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"Solar-dam": for Retrieving Energy from the Sun

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ABSTRACT

A very simple solar engine is described herein. Since it is a mechanical device, with moving parts, its practical usefulness may perhaps be low when compared with modern systems based on semiconductor solar cells. Nevertheless, due to its extreme simplicity, and as it is easy to build in several formats and dimensions, it deserves to be mentioned and described. It should be considered more as a concept than a completely tested device. At least, out of curiosity and as a didactic model, it is hoped that it will be of interest to many. Home-made versions of the *solar-dam* concept have been built using day-to-day materials, and then minimally tested in order to verify their correct operation. Most of the time they behaved as self-oscillating devices, which started automatically at sunrise, and only stopped at sunset. However, it is believed that they could all cycle continuously if they were properly adjusted. Such machines could also be used as dynamic elements of architecture, acting as good examples of the conversion of sunlight into mechanical energy at ambient temperatures.

1. **Introduction**

It is a fact that solar energy enthusiasts have lately become less enthusiastic, whilst around the world, people are complaining about less and less sunlight reaching the Earth's surface due to frequent obstruction by an abnormal quantity of man-made clouds appearing in the skies[1]. Figure 1 shows a strong case of these types of clouds. Recently, solar energy suddenly seems to have been placed in the background.

Fig. 1 Man-made type of clouds observed all over the world.

Unfortunately, as I suffer from rhinitis, which is probably worsened by these cloud forming particulates, the reader will forgive me if I write a few more lines about this topic: it is public knowledge that weather experts have detected a significant increase in the temperature of the planet since 1995, but also that, prior to this data shows something "abnormal" had already started occurring during the period 1920-30[2]. In order to curb such a tendency, some scientists have proposed that our globe should be covered with artificial clouds to

[1] Some people would call this subject a simple "controversy", but the truth is these clouds are extremely well documented all over the world by independent articles and photos and video footage on the Internet. It is also a mystery that no university around the world seems to be interested in studying the phenomenon, while the media keeps silent about it too.

[2] Read about "global warming" in *wikipedia.org*, for example.

reflect 10-20% of the sunlight back to space, thereby reducing the warming affect. Edward Teller, the nuclear physicist closely connected to the first Atomic Bomb, and the "father" of the Hydrogen Bomb[3], seems to have been one of those who advocated and proposed this solution[4]. It is hard to imagine a human being proposing sinister solutions for mankind, but in many cases history tells a different story, and so people should at least become better informed about this subject.

The more we use solar energy, the less the planet will warm. But one of the most concerning issues is not about how to produce clean energy, but instead about questioning what are we doing with the energy we produce. Basically, would it make any sense to spend money and resources generating clean energy if the majority of people would live with open windows during winter, or if such energy would be used for war, for example? How many family houses could be fed, and for how long, by the energy of the simplest Atomic Bomb? Wouldn't it be simpler and more intelligent to close the windows and reduce the astonishing pace of the ever growing weapons industry? Global *efficiency* seems to be the modern issue, not the production of energy, in my opinion, but societies in general are still extremely resistant to understanding this idea.

2. Why "solar-dam"?

This system has been named "solar-dam" because it naturally resulted from an association of thoughts concerning the principle of operation of a normal water dam, roughly depicted in figure 2.

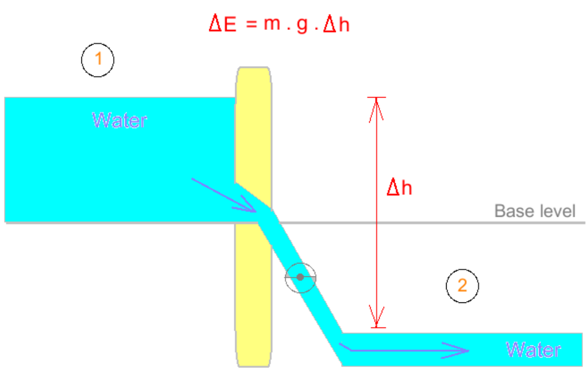


Fig. 2 Simplistic diagram of a water dam.

It is known that these huge water machines are structures made of two sides. They could be thought of as being made of two reservoirs, interconnected by a tube through which the water flows when energy is to be transformed into electricity. This flow is due to the differential of pressure between the two sides. This pressure comes from gravity, that is, from the difference in gravitational energy between side 1 and side 2. With time (and rain), the reservoir 1 is filled with new water, and the potential energy rises with the increase of the *mass* of the liquid and the *height* above the reservoir 2. The stored energy is simply given by $\Delta E = m.g.\Delta h$, g being the acceleration due to gravity, as we know.

