INVESTIGATION OF CLAIMS OF PROPOSED GRAVITATIONAL ENERGY CONVERTERS

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1. Introduction

A claim that resurfaces from time to time in the energy community is that under the right conditions it is possible by means of specially-constructed mechanical devices to convert gravitational energy into useful work Although conversion of gravitational energy into useful work is a known phenomenon (it takes place, for example, in hydroelectric power plants), proven conversion processes to date are based on access to secondary energy sources to function (the solar-energy-driven evaporation/precipitation cycle constitutes the secondary energy source in the case of hydroelectric power).

The physics that lies behind the failure of self-contained mechanical devices is simply the fact that the gravitational potential is conservative; an object of mass m in a gravitational field g dropped a height h delivers energy due to the conversion of gravitational potential energy mgh into kinetic energy, but returning the mass to its original position for a repeat cycle requires that the mgh energy be resupplied – hence no surplus energy gain over the cycle. In a technical sense it is this *position-dependence* of gravitational potential energy that prevents conversion by a self-contained, free-running device, and the literature of naïve attempts to circumvent this basic principle on the basis of overbalanced wheels and related devices constitutes a monument to the proof of the principle. Why then, one might ask, is it a topic for further discussion?

2. Further Consideration

The reasons for further consideration are two, one historical, one theoretical. In the history of claimed gravity-driven mechanical devices one stands out – the Orffyreus Wheel of the early 1700s [1]. Orffyreus' Wheel is claimed by contemporary reports to be the only instance on record of a machine that was observed to be capable of doing external work and yet apparently independent of any external (or hidden internal) known source of power. It was demonstrated numerous times in public, was subjected to official tests, some of quite sophisticated complexity, and, though subject to considerable skepticism, was never disproven, though many tried. Tests by known scientists of the day (such as close colleagues of Newton) included one in which the wheel was reported to have been set in motion inside a locked castle room for 53 days and found to still be revolving when seals on the door were broken and the room reopened. Though details of its construction were never revealed to the public, they were revealed to a well-respected local landholder and leader in the community (a count) who attested that the device was an ingenious invention, not a fraud, and who then financed its further development and demonstrations. Seemingly in support of the inventor's claim, the inventor offered the device for sale, even agreeing to the requirement that the funds be placed in escrow with a third party until the buyer was satisfied that the claims were genuine, but, alas, no one stepped forward and the secrets of the device were taken to the grave by the embittered inventor and never revealed by his patron.

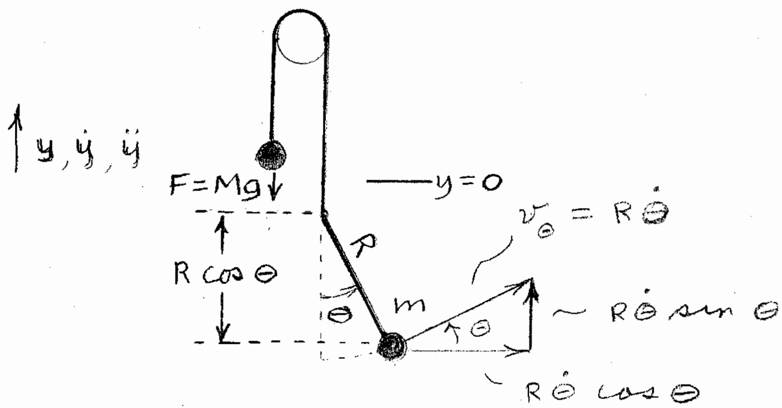
On the theoretical front, a little-known paper by Sir George Airy, Director of the Cambridge Observatory and Astronomer Royal, addressed the issue that if the *position dependence* of a force acting on a body was abrogated (e.g., if the force should depend not on the position of the body at the instant of the force's action, but on its position at some time preceding that action), then the theorem preventing perpetual motion from what on the surface appeared to be an apparently conservative force would no longer be applicable [2]. This has led to speculative investigation of concepts and devices in which, for example, inertial forces in the present that depend not on present but past positions of its components might satisfy this criterion. A simple example that has been oft-proposed to satisfy this criterion is provided by a pendulum whose magnitude of force connecting bob to pivot (inertial plus gravitational) depends not just on the present position of the pendulum bob, but on its earlier position in the gravitational potential, and coupled-pendulum devices have been constructed and patented that claim to take advantage of this principle [3].

