefeuille coil of 10 plates of  $1 \text{ m}^2$  each, which is insignificant on looking at the power of thermal transfer calculated above (diagram 14).

### **Other configurations of the plate**

They are based on the same principle, that is to say, the creation, on the surface of a plate, of an electric field allowing to attract the gas molecules to make them yield energy by thermal accommodation.

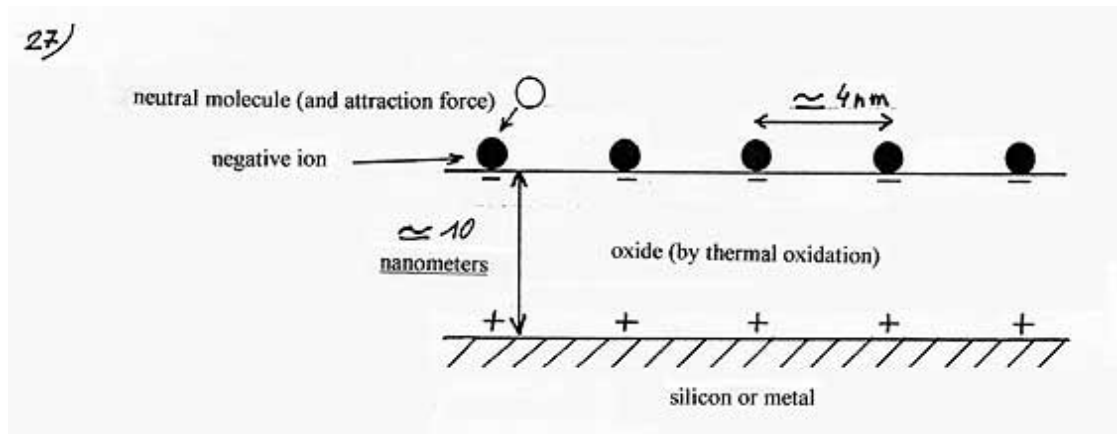
#### 1) Surface ions

Some ions, uniformly spread over the surface, replace the metal grid of the first configuration. The gas molecules would be attracted by a high density electric field close to an ion. The distribution of the ions would be automatically done by repulsion of the ions among themselves. The ions could be produced by electronic emission from a cold cathode (which emits electrons with a weak electric field) into an electronegative gas ( a molecule which easily picks up a supplementary electron) such as SF<sub>6</sub>.



Advantages:

- A high field close to an ion ( $1,5 \times 10^9$  V/m).
- The thinness of the dielectric ( 10 nm) and the static charge of the negative ions prevent a breakdown of the dielectric.
- One avoids the problems linked to the metallic grid, i.e :
  - A too high field next to the metallic ridge which might ionize the neutral-gas molecule.
  - Emission of ions from the metal of the grid which would come and “pollute” the dielectric surface by scattering away the positive charge first concentrated on the grid, which would progressively weaken the electric field in the holes of the grid.



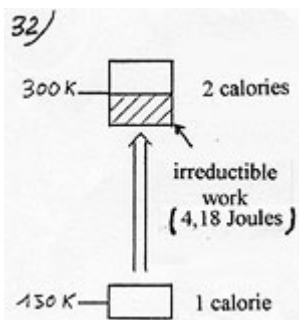
**Advantages of the invention compared to the existing pumps**

The advantages of this invention are those of the thermoelectric pumps: compactness, simplicity, no parts in motion, so no noise, and adding to this, a very good coefficient of performance able to save energy and reduce pollution ( Efficiency coefficient or coefficient of performance or COP = ratio of the quantity of energy rejected at the warm source (in calories) by the work delivered at the pump (in Joules. 1 calorie = 4.18 joules) ). See also in the applications, the new possibilities induced by this coefficient of performance.

Why can the coefficient of performance of this process go beyond Carnot's ?  
Comparison of The thermodynamic cycles.

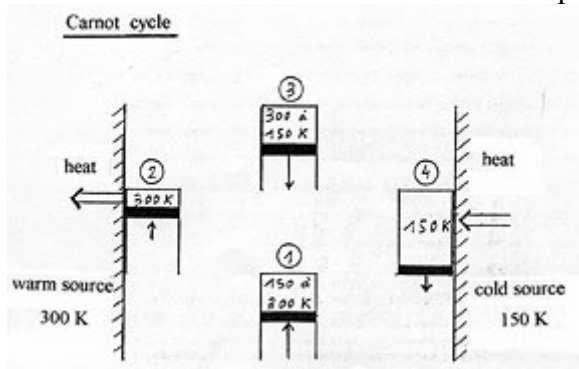
Carnot's theorem :

$$\frac{Q_2 \text{ (heat rejected at the warm source)}}{Q_1 \text{ (heat taken at the cold source)}} = \frac{T_2 \text{ (temperature of the warm source)}}{T_1 \text{ (temperature of the cold source)}}$$



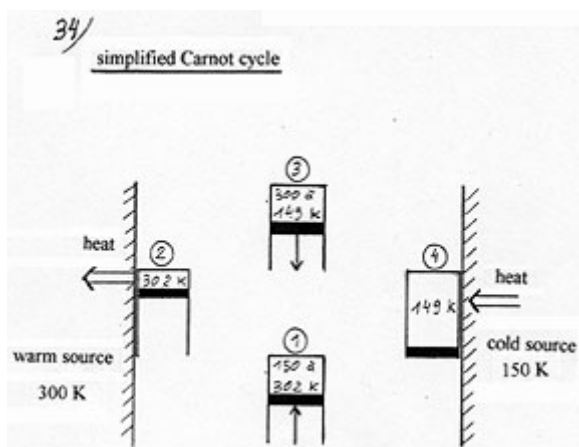
According to Carnot's theorem, if one disposes of a cold source, at 150 Kelvin and a warm source at 300 K ( $T_{\text{warm source}} / T_{\text{cold source}} = 2$ ) and takes off one calorie at the cold source, it induces a minimum rejection of 2 calories at the warm source, the second calorie coming from the minimum work delivered at the pump ( 4.18 joules). In that case, Carnot's COP = 2. To enlighten the cause of the irreducible work to deliver in all the actual processes, it is necessary to closely observe Carnot's cycle which is a perfect method as far as the minimum amount of work to deliver in a mechanical compression heat pump is concerned.

Let's consider a mole of perfect gas at 150K



- (1) Adiabatic compression of the gas to reach the temperature of the warm source.
- (2) After having been put in contact with the warm source, it is compressed again in an isothermal way to pour heat into it. This operation must be done very slowly not to overheat the gas compared to the warm source.
- (3) Adiabatic expansion of the gas to cool it until it reaches the temperature of the cold source.
- (4) After having been put in contact with the cold source, it is expanded again in an isothermal way ( very slowly ) to draw heat from it.

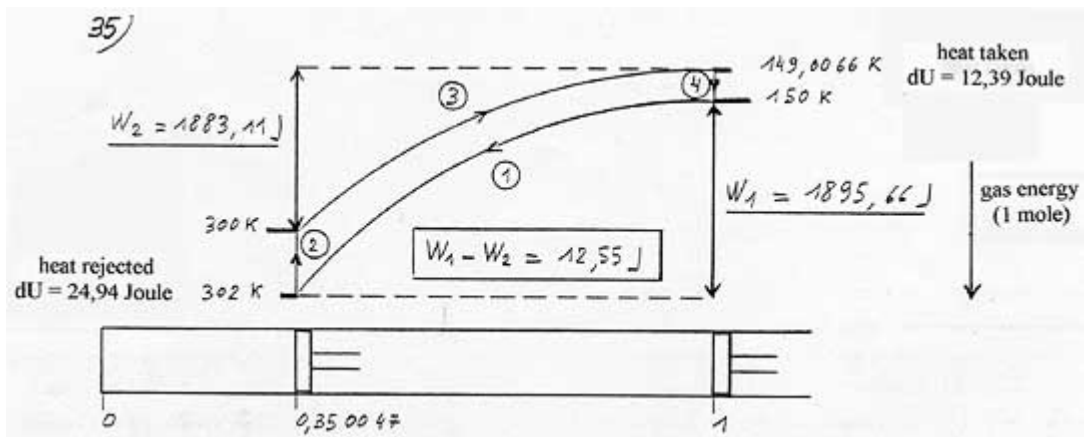
We realize that we reach about the same result by suppressing the compression and the isothermal expansion and by replacing them by a slight difference in temperature between the gas and the cold or warm source when they are put in contact. This method brings us nearer from the thermodynamic cycle of the invention and is going to show clearly the difference and originality of the invention.



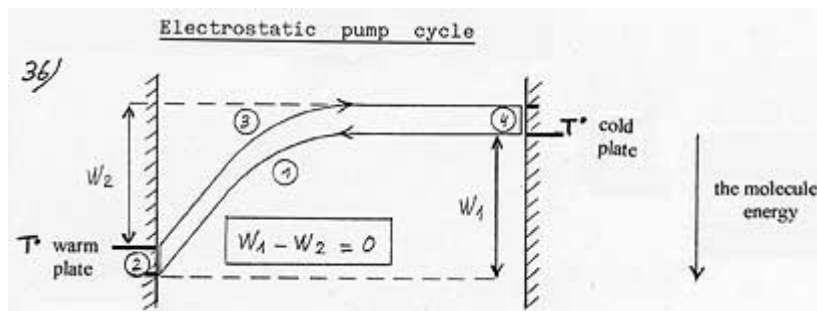
- (1) Adiabatic compression of the gas (1 mole) and warming up from 150 to 302 K (302 K is arbitrarily chosen).  
 $W_1 = 1895.66$  Joules with  $W = \frac{3}{2} R (T_1 - T_2)$
- (2) Cooling of the gas after the contact with the warm source, from 302 to 300K.  
 Heat emitted  $dU = 24.94$  J (with  $U = \frac{3}{2} RT$ ).
- (3) Adiabatic expansion of the gas and down from 300 to 149.0066K  
 $W_2 = 1883.11$  Joules . Now the temperature of 149.0066K is determined by the ratio of the volumes  $V_1/V_2$ , identical in the compression and the expansion.  
 with  $T_2 = (V_1/V_2)^{2/3} \times T_1$  and  $V_2 = V_1 / (T_2/T_1)^{3/2}$
- (4) Warming up of the gas in contact with the cold source from 149.0066K to 150K. Heat received: 12.39 Joules.

