Hot & Motored: Generating Electricity with Footsteps

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***Abstract*—This document examines the plausibility & efficiency of generating power via footsteps, which could be used on pavements to generate electricity used for various purposes, depending on the user's preferences.**
Excuse the pun.

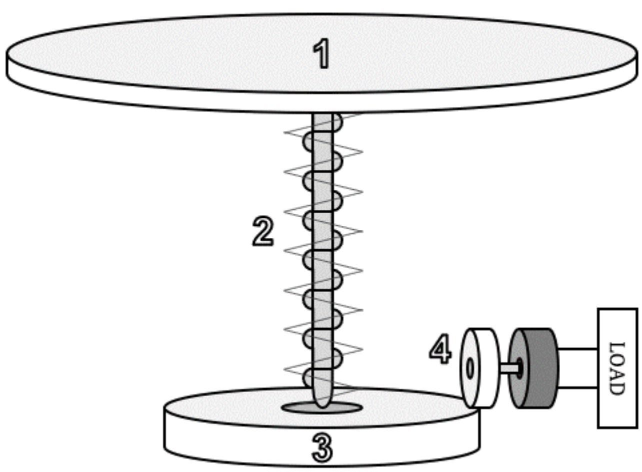
I. Mechanism Proposal

The proposed mechanism to generate electricity is comprised of multiple stages, and such operate in unison to provide the output voltage at the output stage.

A. Components Analysis

The mechanism itself involves a button/plate that, when pressed, would push a spiral down an entry point, compressing a spring. When such button/plate (thus, the spring) is released, the spiral is released to its initial position, in turn spinning the flywheel disc/gear that such spiral is fixed to, causing such to move in a rotational manner.

Fig. 1. Diagram of proposed mechanism to generate electricity from footsteps



Such mechanism is shown in Fig. 1 and is comprised of the following components (refer to labels on Fig. 1):

1) Plate which individual steps onto - such is supported by a compression spring
2) Spiral rod which inserts into Comp. 3's axle - such is attached to Comp. 1
3) Flywheel which Comp. 2 inserts into via an opening fitting the size of the spiral's rectangular body
4) Motor with additional gears connected to Comp. 3, where such is repurposed as a generator; such gears may include transmission stages

B. Operations of Mechanism

The mechanism is intended to operate per the following procedures (refer to labels on Fig. 1):

1) One steps onto Comp. 1, pushing Comp. 2 downwards & compressing the support spring
2) Comp. 2 moving downwards passes through slot in Comp. 3
3) One steps away from Comp. 1, resulting in the spring being released; such results in Comp. 2 moving upwards to its original position
4) Comp. 2 moving upwards now results in Comp. 3 rotating, causing Comp. 4's axle to also be rotated (due to the bevel gear connection)
5) The rotation of Comp. 4's axle results in EMF being generated at its output

One can surmise that power from **linear motion** (due to Steps 1 and 2) is converted to that of **rotary motion** (given by Step 4), and later converted via **induction** (per Step 5).

II. Theory

This section concerns the generator's output characteristics & how such is linked to the mechanical stage prior. Such refers to [1] in regards to theory & formula behind such operations.

A. Assumptions of System

Given reality, it is of no surprise that the system will encounter losses, and thus will not be 100% efficient. This therefore warrants for a number of assumptions to be made, to allow easier calculations & analyses of the system.

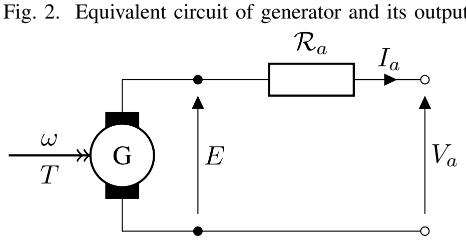
- There is no friction within the spiral - this results in the flywheel rotation a full revolution per one successful spiral turn
- Thermal losses (due to friction or thermal dissipation by the components) are neglegible
- The material themselves do not wear down or permanenently change form, thus allowing for sustained usage
- The flywheel rotates in a constant speed (thus, no acceleration or deceleration), akin to a step response

B. Generator Output Characteristics

The generator's output mechanism can be modelled as an equivalent circuit per Fig. II-B, where the following terms are defined:

- ω/T: Angular speed & torque of generator's input axle, dictated by its transmission gear & stages
- E: Output EMF of generator
- $\mathcal{R}_a$: Generator reluctance
- I_a/V_a: Current & voltage at load output of generator

Fig. 2. Equivalent circuit of generator and its output



Such is governed by the equations given by (1), where k_e is the **electromagnetic constant** of the motor/generator.

$$\begin{aligned} T &= k_e I_a \\ E &= k_e \omega \end{aligned} \tag{1}$$

Given Fig. II-B one can surmise the following information given by (2) and (1).

$$\begin{aligned} V_a &= E - I_a R_a \\ &= k_e\omega - \left(\frac{T}{k_e}\right) R_a \end{aligned} \tag{2}$$

C. Mechanical Input Characteristics

References

[1] N. Simpson, *Electro-Mechanical Energy Conversion*. Bristol, United Kingdom: UNIVERSITY OF BRISTOL Department of Electrical and Electronic Engineering, 2017.

III. Simulation

One utilises MATLAB's SimScape to simulate such mechanisms, and is comprised of three stages.

A. Schematic Diagram