To return to the original argument concerning drop of an object in a gravitational field, the following thought experiment captures the essence of the proposed concept. If one could drop an object and then temporarily "turn off" its mass before repositioning it at its starting point for the next cycle, then, without a doubt, gravitational energy could be converted to useful work. Though a mass cannot be "turned off," its effects can be modulated by, e.g., a pendulum embodiment in which a maximum downward (inertial plus gravitational) force on a pivot at the nadir of the pendulum's motion can be used to do significant work (e.g., raise a mass greater than the pendulum bob mass), only to be repositioned (reset) later in its swing, at which time work is done against a downward force that is considerably diminished – a seductive-sounding argument indeed. It was to investigate, and to clarify the issues surrounding, the range of possibilities (several of whose configurations are employed, e.g., by the Serbian inventor V. Milkovic and associates [3]) that the following analyses were performed.

3. Analysis of Models Simulating Coupled Mechanical Oscillators

(a) Mass-Pendulum

Consider the configuration shown below, wherein a mass M (>m) is connected by roller to a pendulum whose pivot is massless and possesses a bob mass m.



For the pendulum bob the velocity-squared is given by

$$v^2 = v_x^2 + v_y^2 = R^2\dot{\theta}^2\cos^2\theta + \left(R\dot{\theta}\sin\theta - \dot{y}\right)^2 = R^2\dot{\theta}^2 + \dot{y}^2 - 2\dot{y}R\dot{\theta}\sin\theta\,,$$

where the over-dot represents a time derivative, d/dt.

One can express the kinetic energy T and potential energy V of all the masses as

$$T = \frac{1}{2}M\dot{y}^2 + \frac{1}{2}m\left(R^2\dot{\theta}^2 + \dot{y}^2 - 2\dot{y}R\dot{\theta}\sin\theta\right), \quad V = Mgy - mg\left(y + R\cos\theta\right)$$

The dynamic equations for the problem are easiest derived (without approximation) using the Lagrangian technique wherein for any particular variable q (in this case y and θ) one forms the Lagrangian $L = T - V$ (T, kinetic energy; V, potential energy) and determines the equation of motion from

$$\frac{d}{dt}\left(\frac{\partial L}{\partial \dot{q}}\right) - \frac{\partial L}{\partial q} = 0$$

(Alternatively, one can use Newton's laws of motion.)

For the y and θ variables of interest one obtains

$$M\ddot{y} = -m\ddot{y} + mR\dot{\theta}^2 \cos\theta + mR\ddot{\theta}\sin\theta - Mg + mg$$

and

$$\ddot{\theta} = -\left(\frac{g}{R} - \frac{\ddot{y}}{R}\right)\sin\theta$$

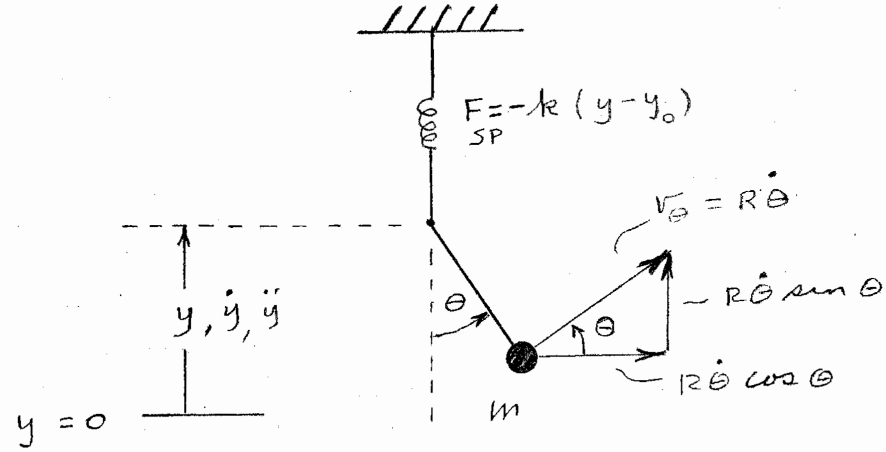
Given that the total energy of the configuration is given by $E = T + V$, one can determine the buildup of energy over time (should it exist) by evaluating dE/dt, substituting the equations of motion where required. The result turns out to be (unfortunately for energy generation) $dE/dt = 0$; i.e., the self-contained energy of the machine's components is conserved. This result indicates that, in the presence of inescapable friction losses, the configuration as diagrammed above does *not* result in the conversion of gravitational energy into increasing device motion which could then in principle be used to perform work on an external system.