One can sum up the situation with the energetic cycle represented below: If one takes 12.39 Joules at the cold source, 29.94 Joules are rejected at the warm source, that is to say a difference of 12.55 J which corresponds exactly to the work globally spent in the cycle ( $w_1-w_2$ ).

As foreseen, 1 calorie taken at the cold source induces the rejection of 2 calories at the warm source ( $24.94/12.39=2.013$ ). The second calorie coming from the work delivered.

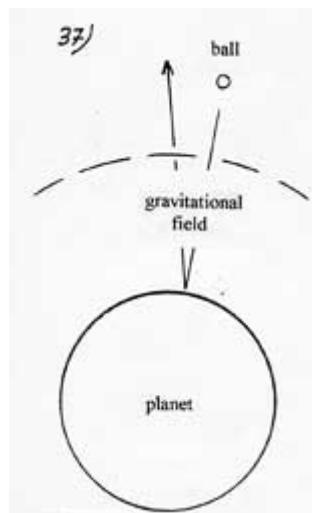


One can see that the gas energy, that is to say its temperature, is on average higher during the compression than during the expansion, simply because it is warmed up just before the compression stage and cooled down just before the expansion stage. Yet, if the gas is warmer during the compression, its pressure is also higher. Consequently the compression work  $W_1$  is inevitably more important than the expansion work  $W_2$ , hence a global irreducible work to deliver. ( i.e.: 12.55J).



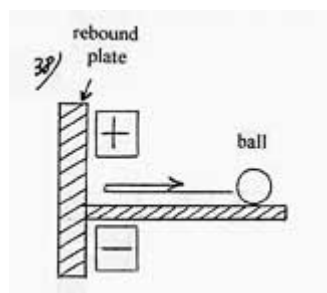
- (1) Acceleration or warming up of the gas molecule in the attraction field.
- (2) Cooling by thermal accommodation.
- (3) Slowing down or cooling of the molecule in the attraction field.
- (4) Warming up by thermal accommodation.

The work of the piston in Carnot cycle is replaced here by the work of the attraction field and the contact with the cold or warm source in Carnot cycle is done here by thermal accommodation. But, while in Carnot cycle the necessary compression work to warm up the gas ( $w_1$ ) was superior to the expansion work ( $w_2$ ) which was cooling it down, this time the attraction field accelerates then slows down the molecule according to the same potential energy.  $W_1 - W_2 = 0$

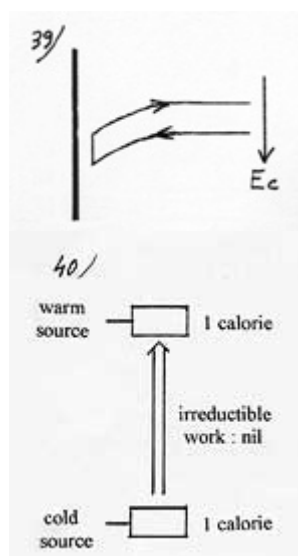


To enlighten this angle, one could compare the molecule which falls on the plate to a ball in space which falls on a planet ( one must assume that there is no atmosphere and that the ball has a very high initial speed). When it penetrates into the gravitational field of the planet, the ball is accelerated. Because of the shock, it yields energy in the shape of heat and so rebounds at a lower speed. When it goes up again, it slows down and goes back into space with a kinetic energy lower than the one it had before falling on the planet. Its energetic curve would exactly corresponds to the one described in the one described in the left part of the diagram above.

Once out of the gravitational field, the ball has no energetic debt owed to the gravitational field. The later accelerates the ball when it falls down but it slows down as much when it goes up again. The principle of conservation of energy is respected. The energy freed during the shock is paid by a final slowing down of the ball but absolutely not by the gravitational field. It is the same for a molecule in the electrostatic attraction field.



One can be persuaded of it by observing the experiment of the blade which is introduced in the condenser. To have a more vivid imagery, we can replace the blade by a ball which would roll on a horizontal plane as represented on the diagram opposite. By penetrating into the electric field of the condenser, the ball accelerates, its kinetic energy increases of a value corresponding to the attraction energy of the ball, it strikes the rebound plate by yielding energy and so goes back at a lower speed, then it slows down when going out ft the electric field of the condenser. During this operation, if the condenser is maintained at a constant charge (and not at a constant potential), there is no loss of electric energy with a perfect electric insulation. It is exactly the same thing for the molecules in this process.



It wasn't the same thing in Carnot cycle where the work done by the acceleration of the molecules during the compression could in no case be totally recovered by their deceleration during the expansion, the heat freed at the warm source was partly paid in return by the work of the piston.

To conclude: there is no longer necessarily a work to provide which would be transformed into heat and rejected at the warm source. In the case where the work is nil, each calorie taken at the cold source is rejected at the warm source and nothing more. We'll see in the applications the consequences induced by this new propriety.

**Traditional applications of the heat pumps but whose interest would be enlarged by a high C.O.P.**

- Heating and air-conditioning of council estates or flats, hospitals, hotels, schools, auditoriums and offices.
- Water heaters, heating for swimming pools, greenhouses, soil for mushrooms culture, water for fish breeding.
- Fridges (see diagram below).
- Refrigerators for preserved food and food industry, for the air-conditioning of port installations.

Heat recycling devices ( without external input of heat at the cold source)

- Fur, meat, wood, paper, cereals (corn, barley) drying.
- Evaporation for the concentration of aqueous solutions in food industry, paper manufacturing and chemical industry.
- To remove salt from the sea.

Provided that the process be able to deliver a warm source up to 120°C

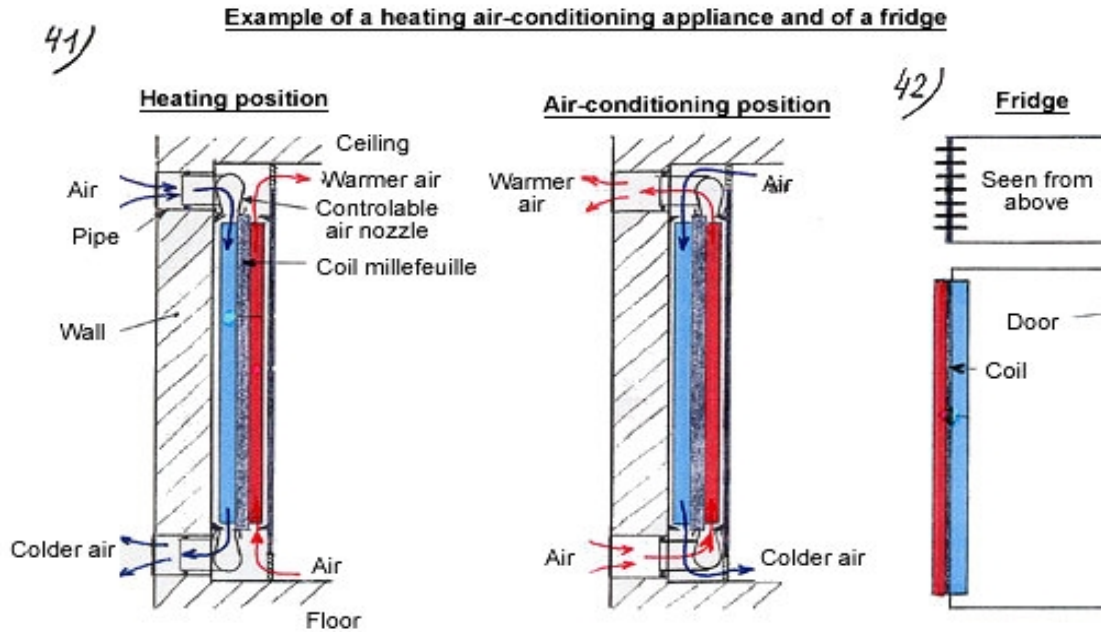
One can note a potential market in:

- Oil refining
- Paper making
- Food industry
- Alcohol distilling

Other applications linked to compactness, simplicity, absence of noise.

- Small portable fridges
- Air conditioned containers
- Heating / air-conditioning appliance for individual lodging (diagram below).

Example of a heating – air conditioning appliance and of a fridge



## SPECIFIC APPLICATIONS OF THE INVENTION

### 1) Conversion-of-ambient-temperature-into-work Station (Thermodynamic station with a sole thermal source)

The principle consists in associating a heat pump to a thermodynamic engine in order to make it deliver more work than the pump consumes. the ambient temperature brawn into the environment ( ground water, river, lake, sea, atmosphere ...) provides the necessary energy to deliver useful work. The thermodynamic engine works by draining off some heat from the warm source to the cold source (warm pipe and cold pipe), while at the same time, converting some of this heat into work, whereas the heat pump carries the heat “up” from the cold source to the warm source.