A question that came to my mind when I was around 16 years old[5], was the following: could there be a way of inverting the process after the reservoir 1 is empty, in order to create a sort of oscillating device based on this principle? Around that time the answer appeared to be: yes, that could be done if, after emptying reservoir 1 into reservoir 2, one would elevate the reservoir 2 and lower reservoir 1. That, of course, is difficult to do in a normal water dam, but the process is much simpler to implement when the "pressure" of gravity is replaced by the "pressure" induced by sunlight, as we will see.

3. The "solar-dam" concept

Two equal reservoirs are used in the "solar-dam", through which a *constant volume* of a fluid is made to oscillate. In some ways, this is similar to the concept of the *Stirling engine*[6] due to the fact that the same fluid will forever be maintained in the interior of the machine, and the transfer of heat (thermodynamic energy) into mechanical work is made at each oscillation of the fluid.

In the first version of the "solar-dam", these two reservoirs communicated through separate tubes, one for each direction of flow, allowing the fluid to be transferred from reservoir 1 into the reservoir 2 and vice-versa. Each time the fluid was transferred, mechanical energy was produced. To guarantee that the machine cycled, once the fluid had been transferred, the machine was rotated to invert its

[3] http://en.wikipedia.org/wiki/Edward_Teller

[4] Search the internet for the article "*Global Warming and Ice Ages:*"

[5] In effect I have imagined the "solar-dam" around that age, but the very first model, made of balloons of glass, which funnily had exploded in my hands, could not let me be sure if it would really work or simply explode. It is also funny that only some years ago I could return to the idea and verify that it works.

[6] http://en.wikipedia.org/wiki/Stirling_engine

position relative to the source of heat (See fig. 3).

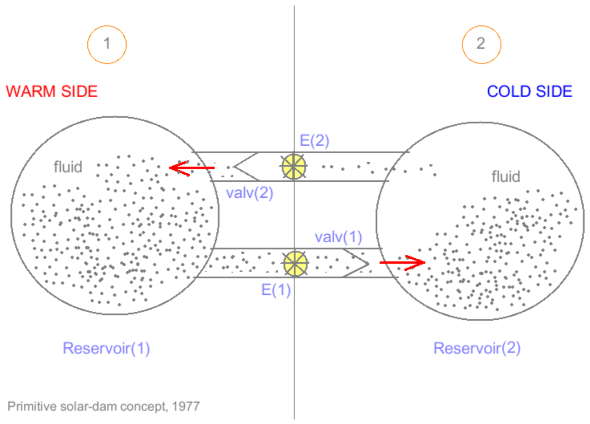


Fig. 3 The very first solar-dam engine, built of glass.

In this case, the fluid was heated on side 1, expanded through valve 1 into side 2, while producing the mechanical energy *E(1)*; once equilibrium was achieved, the entire system was rotated manually through 180º in order to invert the process. It was precisely at the moment I was touching side 1 to warm it with my hand that the machine exploded. The calculations were elemental and considered the fluid as being an ideal gas, with internal energy E_i roughly given by:

$$E_i = P.V = n.R.T_k \qquad (1)$$

which relates the pressure (P), volume (V), temperature in degree Kelvin (T_k), the perfect gas constant[7] (R), and the quantity of material (n) in number of moles.

We may now notice that there are *three* very important *rates* dominating the thermodynamics of this system: (1) the rate at which the energy increases in the warm side; (2) the rate at which energy decreases in the cold side; (3) the rate of transfer of material from one side to the other. To treat this problem in a thorough way is not so simple, and it is beyond the scope of this article, but at least we may realise that both the *quantity of material* and the *temperature* in each side are time-dependent functions, and it holds, for any instant of time:

$$n_1(t) + n_2(t) = constant = N_0 \qquad (2)$$

[7] R = 8,314472(15) J.K^{-1}.mol^{-1}

As well as a difference of energies of:

$$E1 - E2 = n1(t).R.T1(t) - n2(t).R.T2(t) \qquad (3)$$

As long as E_2 is different from E_1, the fluid may move from one side to the other and produce mechanical work. Notice that equation 3 may also be shortened as:

$$(E_1 - E_2)/R = n_1.(T_1 + T_2) - N_0.T_2 \qquad (4)$$

To this, we should now superimpose the *periodic rotation* of the system, which controls both the *time of exposure* to the heat source and the *period* of its cycle. Since it was not easy to make an estimation of the behaviour of the machine analytically, a software simulator was developed to provide an idea of what to expect from a real system, if it rotates with a certain frequency. For example, figure 4 shows the changes of pressure (P) in both reservoirs obtained from simulation.