(b) Spring-Pendulum

Analysis of a spring-pendulum configuration (shown below) proceeds as in the case of the mass-pendulum of (a) above, with the kinetic and potential energies given by

$$T = \frac{1}{2}m\left(R^2\dot{\theta}^2 + \dot{y}^2 + 2\dot{y}R\dot{\theta}\sin\theta\right), \quad V = mg\left(y - R\cos\theta\right) + \frac{1}{2}k\left(y - y_o\right)^2$$

where y is the position of the (massless) pivot.



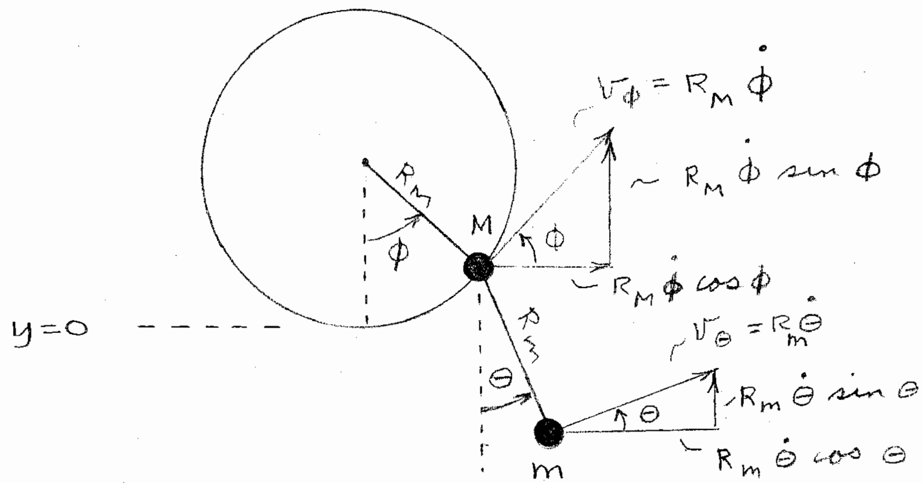
Following the procedure of (a) above, one again obtains the equations of motion, forms the expression for the energy $E = T + V$, and by substitution of the equations of motion into the expression for dE/dt finds that for this case also, $dE/dt = 0$. Once again we arrive at the result that the configuration as diagrammed above does *not* result in the conversion of gravitational energy into increasing device motion which could then in principle be used to perform work.

(c) Wheel-Pendulum

Analysis of a wheel-pendulum configuration (shown below) proceeds as in the cases above, with the kinetic and potential energies reducing to the form

$$T = \frac{1}{2}(M+m)R_M^2\dot{\phi}^2 + \frac{1}{2}mR_m^2\dot{\theta}^2 + mR_M R_m\dot{\theta}\dot{\phi}\cos(\theta-\phi)$$