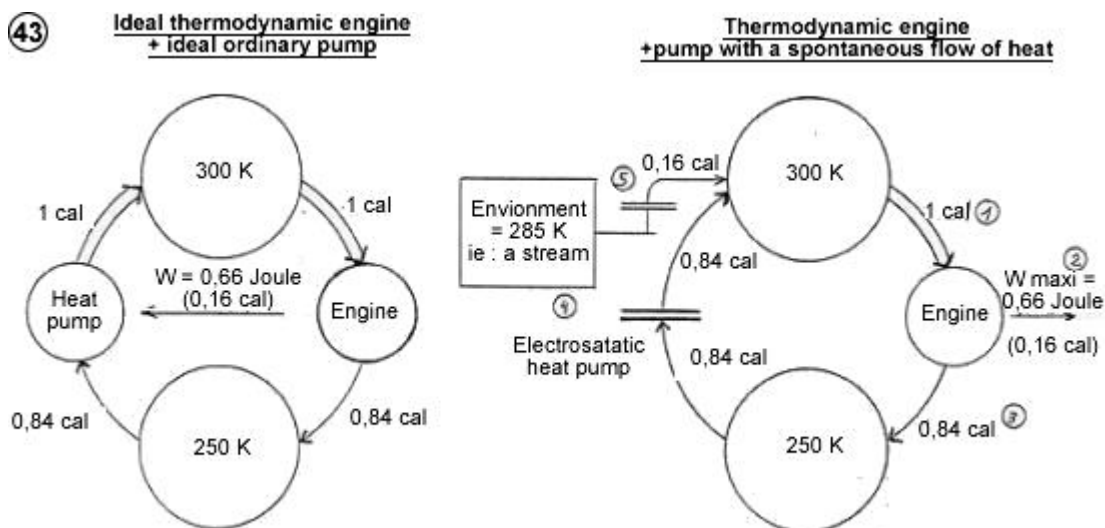
Such a system can only work with a heat pump whose C.O.P is superior to Carnot’s. Indeed, as long as the heat pumps were limited by Carnot’s C.O.P, the coupling of such a pump with a thermodynamic engine could, at the best, only reach to the reciprocal neutralization of their effects, the totality of the work delivered by the engine being consumed by the pump (see diagram below on the left).

But we would get the required effect if the C.O.P of the pump became superior to Carnot’s. In the case where there is no work to deliver at all at the pump, all the work delivered by the engine can be freed. This work would come from the conversion of the ambient temperature drawn into the environment (see diagram below on the right.)

Thermodynamic cycle (the temperatures are arbitrarily chosen).

- (1) Given a calorie taken at the warm source by the evaporator of the engine.
- (2) The engine transforms some of this calorie into work (0.16 calorie max.)
- (3) The remaining part (0.84 calorie min.) is discharged by the condenser at the cold source.

- (4) To maintain the temperature of the cold source the heat pump must take this quantity of heat back to the warm source. If the work to deliver at the pump is nil, this quantity of heat is transferred to the warm source, nothing more.
- (5) In the end, the warm source has cooled down of 0.16 calorie, that is to say the quantity of heat converted into work. One can warm it up by taking some heat into the environment with an auxiliary heat pump since the environment is usually colder than the warm source in our case.



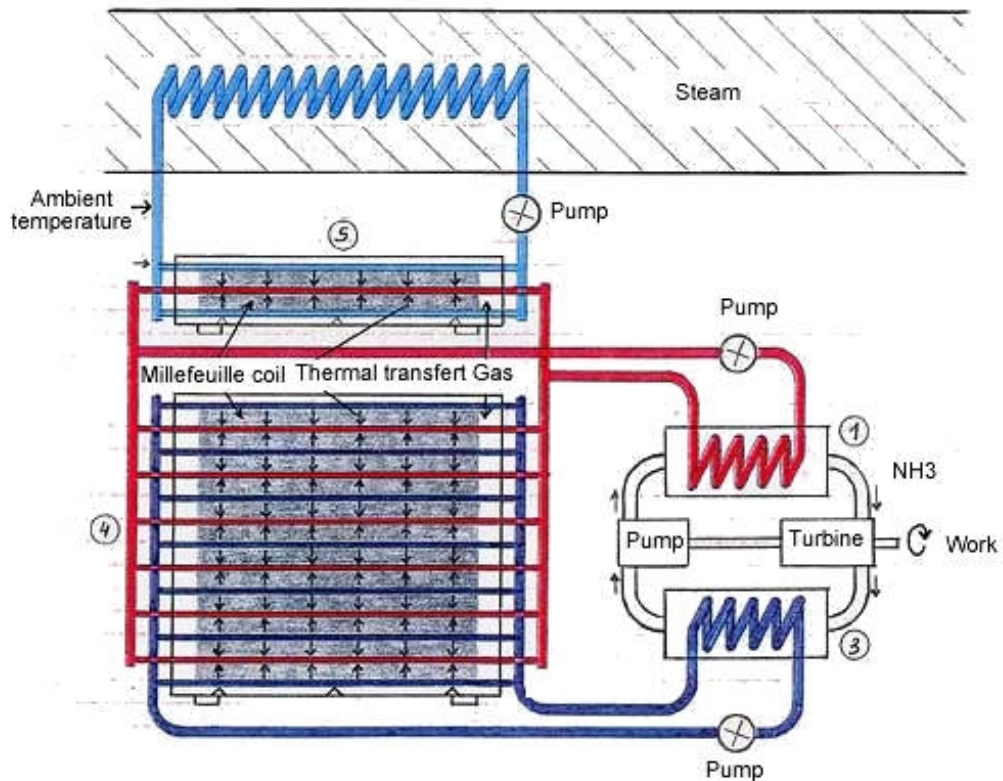
Working principle ( the station having been started) (see diagram 44)

- (1) The work fluid, generally ammoniac arrives into the evaporator where it takes heat at the warm source. The warm fluid (in red) undergoes a cooling down of a few degrees ( the warm plates of the heat pump could play the role of evaporator. In the same way the cold plates could play the role of condenser).
- (2) Ammonia vapor arrives into the turbine where it expands by delivering a work whose value depends on the difference of temperature between the warm source and the cold source.
- (3) The vapor penetrates into the condenser where it yields heat at the cold source. The cold fluid (in blue) then undergoes a warming up. The ammonia now a liquid is pumped and compressed again, then a new cycle starts.
- (4) To maintain the temperature of the cold source, the heat pump must take “up” again the heat drained by the engine. thanks to its high C.O.P, it can do it by using only a small part of the work delivered by the engine with the help of a generator connected to the engine. But we could also make it work with the electric-grid system if the work delivered by the station isn’t converted into electricity.
- (5) The role of the auxiliary pump is to take some heat into the environment to introduce it at the warm source. It is this energy that will be converted into work. But one could also directly warm the cold source with the help of a simple thermal exchanger (see configuration on the page 25).

Available power

Each calorie taken into the environment is entirely converted into work. If it is a stream, each gram of water discharged and cooled of 1°C would provide 4.18 Joules (4.18 MW/m<sup>3</sup>/s). A station that would cool down of 1°C the water running in the river Rhine, would give on average 9196 MW ( average flow: 2200m<sup>3</sup>/s), the river Rhône: 7106 MW, the river Loire: 3300 MW, the river Seine: 1567 MW, the river Garonne: 836 MW.

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**2) House supplying power and fresh water with sea water**

The principle is the same as in the configuration mentioned before, except that the work fluid used in the thermodynamic engine is now sea water, with production of fresh water at the condenser. This possibility has already been applied in the sea thermal energy ( Georges Claude's process) but one had to have a warm source and a

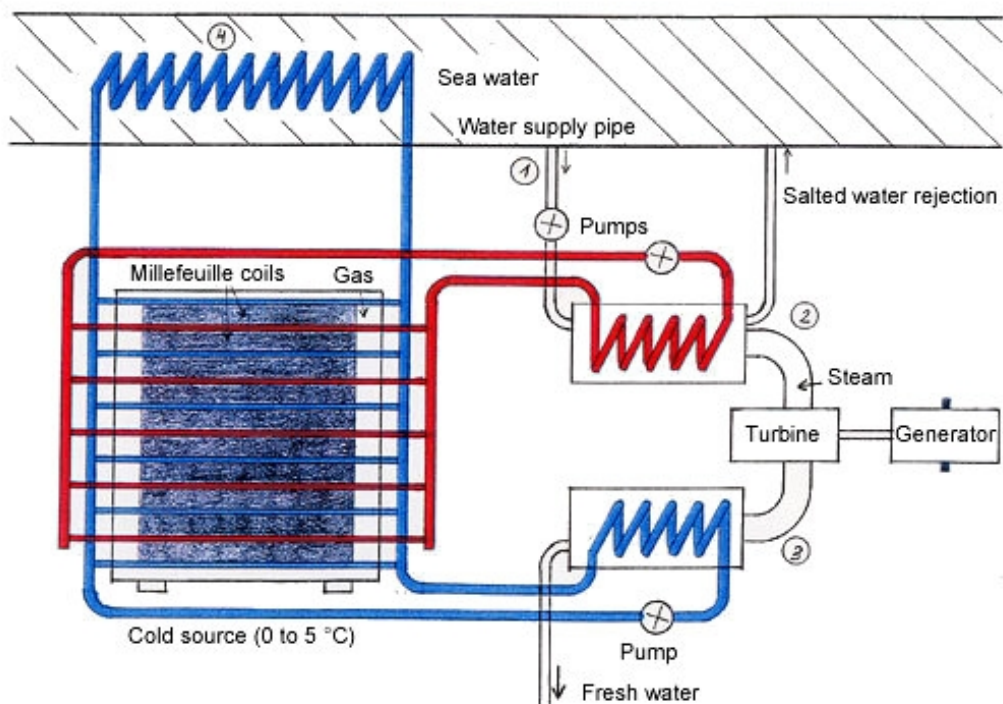


cold source at one's disposal, the later being the deep cold water reservoir of the tropical seas ( about 5°C. See Ph. Marchand's book: *L'énergie thermique des mers* , IFREMER edition), while the warm source is the surface water (20 to 25°C). In the actual case, the surface water is enough and all the seas can be suitable.

### How it works

- (1) Some of the water aimed at warming the cold source is diverted by a pump towards the evaporator where it is heated at the temperature of the warm source.
- (2) Under the influence of heat and depression (the evaporator and the condenser are at 10 meters above the sea level) the water evaporates. To avoid the formation of salt into the evaporator, one introduces a bigger quantity of water than the one to evaporate in order to be able to evacuate the salt with the extra water.
- (3) The steam goes through the turbine where it expands itself by delivering work. Then it penetrates into the condenser and liquefies into fresh water at the temperature of the cold source (between 0 and 5°C – under this temperature the water freezes).
- (4) As in the configuration where one introduces only electricity, the system must be fed with heat taken into the environment to produce work. In the actual case, the sea water being only slightly warmer than the cold source, one can directly warm the cold source with the help of an ordinary thermal exchanger, which avoids the auxiliary heat pump.