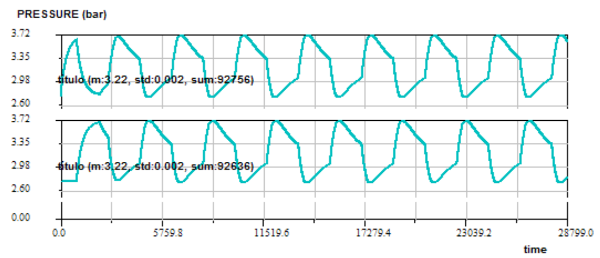


Fig. 4 Simulation record of the pressure inside recipients.

As one may notice, there is a 180º phase difference between the simulated pressures in the two recipients. The frequency of rotation was previously defined, and in practice it should be chosen in a way to achieve the best performance. Notice that this system is a case of an asynchronous system, and that more complex typologies can be tested, using a different number of recipients, instead of two.

4. The synchronous version

Although it would have been interesting to think about an asynchronous machine where the frequency of exposure of the recipients to the heat side could be monitored and controlled by a low power computer, it was decided that the next challenge would be the design of a practical "solar-dam" which would be self-synchronised by its own levels of pressure, thereby eliminating the need for any pre-programmed control. This issue has been reduced to the following two questions: (1) How to transform the "solar-dam" concept into a practical device with which electrical energy could be produced? (2) How to make the "solar-dam" rotate properly by its own "decision"?

The first problem was addressed by inserting, in each direction of fluid flow, a small turbine connected to an electrical alternator. To improve the efficiency of the process, a second fluid of higher density than the original gas was added to the machine, in order to drive the turbines more efficiently. Water was used for this purpose due to its low viscosity. The pressure inside each side of the devices was controlled by the heating and cooling of two independent and specially designed solar panels, one pointing directly towards the sun, the other directed away from it.

Thermodynamically, one can say that this model would operate between those two temperatures. The entire machine, which had been designed to rotate around its central axis, assumed the aspect shown in the Figure 5 below:

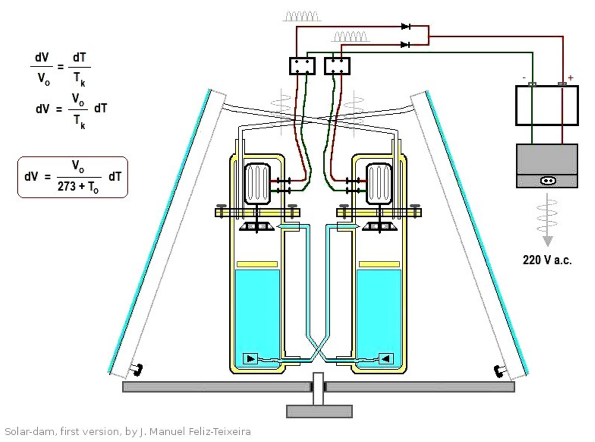


Fig. 5 First "solar-dam" model, from 2007.

This machine is vertically symmetrical, and can be considered as twin systems connected to each other. The only requirement to start it's operation is to rotate it such that one panel faces the sun. Each solar panel contains a gas and each reservoir is filled with a quantity of water. As the gas heats up, it expands, forcing some reservoir water through the communicating tube and valve, such that a jet stream of liquid periodically drives the opposite turbine. The two electrical generators are independent, being connected in parallel after rectification of their signals and finally charge a battery bank. Unfortunately, a prototype of this idea was never constructed due to the lack of financial support.

The second problem was resolved using the force of gravity. Since the machine changes its centre of mass while in operation due to the movement of the liquid, and masses "tend to fall to the centre of mass", a slight inclination of the machine from vertical was enough to make it start oscillating.

5. Maximum efficiency

The real efficiency of this machine could not be tested, but it is interesting to try to estimate its maximum value based on the ideal Carnot Cycle efficiency, which depends solely on the absolute temperatures of the warm (T_{wk}) and cold (T_{ck}) sides, and is given by:

$$eff_{carnot} = 1 - T_{ck}/T_{wk} \quad (5)$$

Or, considering the temperature difference:

$$T_{wk} - T_{ck} = \Delta T$$

by:

$$eff_{carnot} = \Delta T / T_{wk} \quad (6)$$

During some measurements performed on a different "solar-dam" model, it was observed that it operated easily within temperature differences of the order of ΔT = 60ºC on an average sunny day. So, under these circumstances, considering an ambient temperature of 25ºC (298 K), the maximum possible efficiency for this machine would be 20%, which may be considered as an interesting value.

6. More recent "solar-dam" design

Further work based upon these ideas led to a much simpler "solar-dam" device design, of which it would make sense to build a prototype in order to test its behaviour and efficiency. The simplification achieved resulted from the elimination of most of the components of the previous solution, reducing it to a device composed of two recipients connected by a single tube, into which pressure is supplied by two independent solar panels, as shown in figure 6.