$$V = MgR_M(1-\cos\phi) + mg\left[R_M(1-\cos\phi) - R_m\cos\theta\right]$$



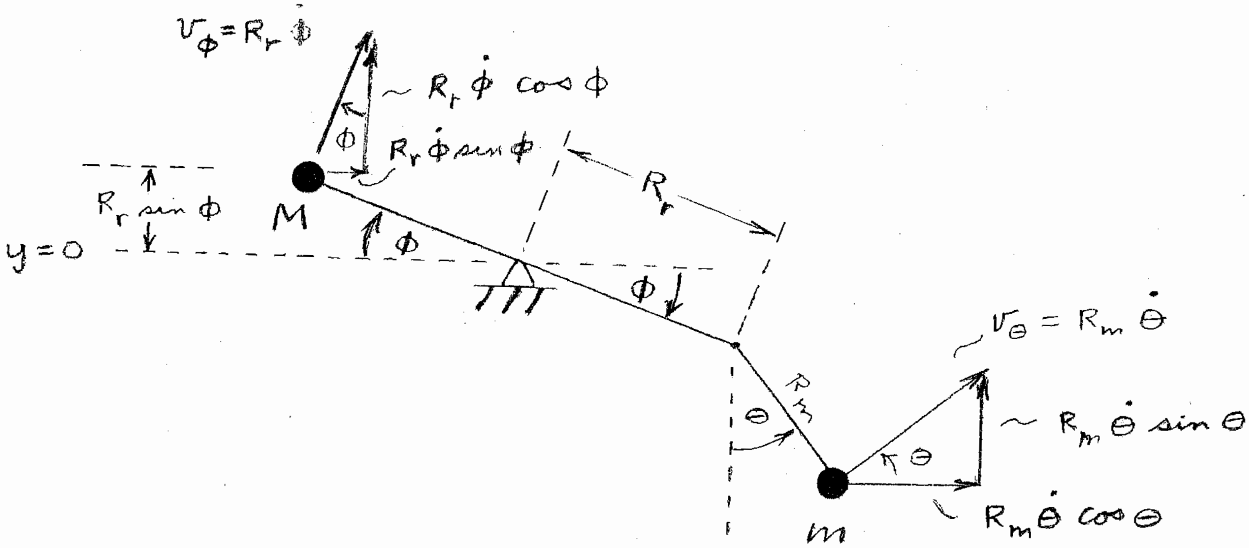
Following the procedures of (a) and (b) above, one again obtains the equations of motion, forms the expression for the energy $E = T + V$, and by substitution of the equations of motion into the expression for dE/dt finds here also that $dE/dt = 0$. Therefore, this device, as the others analyzed above, does not result in the conversion of gravitational energy into increasing device motion which could then be used to perform work.

(d) Rocker-Pendulum

As a final example in this series we consider the rocker-pendulum configuration (shown below). The analysis proceeds as above, with the kinetic and potential energies taking the form

$$T = \frac{1}{2}(M+m)R_r^2\dot{\phi}^2 + \frac{1}{2}mR_m^2\dot{\theta}^2 - mR_m R_r\dot{\theta}\dot{\phi}(\sin\theta\cos\phi + \cos\theta\sin\phi)$$

$$V = (M-m)gR_r\sin\phi - mgR_m\cos\theta$$



As in the previous cases, analysis by the Lagrangian technique leads to the conclusion $dE/dt = 0$, and therefore demonstrates that this device also does not result in conversion of gravitational energy into device motion that could result in useful work.

In place of considering further particular cases, we simply outline in the attached Appendix those specific conditions under which the Lagrangian technique leads to the outcome $dE/dt = 0$, in which case gravitational energy is not converted into useful work.

4. Conclusion

Although the results generated by the above analyses could have been anticipated on the basis of general principles, researchers on occasion call into question whether such umbrella treatments are in fact applicable to difficult-to-model configurations involving multiple interacting mechanisms, each part interacting independently with an external force such as gravity. As a result, detailed analyses are attempted, often without sufficient mathematical detail and on the basis of questionable approximations. Therefore, it is instructive to examine in detail (as was done here), and on the basis of appropriate equations without approximation, the class of standalone, free-running configurations most often considered (incorrectly, as it turns out) as potential converters of gravitational energy.

REFERENCES

[1] J. Collins, *Perpetual Motion: An Ancient Mystery Solved?* (Permo Publications, Leamington Spa, UK, 1997).

[2] G. Airy, "On certain conditions under which a perpetual motion is possible," *Cambridge Philosophical Transactions*, pp. 369-372 (1830).