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### 3) **Thermoelectric generator**

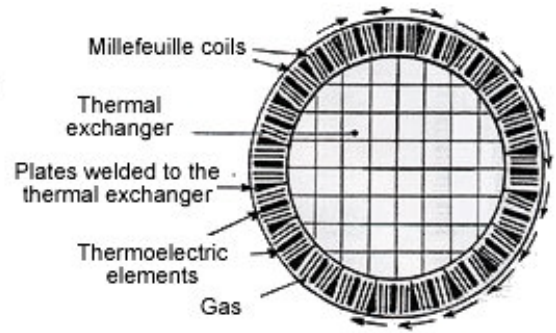
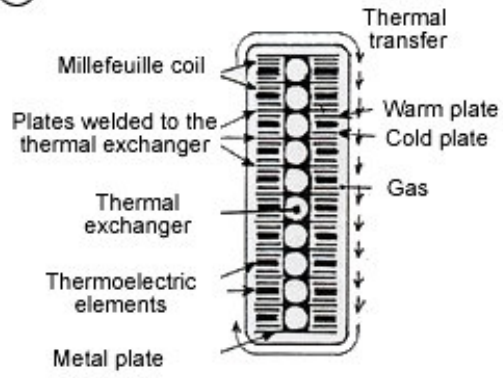
The principle consists in interposing a thermoelectric element between the warm and the cold plate of two close millefeuille-coils, the thermoelectric element replacing the turbine and the generator of the thermodynamic station. The alternated disposition of millefeuille-coils and thermoelectric elements allows a constant and homogenous circulation of the heat, as is shown on the diagram below. Indeed, contrarily to the thermodynamic station where the heat of two juxtaposed coils had to go towards the warm pipes, here the coils are all placed in the same direction so as the heat can circulate in the same direction. The thermoelectric elements leave the heat flow from the warm part to the cold part by converting a small part into electric power, while the coils take this heat backward from the cold part to the warm part. So, they recycle the heat which flows into the thermoelectric elements to integrally convert it into work (electricity).

#### How it works

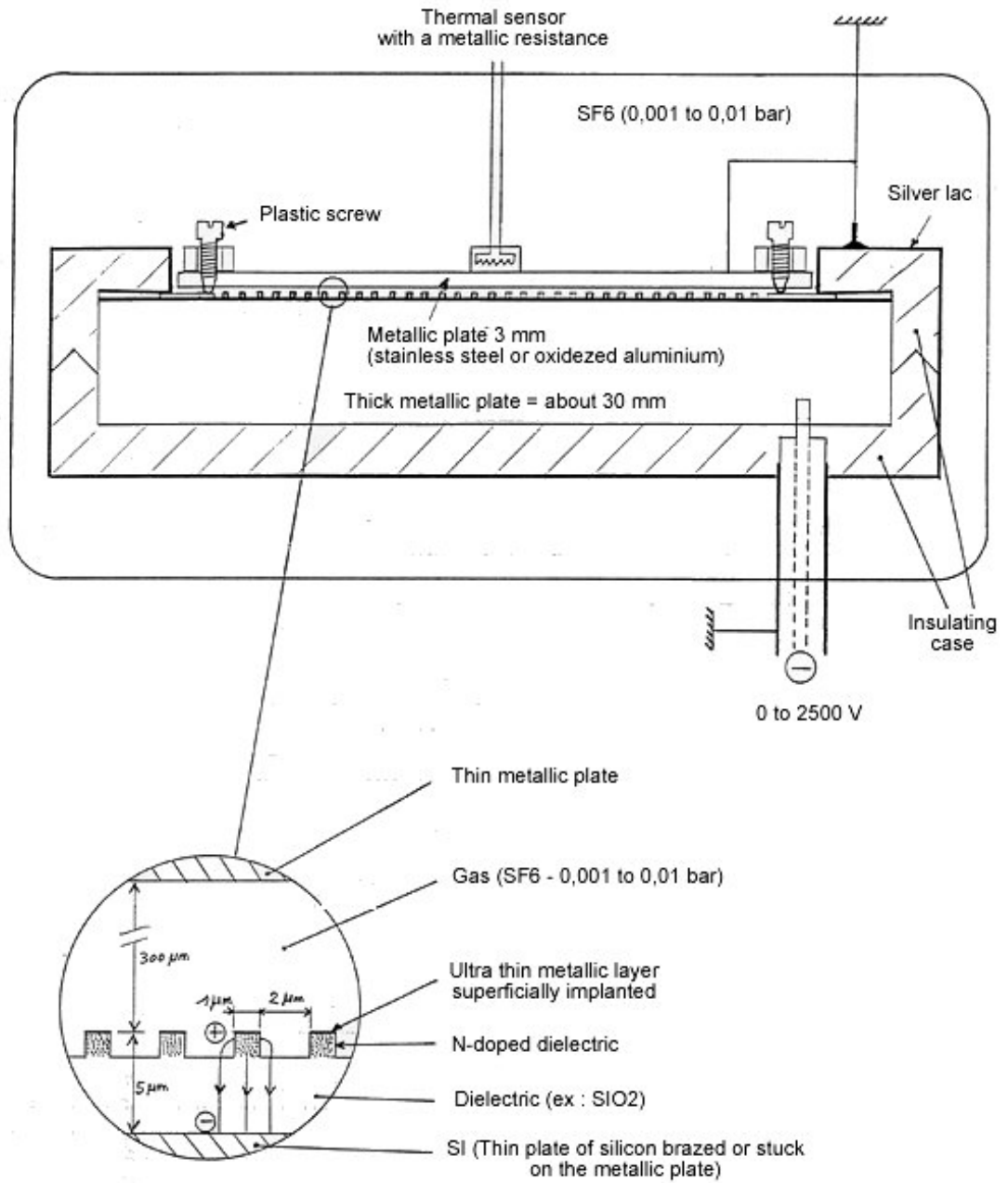
- Starting: With the help of a battery, one starts the millefeuille-coils. The warm plate of each coil warms up and the cold plate cools down. Meanwhile the heat starts flowing into the thermoelectric elements according to a more and more intense power which produces electricity.
- The millefeuille-coils recycle the heat which flows into the thermoelectric elements but as some of it is converted into electricity, the system might cool down. Hence the introduction of metal plates welded to the thermal exchanger and stuck in the middle of each coil whose role is to feed the system with the ambient heat taken by the thermal exchanger. This heat can be brought by a fluid (air, water...) or by a burning gas, a radiance or by mere thermal transfer with a solid supporting the apparatus (ex: the ground).

Applications: generator for satellite, isolated resorts, beacon, buoy, meteorology, generating unit, battery for thermal engine, batteries...

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**Experiment : 1<sup>st</sup> possibility. Condenser- non metallic grid configuration**



### Advantages – difficulties

This configuration, close to the reference pattern, aims at solving the point-effect problem that would occur by the ribs of a metallic grid. A very high electric field, of about  $10^{10}$  V/m, could induce an auto-ionization of the neutral gas molecules, that is to say without collision with another particle, just because of the intensity of the electric field by the ribs. In the present case, the positive charge would be ingrown into the dielectric mass thanks to the grafting of donor atoms. These atoms would get ionized by the application of the electric field and the electrons would flow into the ultra-thin layer superficially grafted. The dose of donor atoms would be calculated so as the positive charge be not only located on surface like a metal, but grafted into the volume of the material in order to avoid the point effect.

About the risk of emission of positive ions from the grid which scatters the positive charge and progressively weakens the electric field in the holes of the grid, we may suppose that the use of a dielectric would be preferable to the one of a metal whose emission certainly comes from the ionization of the gas absorbed superficially. If, in spite of all that, the problem remains, a solution to re-establish the electric field in the holes of the grid would be to momentarily inverse the polarity of the process ( negative charge on the grid and positive charge under the dielectric). Another way would be that while the tension in the dielectric is suppressed, to periodically emit electrons on the whole surface of the dielectric to discharge the positive ions thanks to a cold cathode located on the inferior side of the thin plate.

About the risk of breakdown of the dielectric, the problem could be solved in the following way: we apply the voltage to the plate in the vacuum case. If a breakdown occur, a dark spot should appear and help us to locate the place where the breakdown occurred. It would then be necessary to clean the grid in this right place to isolate it from the conductive canal which took shape during the breakdown. The cleaning can be made with an ionic canon or a laser.

The dielectric rigidity will be all the higher as the holes of the grid and its thickness will be small because we will be able to reduce the thickness of the dielectric accordingly.

Besides, I have experimented a strategy at the L.C.I.E (Laboratoire Central des Industries Electriques in Paris) in order to increase the dielectric rigidity. It is based on the interfacial polarization. It consists in interposing a weak-resistivity insulation ( $10^{10}$  to  $10^{14}$   $\Omega$  cm) between the metal of the cathode and the high-resistivity insulation destined to be laid under the grid, in this case, Parylene ( $10^{17}$   $\Omega$ cm). This strategy has the effect of nearly canceling the electric field in the weak-resistivity insulation, and by so doing, avoids any electronic injection in the Parylene because the cathode is now only submitted to a very weak electric field. This experiment demonstrates that with an equal electric field and an equal thickness of Parylene, we get a high reduction of the measured current, of about the half, but also a high increase of the dielectric rigidity of about 70%.

### Thickness of the plates

The thick metallic plate (about 30mm) is the warm plate called electrostatic. Its thickness must allow an inertia of temperature that is to say a very weak warming

which will facilitate the measurement of the cooling of the thin metallic plate (about 3mm).

It is preferable to measure the cooling of the thin plate to precisely enlighten the transfer of heat between both plates and this rather than the warming of the warm plate which could be interpreted in other different ways.