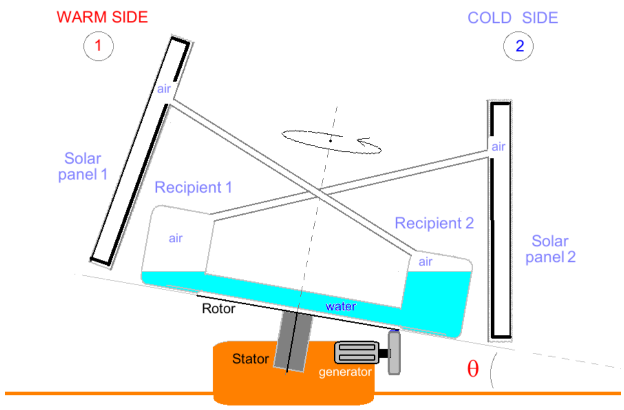
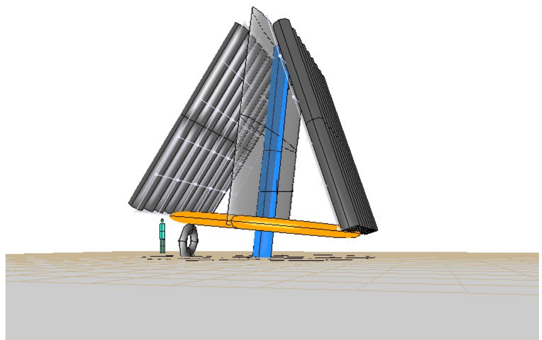


Fig. 6 The simplest "solar-dam" model, from 2009, showing properties of both a solar and a gravitation engine.

Obviously, when the pressure from the panels moves enough water to the opposite reservoir, the system rotates by 180º and the process repeats. Notice that, at any instant, both the *warming effect* and the *cooling affect* contribute to moving the water into the same side of the machine. The changing of the centre *of mass* is, therefore, very effective, allowing the system to easily start oscillating. In this case, the machine is a gravitation engine, since gravity is used to rotate it. The pressure forcing the centre of mass into movement comes from sunlight (thus it is also a solar engine) but can also be supplied by anything that introduces a difference of temperature between the two sides. Notice also that the optimum condition of operation can be adjusted by simply adjusting the angle *θ*.

7. **Some solutions and conclusions**

As one can imagine, a variety of devices could be created based upon this principle. The ones presented in the following figures are only some conceptual examples of what can be made. In figure 9, however, a very rustic model made of plastic water bottles is shown, with its four recipients mounted in a cross, instead of two. The dimensions of these systems can obviously vary, from some centimetres to the height of a building. Since they are very light engines, it would be ironically funny to build one the size of a real water dam. However, we would be delighted to participate in such a project, if



anyone is willing to finance it.

Fig. 7 Concept of a "solar-dam" of around 7,5m high and 25m^2 of exposed area (~25KW of sunlight). The wheel on the ground represents the electric generator.

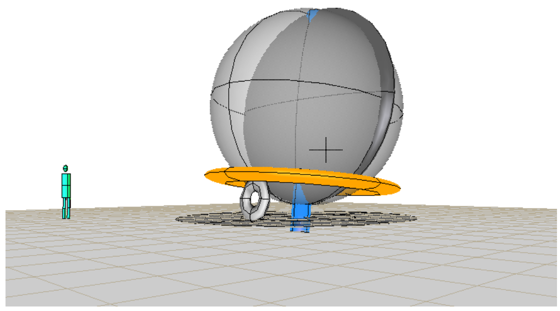


Fig. 8 A "solar-dam" oscillating sphere (~20KW).

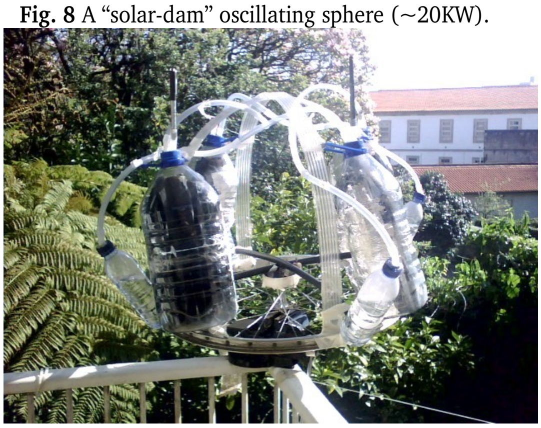


Fig. 9 A rustic "solar-dam" experiment which worked.

Author's Biography:

J. Manuel Feliz-Teixeira graduated in Physics at the Faculty of Sciences in the University of Porto, Portugal, and received an MSc in Mechanical Engineering and a PhD from the Faculty of Engineering of the same university. He is now dedicated to new approaches for renewable energy, as well as trying to relate anti-gravity phenomena and Classical Mechanics.