[3] See, e.g., devices constructed by Serbian inventor V. Milkovic discussed on his website **http://www.veljkomilkovic.com/**

APPENDIX

The analysis procedure used to investigate the class of devices considered in this study was a standard Lagrangian technique which, in each case examined, led to a result that the sum of component energies in the self-contained, free-running device under consideration was conserved (i.e., $dE/dt = 0$). One might ask whether the derived results were implicit in the Lagrangian technique used based on an ingoing, but not explicitly expressed, assumption of energy conservation, in which case the derived results were inevitable. The answer for the class of devices examined here is a qualified yes, and examination of the steps involved in the development of the Lagrangian technique as employed here reveal where (and how) certain assumptions come into play.

We begin with a definition of total device energy as the sum of kinetic and potential energies *T* and *V* of its component parts,[1]

$$E = T + V .$$

The kinetic energy *T* (sum over separate mass components understood) takes the form

$$T = \frac{1}{2} m\dot{q}^2$$

where q is a position variable of interest, say, x, θ, etc. We note that

$$\frac{\partial T}{\partial \dot{q}} = m\dot{q} \text{ and thus } \dot{q}\frac{\partial T}{\partial \dot{q}} = m\dot{q}^2 = 2T$$

which leads to

$$E = \dot{q}\frac{\partial T}{\partial \dot{q}} - T + V .$$

We now define a Lagrangian function $L = T - V$, yielding

$$E = \dot{q}\frac{\partial T}{\partial \dot{q}} - L .$$

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[1] Assumption #1

Under the condition that the potential energy is not a function of velocity, $V \neq f(\dot{q})$,[2]

$$\frac{\partial L}{\partial \dot{q}} = \frac{\partial T}{\partial \dot{q}} - \frac{\partial V}{\partial \dot{q}} = \frac{\partial T}{\partial \dot{q}}$$

and thus we have

$$E = \dot{q}\frac{\partial L}{\partial \dot{q}} - L$$

If we now assume energy is conserved, $dE/dt = 0$,[3] we obtain

$$\frac{d}{dt}\left(\dot{q}\frac{\partial L}{\partial \dot{q}} - L\right) = 0 \quad \Rightarrow \quad \frac{dL}{dt} = \frac{d}{dt}\left(\dot{q}\frac{\partial L}{\partial \dot{q}}\right)$$

which expands to

$$\frac{dL}{dt} = \dot{q}\frac{d}{dt}\left(\frac{\partial L}{\partial \dot{q}}\right) + \frac{\partial L}{\partial \dot{q}}\frac{d\dot{q}}{dt}$$

By the chain rule, however,

$$\frac{dL}{dt} = \frac{\partial L}{\partial t} + \frac{\partial L}{\partial q}\dot{q} + \frac{\partial L}{\partial \dot{q}}\frac{d\dot{q}}{dt}$$

Under the condition that $L \neq f(t)$ explicitly,[4] $\partial L/\partial t = 0$, in which case the above reduces to

$$\frac{dL}{dt} = \frac{\partial L}{\partial q}\dot{q} + \frac{\partial L}{\partial \dot{q}}\frac{d\dot{q}}{dt}$$

Comparison with the expression preceding the chain rule indicates that

$$\dot{q}\frac{d}{dt}\left(\frac{\partial L}{\partial \dot{q}}\right) = \frac{\partial L}{\partial q}\dot{q}$$

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[2] Assumption #2
[3] Assumption #3
[4] Assumption #4

As a result, given the assumptions considered applicable to the class of devices under study, Lagrange's equation as used in this study take the form

$$\frac{d}{dt}\left(\frac{\partial L}{\partial \dot{q}}\right)-\frac{\partial L}{\partial q}=0$$

Therefore, exhaustive analysis of specific devices is not called for, only examination as to whether assumptions Nos. 1 - 4 outlined above apply to the class of device under consideration, in which case one must arrive at $dE/dt = 0$, and thus lack an energy gain mechanism that can be exploited for use.[5]

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[5] For further discussion see, e.g., H. Goldstein, *Classical Mechanics*, (Addison-Wesley Publ. Co., 1950), pp. 53-54; D. Wells, Schaum's Outline of Theory and Problems of Lagrangian Dynamics, (McGraw-Hill, 1967), pp. 91-92.