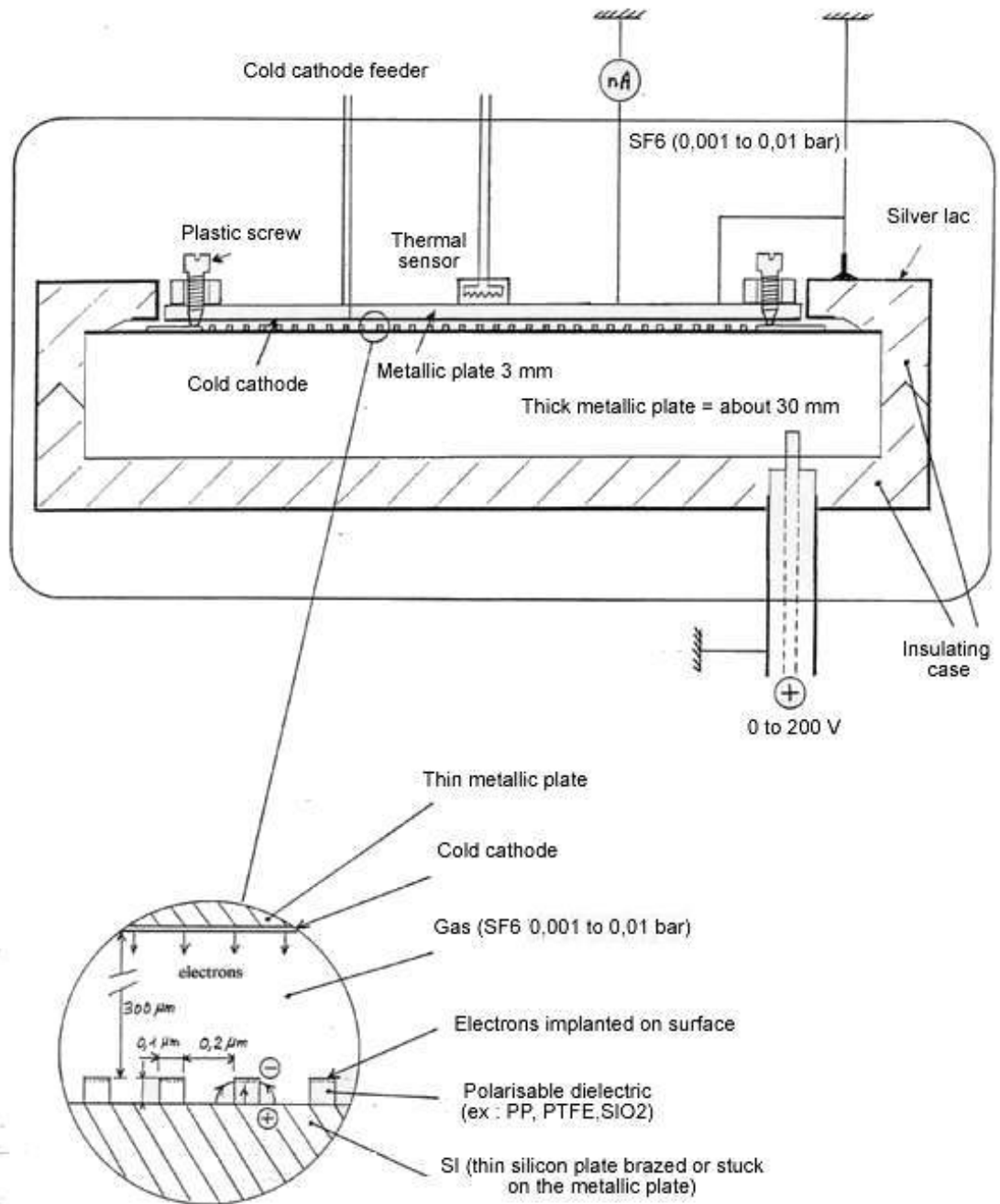
#### Role of the insulating case

It is made of two half plastic lids jointed the one into the other, and covered with a thin silver lac linked to the nil-potential mass. It is destined to suppress all electric field out of the process, in order to avoid a breakdown in the gas between two parts away the one from the other and with different potentials.

#### Measurement of the cooling

Once the vacuum is established, we let the tension rise slowly, then once we get the required tension, we introduce the gas at 0.001 bar first. A cooling of the thin metallic plate must then be noticed, of about 1°C at 1250 V (250 KV/mm in Parylene and 500 KV/mm on surface) because one must take into account that the holes of the grid represent only the half of the whole surface.. The cooling will be proportional to the square of the electric field, consequently, we should have 4°C with a field of 500 KV/mm, 16°C with a field of 1000 KV/mm. We will make a note of this cooling at different moment after the introduction of the gas to know the cooling speed, then the power of thermal transfer, and then the equilibrium temperature when the transfer is cancelled.

**Experiment : 2<sup>nd</sup> possibility. Grid-electret configuration**



Advantages – difficulties

Some electrons are emitted from a cold cathode laid under the thin plate, and get grafted into a polarizable material such as PP, PTFE, or SiO<sub>2</sub>. By positively charging the thick plate and by grounding the thin plate, an electric field is created between the two plates and it is going to attract the electrons and provoke their implantation to a deepness of about 10 nanometers for a potential of 100 volts. The uniform repartition of the implanted electrons must avoid a too important concentration on the edges as well as a point effect.

Contrarily to the previous configuration, the ionic emission from the anode, if it takes place, wouldn't imply the obligation of stopping the device anymore. One just have to make the cold cathode work and to re-implant the electrons. The dielectric layer becomes too thin for a breakdown to occur and the implanted electronic charge, which is static, also contributes to limit the risk.

The interest of this configuration will depend mainly on the difficulty to get the required charge ( 0.01 Coulomb minimum / m<sup>2</sup>). One of the reasons why this difficulty might occur is that some of the electrons are going to fall on the edges of the grid and skim its vertical sides, which might ionize the dielectric and the freed electrons would be immediately sucked in the vacuum towards the silicon surface because of the high electric field in this zone. In that case it would become impossible to increase the charge of the electret as soon as the electric field in the holes of the grid reaches a certain level. The most obvious solution consists in reducing the energy of the implanted electrons as much as possible because it is from this energy that depends the power of ionization of the dielectric by the electrons. Another solution would be, not to implant electrons but negative ions on the surface of a micro porous dielectric. The ions power of ionization is a lot weaker, at a low energy, than the electron's.

#### The charge control

The charge level of the electret will be controlled thanks to the tension switch and a nano or pico-ammeter. During the charging operation of the electret, the necessary tension to accelerate the electrons to implant is set. The charge level is estimated by the measurement of the time elapsed . If we want to know the exact level, we stop the feeder of the cold cathode then we let the tension drop slowly until the potential at the level of the implanted zone is cancelled and then becomes negative. At this moment, the thin metallic plate must start to charge positively and some unstable electrons in the electret must go back towards the thin plate, what must be detected with the nano or pico ammeter. At this moment, the tension control will indicate the tension level in the electret and consequently its charge level and the value of the electric field in the holes of the grid.

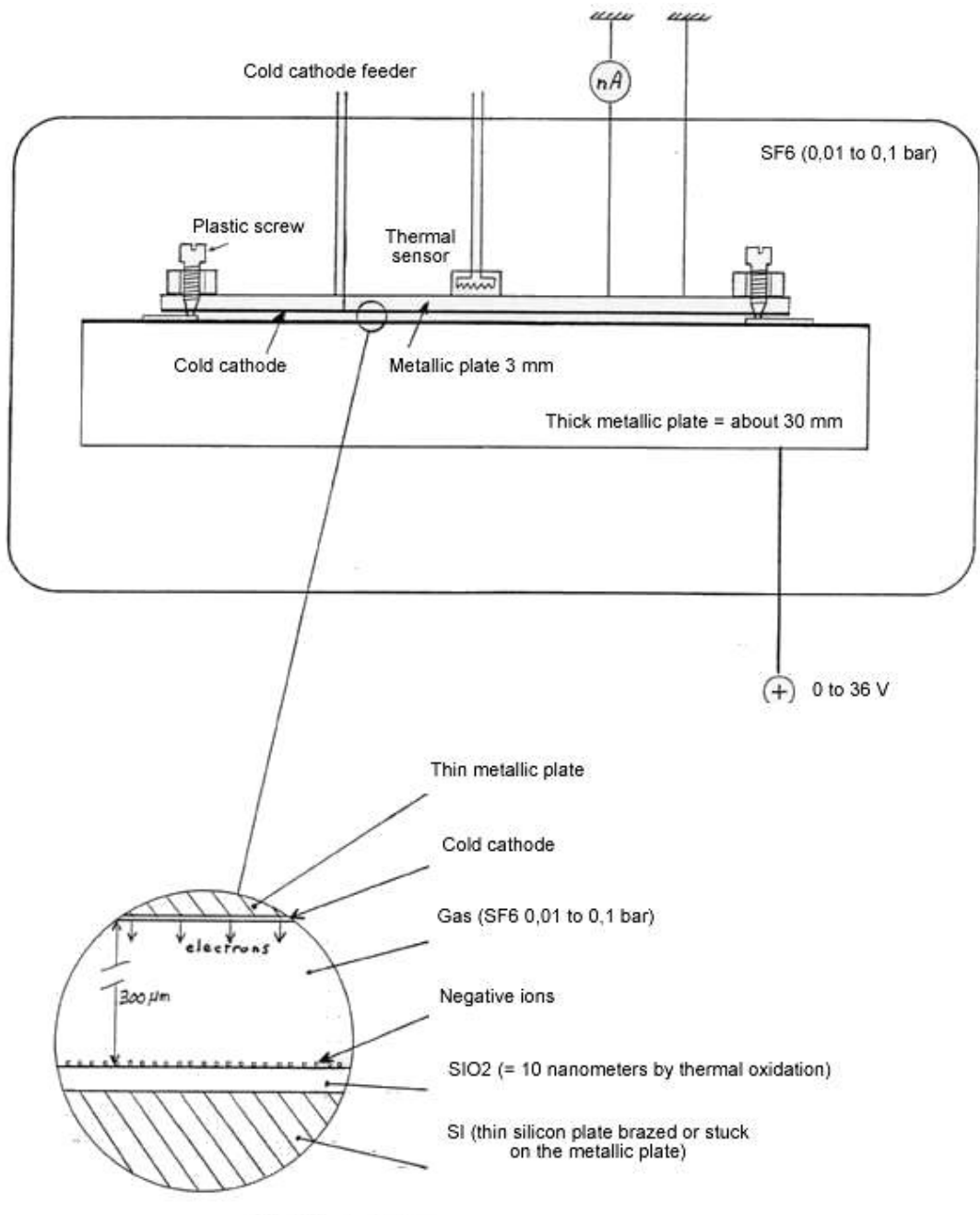
Thickness of the plates- insulating case- measurement of the cooling: see 1<sup>st</sup> possibility .

#### Electric power consumed

It will essentially depends on the stability of the implanted charge. The life span of a conventional electret is about of a century which means that it would have to be re-charged every century. But in the actual case, the required charge level would be, at the minimum, ten times higher than the most highly-charged-conventional electrets, and to compensate one can expect a considerable diminution of the stability. Let us imagine the very unfavorable case in which the life span would fall to 10 seconds. It would then be necessary to re-charge the electret every ten second, which induces a constant emission current of about 10<sup>-3</sup> ampere/m<sup>2</sup>. With a potential of 200 volts, we would then get a consumed power of 0.2 Watt/m<sup>2</sup>, which is still negligible compared to the power of thermal transfer to expect.



Experiment : 3<sup>rd</sup> possibility . Configuration with the ions on surface. See page 17



### Ions production

Once a vacuum is created, the gas is introduced (ex: SF6 at 0.01 bar) then the cold cathode is fed while creating a positive tension on the thick metallic plate which is going to attract the electrons and the negative ions produced by the electronic emission of the cold cathode. The negative ions are going to come and settle on the dielectric layer of silica. The cathode is fed until we get an electric field of 250 to 500 KV /mm in the layer, that is to say a tension of 2.5 to 5 volts for a 10-nanometer layer, and an ion density of 0.01 to 0.02 Coulomb/ m<sup>2</sup> corresponding to a distance of 3 to 4 nanometers between two neighboring ions.

### The charge control

Like in the configuration with the electret, the charge will be controlled thanks to the tension switch and a nano or pico-ammeter. While the plate is getting charged, there must be a maximum tension (36 V) to attract the negative ions. If we want to know the charge level, we stop the cold-cathode feeding and we let the tension of the plate drop until the potential at the level of the gas-silica interface is cancelled and becomes negative. At this moment, the thin metallic plate must start charging positively and some negative ions must go back towards the thin plate, what must be detected with the nano or pico-ammeter. The tension switch, at this moment, will indicate the tension level in the dielectric layer as well as the charge level.

### The gas nature

The qualities of the gas must be:

- A good polarizability ( or dielectric susceptibility:  $\epsilon_r - 1$ ) because the acceleration of the molecule in the electric field of an ion depends on it.
- A strong electro negativity to produce a stable ion, that is to say able to strongly withhold the electron on the dielectric layer.

To gather those two qualities more easily, it might be judicious, instead of using only one gas, to mix two gas, a majority one endowed with a good polarizability, and a minority one which would be endowed with a strong electro negativity.

### Negative-ions lifespan and consumed power

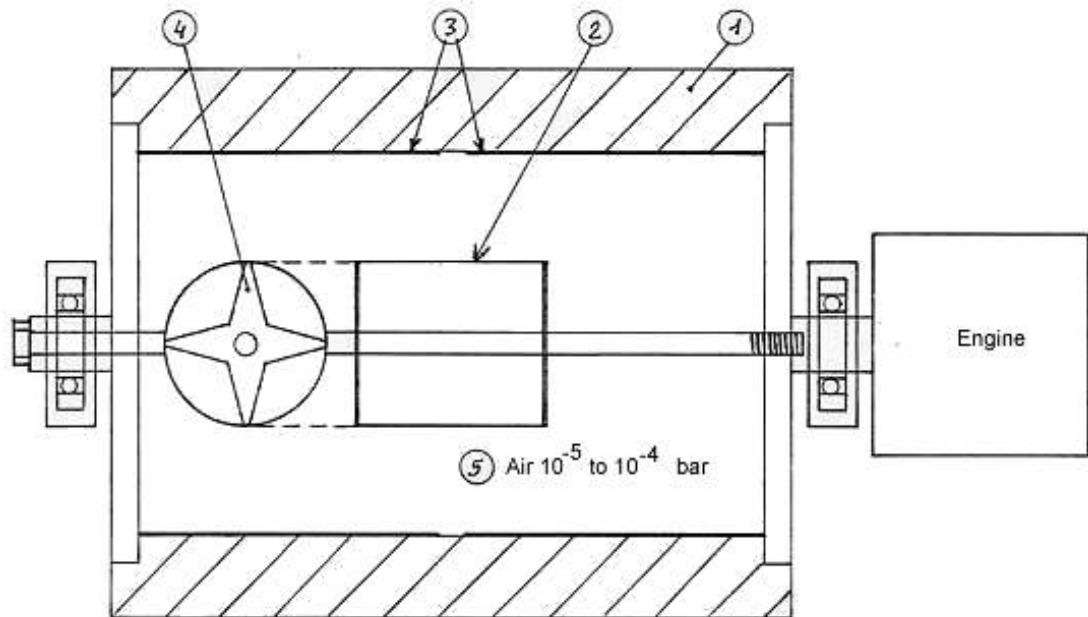
About the negative ions lifespan or stability, one must consider the electronic-barrier role played by the silica-gas interface owed to the very high resistivity of silica, of about  $10^{17}\Omega\text{cm}$  if it is dry enough. It will be necessary to eliminate as much water as possible by creating an advanced vacuum before the experiment, or by drying it or by using a silica gel.

With a resistivity of  $10^{17}\Omega\text{cm}$  and an electric field of 500 KV/mm ( $5 \times 10^6$  V/cm) we would get a current of  $5 \times 10^{-11}$  A/cm<sup>2</sup> that is to say  $5 \times 10^{-7}$  A/m<sup>2</sup>. even if the instability of the ions induced a current 10 000 times more intense, which is unlikely, we would only have  $5 \times 10^{-3}$  A/m<sup>2</sup>, and a consumed electric power of 0.2 Watt/m<sup>2</sup> for a total voltage of about 40 Volts, which is again negligible compared to the thermal transfer power to expect.

Advantages – difficulties

This configuration presents some undeniable advantages compared to the two previous configurations and first of all the simplicity of the realization. Yet it also allows unknown data which can make the analysis very difficult even impossible in case of failure of the experiment: Will the distance of attraction of the molecules by the ions, of about 2 to 3 nanometers be long enough? Will the ions resist on surface or will they bury themselves of a few nanometers into the dielectric? In the last case, will the attraction zone also be buried and become inefficient?. Will the surface of the dielectric be flat and compact enough at an ion scale such as ball on a golf course? If it ends up looking like a ploughed land, the ions will bury themselves and their electric field will be unreachable for the gas molecule.

**Preliminary experiment to reveal the variation of temperature in a gas submitted to an acceleration field.**



The first obstacle toward the acknowledgement of the concept of the invention could be cleared thanks to the realization of this experiment.. The aim is only to demonstrate that in a gas in a thermodynamic equilibrium in which there is an acceleration field (or attraction field), that there reigns not only a gradient of pressure but also of temperature.

The experiment consists in having a spinning top turn at a high speed ( 10 000 to 15 000 turns /minute), that is to say a hollow glass cylinder equipped with a thin plastic cylinder on its axis, to produce a centrifuge acceleration field able to cool the plastic cylinder of a few degrees ( according to the speed, the diameter of the glass cylinder and of the plastic cylinder).

this experiment might open a breach into the zero principle of Thermodynamics, principle which indicates that two objects in contact, even thanks to a gas, tend to put themselves at the same temperature (Clausius postulate) . This wouldn't be true anymore if there is, in the gas, an acceleration field perpendicular to the gas layer. It is this breach, this non absolute characteristic of the zero principle which would be at the origin of the contradiction with the second principle of Thermodynamics in this invention.

(1) The glass cylinder. It is the warm plate. It must be thick enough to limit as much as possible its warming during the experiment in order to measure as precisely as possible the cooling of the thin plastic cylinder. One must take into account the frictions in the bearings and the vibrations which will tend to warm the glass cylinder through the medium of the lateral circular metallic plates. If those losses of energy induce a too fast warming of the glass cylinder, the measurement of the cooling of the plastic cylinder will be difficult. One of the solutions would be to also measure the temperature of the glass cylinder and to calculate the cooling of the plastic cylinder by comparing the two temperatures

(2) The plastic cylinder, 1 millimeter thick or less if possible. The aim is to reduce as much as possible the calorific capacity of the cylinder in order to be put at the air temperature with which it is in contact as quickly as possible.

(3) Thin metallic layer vacuum-laid on the polished glass. Considering the important distance between the cold and warm plates, that is to say between the two cylinders, the power of thermal transfer by conduction in the gas would be equal to the power of thermal transfer by radiation if they were two black bodies. To limit the return of heat by radiation on the plastic cylinder, the glass cylinder will have to be coated with a thin metallic layer in order to reduce the emissivity of the glass by leaving a narrow strip in the middle of the cylinder (between the two arrowed axis (3)) which will allow, through the glass transparency, to read the temperature of the plastic cylinder by optical process.

(4) The cylinder's plastic washers. They will be cut as is described on the diagram to reduce as much as possible the contact with the cylinder and consequently the thermal bridge between the metallic axis (warm) and the cylinder (cold). Still in the aim of reducing the thermal transfer between the metallic axis and the plastic cylinder, the metallic axis will be of a small diameter and it would be preferable if it was buffed to limit as much as possible the thermal transfer by radiation.

(5) Air pressure. With a gas at the atmospheric pressure, we might have a warming of the plastic cylinder by convection, in which the air in contact with the lateral metallic walls would get warmer and would converge towards the center of the glass cylinder to then go and warm the plastic cylinder. The best solution to avoid this problem consists in introducing the apparatus into a tank in which a vacuum of about  $10^{-4}$  to  $10^{-5}$  bar would be created ( mfp of about 0.5 to 5 mm). At this pressure the density of the gas molecules becomes so weak that the movements of convection don't happen anymore and the power of thermal transfer by conduction in the gas would then be only slightly reduced.

The geometrical calculations that follow aim at calculating the cooling of the thin plastic cylinder and to demonstrate that we would get the expected effect with a rarefied gas. By arbitrarily choosing the value 100 for the average relative speed between a molecule and the wall at its point of departure, we aim at knowing the relative speed between the molecule and the wall at its point of impact ( located as **O** on the circumference of the inside or outside circle of the diagram) by supposing that

there is no intermolecular collision between both walls. It is proposed that the linear speed of the inside wall of the external cylinder be equal to the fifth of the average speed of a molecule, which is represented by a 20mm line on the diagram, and 10 mm for the linear speed of the wall of the internal cylinder whose radius is twice smaller.

The absolute speed of the molecule ( $V_a$ ) is the speed measured by a motionless observer. It doesn't change during the journey of the molecule between the two walls. It can be determined by drawing a parallelogram, the length of the small side corresponding to the speed of the wall and the length of the long side to the relative speed between the molecule and the wall. By re combining the speeds on the point of impact thanks to another parallelogram, one can find the relative speed between the molecule and the wall at its point of impact. I have thus tried to know the variation of the relative speed between the two walls, according to three different directions. The measurements were made on a professional drawing table where I drew parallelograms three times bigger than the of the previous diagrams, in order to increase the accuracy of the measurements. I then divided all the measured dimensions by three to re transcribe them on the actual diagrams.

When a molecule goes from the wall of the inside cylinder to the external cylinder's, one can see that the relative speed between the molecule and the wall of the external cylinder ( $VR_{m.C}$ ) increases of about 1.5% compared to the relative speed between the molecule and the wall of the internal cylinder ( $VR_{m-c}$ ) that is to say an increase of 3% of the kinetic energy of the molecule since it increases like the square of its speed ( $1.015^2 = 1.03$ ), which gives a warming of about 9°C for a rare gas ( $300K \times 0.03$ ) and of about 5.5°C for air since the energy of translation of an air molecule only represents three fifth of its total energy, the remaining part being rotation energy. One can notice that the increase of the relative speed is identical in the three studied directions. When a molecule goes from the wall of the external cylinder to the internal cylinder's, the relative speed decreases of about 1.5% in the three directions, that is to say a decrease of 3% of the kinetic energy.

Consequently, in this example the thermal equilibrium would be established when the wall of the internal cylinder is colder than the external cylinder's, of 9°C for a rare gas and of 5.5°C for air, neglecting the different causes of heat return mentioned above. Consequently the difference of temperature will be less important in reality. The calculations show that the increase or the decrease of the relative speed from a wall to another varies like the square of a spinning-top speed

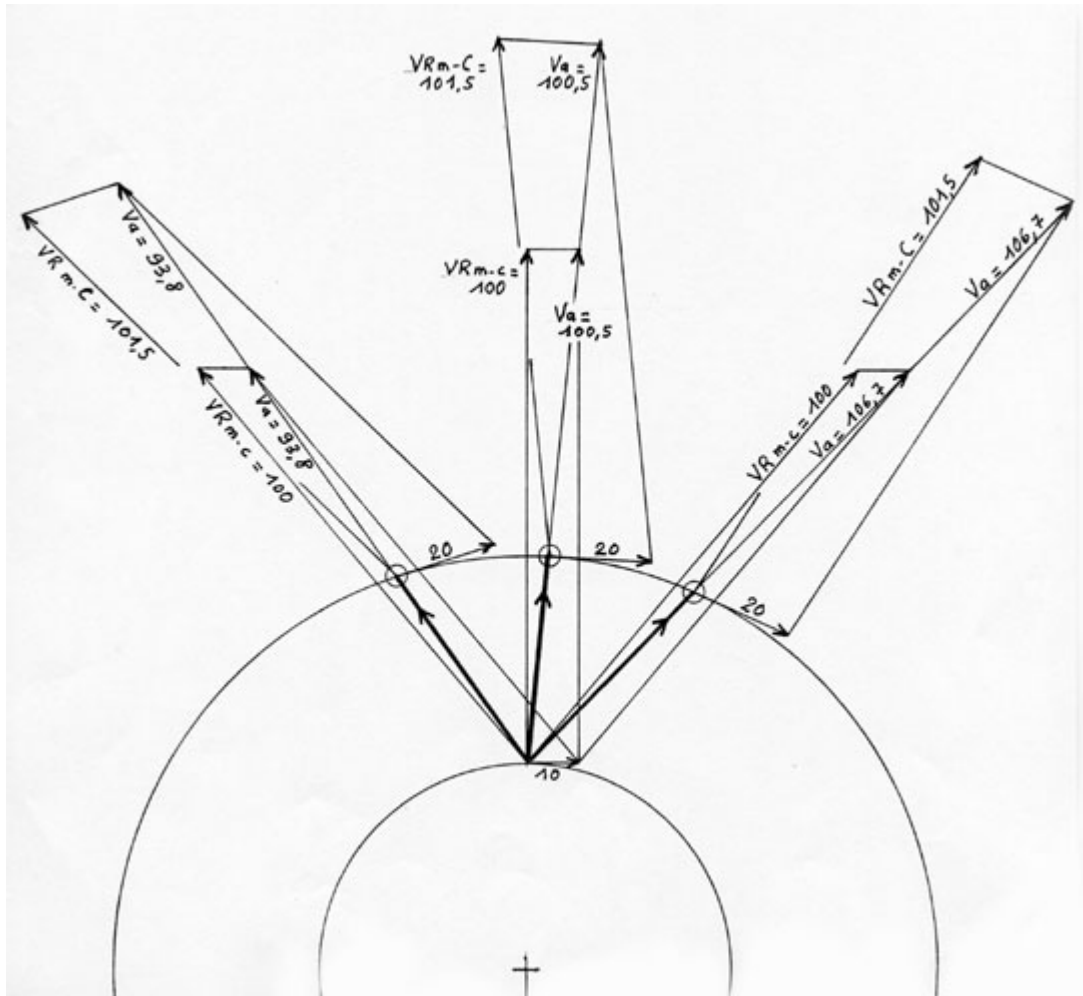
Generally speaking, this calculation demonstrates that a molecule going towards the external cylinder sees its relative speed and its kinetic energy increase, whereas they decrease when the molecule goes towards the internal cylinder, and this depending on the distance or the closeness of the molecule from the axis of the moving spinning-top.. For instance, if one measures the increase of the relative speed from the wall of the internal cylinder until an intermediary impact between the two walls, integral with the spinning top, then from this intermediary impact until the wall of the external cylinder, the two increases put together correspond to the one we get when the molecule goes directly from one wall to the other. Consequently, the difference of temperature between the walls will not vary according to the free mean path of a molecule in the gas, that is to say according to the density of the gas. If there is a variation of this gap, it will be due to a weaker difference of temperature

coming from the air at the atmospheric pressure, certainly induced by the movements of convection that I have described above (see air pressure).

Passage of a molecule from the internal cylinder to the external cylinder.

$$\frac{VR_{m.C}}{VR_{m.c}} = 1,015$$

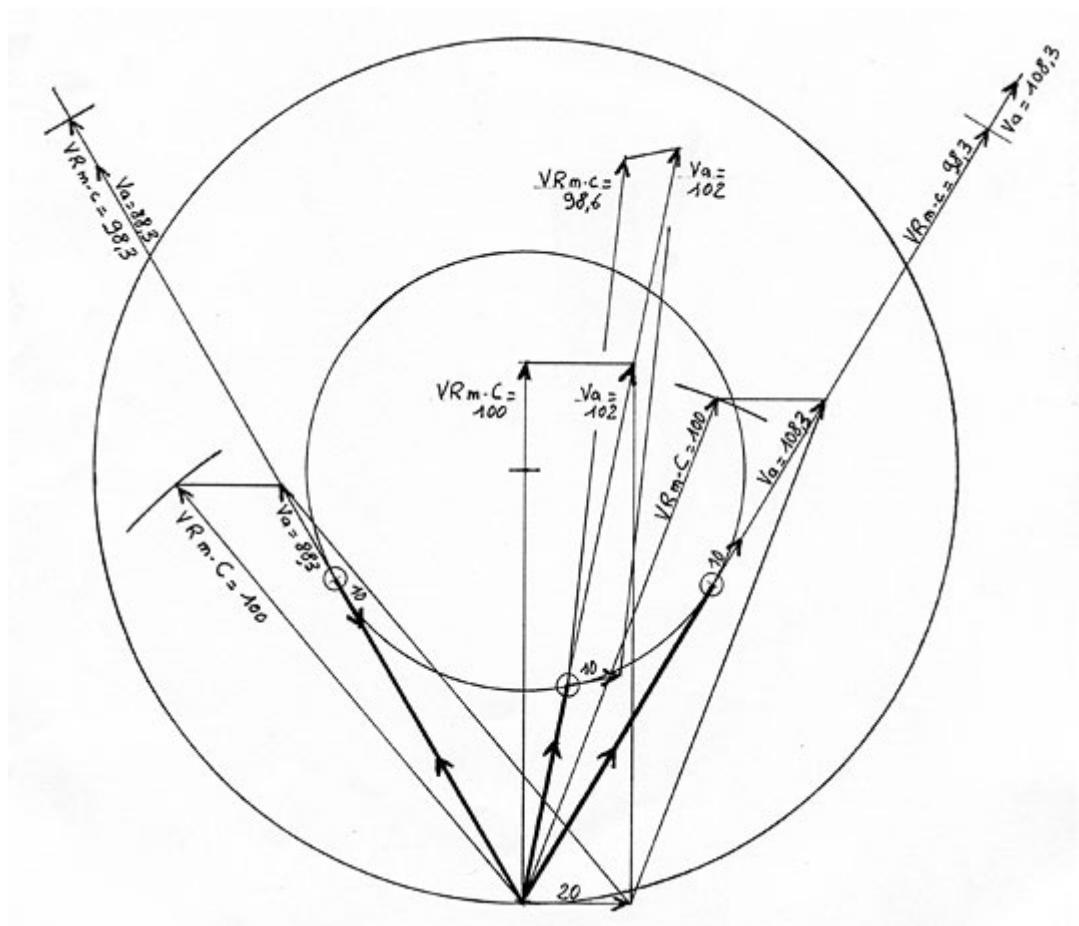
In the three directions, the relative speed increases of 1.5% that is to say an increase of 3% of the kinetic energy.



Passage of a molecule from the external cylinder to the internal cylinder

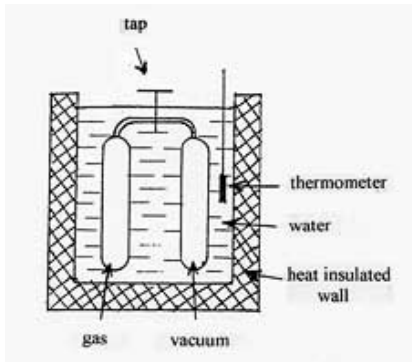
$$\frac{VR_{m.c}}{VR_{m.C}} = 0,985$$

In the three directions the relative speed decreases of about 1.5%, that is to say a decrease of 3% of the kinetic energy.





## Illustration of the principle by the Joule experiment



It is an experiment in which a gas is let to expand from one compartment to the other. The two compartments are linked together through a narrow aperture as indicated on the diagram opposite. Shortly after the gas has been distributed in both compartments, the temperature is measured and compared with what it was before.

### Perfect gas:

It doesn't change in the case of an ideal gas in which no intermolecular attraction occurs (Van der Waals' interactions). This can be easily understood as no energy is freed out of the system, contrarily to what takes place in an engine in which the gas yields energy to the piston which turns it into work.

### Imperfect gas:

It is different with a real gas in which a cooling occurs just after the expansion, which is due to the increase of the volume taken which moves the molecules away the one from the others. Indeed, when two molecules belonging to such a gas get close enough the one from the other, they attract each other, they fall on themselves as in a hole and so, their kinetic energy and their temperature increase. Consequently, when the gas expands, the free mean path of the molecules increases and the molecules don't "fall" so often, their average level of kinetic energy is less high and the gas is cooler.

### Natural and artificial attractors

The molecules behave like attractors with one another. One thus realizes that the temperature of the gas could vary if one could diminish or increase the role of the attractors, that is to say modify the frequency of the interactions. We can't make the molecules meet more or less frequently but we can add some artificial attractors. This invention rests exactly on this principle. By fixing some attractors at the surface of a wall, which can be a metal grid charged as described in the experimental configuration, some ions, one increases the energy of the particles which come and hit the wall and we warm it.

**Comparison between this process and the process based on a vacuum diode**

Some people told me that my process looked like the one based on a vacuum diode, in which a cathode with a very low work function cools under the emission of electrons and they didn't really see why this process should spend less energy.

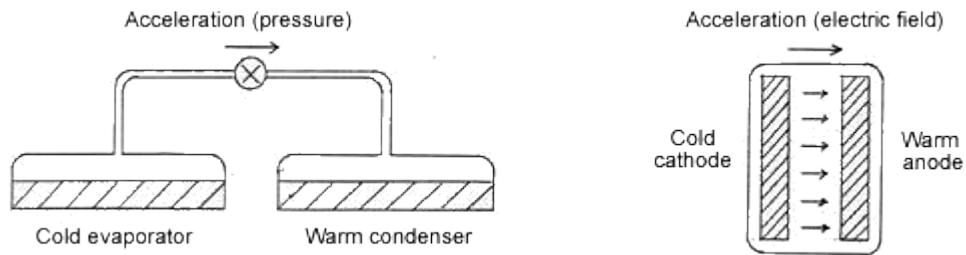
In both process, we actually find particles which transfer energy from a cold plate to the opposite warm plate thanks to an acceleration force of the particles. In the vacuum diode, we have charged particles ( electrons) accelerated by an electric field , in the actual process, we have electrically neutral particles (gas molecules) which polarize themselves by penetrating into an electric field located at the surface of the plate called "electrostatic" and which by so doing, are attracted towards the plate.

Why is there no energy consumed with this principle of acceleration? Indeed , in the ideal device, in which the electric insulation would be perfect or in a configuration in which an electric field is produced without a generator, a molecule polarizes itself and let itself being attracted into the electric field but, after having hit the plate and yielded energy by thermal accommodation, it bounces, depolarizes itself when getting out of the electric field and consequently slows down while undergoing the same attraction energy. So there is no more energy globally spent ( $W=0$ . We remember the imagery of the ball falling on a planet mentioned before). The only wanted effect is for the molecule to get out of the electric field with a kinetic energy lower to the one it had before penetrating into the electric field, as if it hit an ordinary cold plate.

But, in the vacuum diode, the heat transfer from one plate to the other depends on the acceleration of the electrons from the cold cathode towards the warm anode. The electrons acceleration work from the cathode towards the anode is made necessary by the fact that the cold cathode has more difficulties to emit electrons than the warm anode.. Indeed, the electric current can only circulate freely (without resistance) if both electrodes are at the same temperature. As soon as the cathode is colder than the anode, it has more difficulty to emit electrons than the anode and there would be a return of electrons from the anode towards the cathode if the accelerating electric field was suppressed (it is the principle of a thermoionic generator). It is thus necessary to compensate this emission "difficulty" of the cathode by the acceleration of the electrons towards the anode.

This can be simply compared to a mechanical compression pump by replacing the cathode by the evaporator and the anode by the condenser (see diagram below). When the evaporator and the condenser are at the same temperature, the steam can flow freely (without any resistance) from a compartment to the other. Because of this steam flow, there is, in the evaporator, a higher number of molecules which evaporate ( than molecules which condensate) and in the condenser, a higher number of molecules which condensate (than molecule which evaporate). The evaporator is thus going to cool down and the condenser to warm up. Therefore the molecules have more difficulty to evaporate in the cold evaporator and there would be a return of steam from the condenser towards the evaporator if the passage between both compartments was freed ( it is the principle of the thermodynamic engine). It is therefore necessary to "accelerate" the molecules towards the condenser, which

means, practically speaking, that a depression must be created into the evaporator with the help of a pump.



The present process doesn't belong to this schema any more. The great difference with all the existing processes can be explained as follow: the work fluid, here some polarizable gas, SF6 or other, doesn't undergo anymore cycles of thermodynamic change of state. For instance, in the mechanical compression pump, the fluid evaporates in the cold evaporator, then liquefies in the warm condenser. The temperature, the pressure and the state of the matter are changed when changing of compartment. This is the same for the vacuum diode: the electronic fluid "evaporates" at the cold cathode, then "condensates" at the warm anode. The temperature, but also the "electronic pressure" increase when passing from the cathode to the anode, the electronic fluid therefore undergoes a thermodynamic change of state.

In this process, there are no more cycles of thermodynamic change of state but several thermodynamic states co-exist in the gas, the pressure and the temperature being higher against the electrostatic plate. The same thing occurs in the atmosphere where the pressure and the temperature decrease as one rises in altitude. The gas can be in thermal equilibrium in spite of these differences in temperature and pressure.. In this process, the heat transfer comes from the thermodynamic disequilibrium that is created in the gas by reducing the difference of temperature between the plates compared to the one we would have if it was only due to the attraction field. This reduction can be achieved, for instance, by cooling the warm plate or by warming the cold plate (or both at the same time).

It is also necessary to stipulate that if the particles don't collectively undergo a cycle of change of state anymore, an individual or molecular cycle remains which performs exactly the same function. That is to say that it is impossible to follow a group of particles whose pressure and temperature increase in a compartment, maybe with a change of state of the matter and which then turn back into their initial state in another compartment, etc...; but each molecule of gas located between the plates carries out at any moment a phase or another of a cycle called molecular and this absolutely independently of their neighbor-molecules: a molecule will be accelerated when penetrating into the electric field while another one yields energy by thermal accommodation on the warm plate, while still another one slows down when getting out of the electric field or while another one recovers energy by thermal accommodation on the cold plate.. All these phases of the cycle take place at the same time and it is impossible to detect a macroscopic motion as it was possible to do with the existing processes.

## **An invention on the Internet , why ?**

After having read those pages, I hope the reader will understand the hope brought by this idea. As far as I am concerned, I must admit that it is a considerable challenge but considering the technical tools we nowadays have at our disposal ,I think it is a much easier challenge to take up than the one of other inventions in their time, such as the steam or the explosion engine for instance. This is nothing compared to the aviation which was not only a technical achievement, the engines of that time being not powerful enough compared to their weight, but also a scientific challenge .

Undeniably, the solution goes through a public research, where each company, each organization or institute, each researcher would have the possibility to participate in the launching of the project. So, following this logic, the internet seems the ideal solution to spread a project such as this one. But this means of information presents an absolutely new advantage. Some space on the site is available for all those who want to intervene, give an advice, ask a question (or answer it) or propose their services. It becomes possible for those who wish it to directly act in concert with the others to gather all the data, material, intellectual and financial forces which are necessary to launch the project.

So, if you wish to participate in a way or another, you can have it known publicly by sending me, by letter, fax or E-mail, a note that I will introduce on the site in the readers mail file. You can also use the News group.

I propose to yield the French patent to any person able and willing to promote the project in the best way.

I thank all those who will accept to get interested in this project, to give it some of their time, their skills, their energy and talents.

French patent            publication number: 2 775 340  
Patent PCT            publication number: W0 99/43995

J.L. Brochet.



- If you notice any translation mistake, please let me know.
- You might be a member of a News group on the internet and might wish to talk about my project in your language. In that case I would like you to send me the address of your News group that I will introduce in the file: “News groups where the P.A.C.E.S is discussed” ( at the end of the French site)
- For country without translation, I encourage you to create another similar site in your language. In that case also, I will insert your site in the file “Foreign equivalent sites”. There are some software to ‘absorb’ an internet site. Ask a site creator.