(54) Title of the Invention: Electrical generator
Abstract Title: Regenerative shock absorber comprising electromagnetic linear generator or mechanical movement converter

(57) An apparatus for converting vibrations or undesired movements in a vehicle to utilisable electrical energy, one end of the apparatus being connected to a vehicle's body and the other being connected to the vehicle's wheel or a massive object within the vehicle, e.g. spare wheel or luggage. The apparatus may replace the shock absorber or damper of the vehicle, or may be connected to it. The apparatus may comprise magnets 211 arranged with alternating polarity and coils 231-238 to convert the AC derived from the magnetic flux to DC; or may alternatively comprise a mechanical system, such as a rack 193 and pinion 194, to convert linear movement to rotational movement to rotate an alternator.

FIG. 6
FIG. 11
GB 2465423 A continuation

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FIG. 2
FIG. 13
Electrical Generator

This invention relates to energy reuse in vehicles, and especially to utilization of energy caused by vehicle’s vibrations.

A great potential of energy is available in vehicles’ vibrations. Thus it may be desired to convert a portion of the kinetic energy of sideways movements, rotations and/or vibrations into electricity, rather than it being wasted as heat, as is common today.

The utilization of vehicle’s vibrations, such as vertical, rotational, side movements or any other unwanted movement or rotation of the vehicle’s body, caused as a result of the vehicle’s movement on the road, can be used for generating electricity. All types of these movements and/or rotations will be referred herein as vibrations.

This invention provides solutions on a system level – for a vehicles or crafts to utilize some of the vibrations’ energy, and convert it into electricity. The invention also details apparatuses capable of delivering electricity out of vibrations, thus these apparatuses and the system need not be combined together.

The invention further includes stroke movement enhancer means, using for example mechanical, hydraulic or "rack and pinion" like means. Other terms for indicating stroke movement enhancer means may include Stroke enhancer, Stroke amplification, Amplitude enhancer or similar terms as used in the art, which may be used interchangeably.

Further implementation of the system may be adjusted to movements of crafts over water and for motor vehicles on land - from private cars to trucks. Also usable in the air.

Two main apparatuses approaches are provided:

Apparatus A: to be connected between the vehicle’s body (such as the chassis) and the axels, wheels and/or to or instead of any form of vibration absorbers or dampers.
This apparatus can be used for any type of vehicle.

Apparatus B: to be connected between the vehicle’s body (such as the chassis) and a moving weight, such as a trunk, luggage, spare wheel etc, through a spring and/or any other form of vibration absorbers or dampers.

This apparatus can be used for any type of vehicle on road or craft at sea.

Thus, using any of these apparatuses, it is possible to utilize the kinetic energy caused by vibrations between two (or more) objects, to create an electric energy. The electric energy can be converted, such as from AC to DC, and can charge an electric battery.

Any one or more of several power transformation solutions can be implemented for utilizing the kinetic energy:

1. Direct mechanical connection – such as attaching a sprocket cluster to a chain.
2. Using hydraulic fluid or other piston device.
3. Using magnets arrangement – for converting the movement to flux.

These solutions may be beneficial; in addition to the profit of generating electricity and having additional energy supply source, there may be minimal overload on vehicle’s performance and/or engine.

The energy provided is clean. The system and/or apparatuses may have relatively low weight (in Watt/Kg ratio). There may be minimal friction, wherein the moving parts could be the bearings that support main magnet, for example.

Several apparatuses can be mechanically and/or electronically combined together in a vehicle.
BRIEF DESCRIPTION OF THE DRAWINGS

Fig. 1 details a top view of a vehicle with vibration absorbers / energy generators.

Fig. 2 details a side view of type A apparatus connection to a vehicle’s wheel.

Fig. 3 details a top view of a linear electrical generator using magnet device for converting kinetic energy to electrical.

Fig. 4 details a side view of magnets arrangement for utilizing kinetic energy.

Fig. 5 details a top view of slotted channel for efficient magnet device with rollers.

Fig. 6 details a side view of a cylinder with magnets arrangement and coils.

Fig. 7 details a top view of a cylinder with magnets arrangement and coils.

Fig. 8 details a perspective view of kinetic energy absorber bar with rollers.

Fig. 9 details a mechanical setup for a vibration amplitude enhancement using a lever (shock) absorbers / energy generators.

Fig. 10 details a mechanical setup for a vibration amplitude enhancement using hydraulic means.

Fig. 11 details a mechanism with a sprocket cluster connected to a moving column for converting linear movement to rotational movement.

Fig. 12 details two bars arrangement one of coils and another of magnets adjacent to each other.
Fig. 13 details magnets arrangement within a magnets bar.

**DETAILED DESCRIPTION OF THE INVENTION**

5
A preferred embodiment of the present invention will now be described by way of example and with reference to the accompanying drawings.

Fig. 1 details a top view of a vehicle 1 driving in direction V and having vibration (shock) absorbers / energy generators 2, four of them in the present example. For example, a four wheels vehicle can include two energy generator apparatuses 2 near its front wheels 11, and additional two energy generator apparatuses 2 near its rear wheels 12. The apparatuses should be symmetrical, however the front and back apparatuses, near the front and back wheels respectively, need not be the same. The energy generators 2 can replace existing vibration absorbers, or be connected next to them, so that some of the kinetic energy is delivered to the energy generators 2.

Fig. 2 details a side view of type A apparatus 2 connection to a vehicle’s wheel 11. The apparatus 2 can be connected to a vehicle’s chassis 13, next to existing (or new) spring 15, wherein some of the kinetic energy is delivered to the vibration (shock) absorbers / energy generators 2.

Thus, as there is a vertical, or other movement of the wheels relatively to the vehicle’s body (or chassis), some kinetic energy is created, and can be saved, rather than being wasted as heat on the spring 15.

Fig. 3 details a top view of a linear electrical generator using magnet device for converting kinetic energy to electrical.

A type A vibration absorber / energy generator, can be comprised of a stator ferromagnetic core 22 (and an outer package), a moving magnetic core 21 and a stator coil 23. The magnetic core 21 can be connected to one end of the apparatus, allowing it to move up and down and create a magnetic flux Φ at the ferromagnetic core 22, which
would create an induced AC voltage at the coil. The induced voltage can be delivered to an electric circuit, for charging a battery.

Fig. 4 details a side view of magnets arrangement for utilizing kinetic energy. Attaching means to chassis 229B on one side, and attaching means to wheels’ axle 229 on the other side, allow utilizing kinetic energy by vertical movement of magnets, part of core 211 (shown in upright, vertical orientation in the drawing). The adjacent magnet parts 211-215 are isolated between each other, and create a flux within the ferromagnetic cores 221-225, each magnet within one of the ferromagnetic cores, respectively.

The ferromagnetic cores 221-225 may encircle the magnets from below, and have an aperture at their top, allowing the magnets to move out (upwards) and in (downwards) for creating the magnetic flux. Each of the ferromagnetic cores 221-225 may have a stator coil 231-235 connected to it, respectively, for delivering induced voltage.

Fig. 5 details a top view of slotted channel cylinder 228 for efficient magnets’ bar 219 device with rollers 218. The magnets’ bar 219 may move upwards and downwards to the page, and be secured with rollers, allowing it to form magnetic flux as a result of the magnets movement within the ferromagnetic core cylinder 228, in a similar manner to that described.

This is a simple and practical implementation of the type A apparatus within a cylinder. A part of the cylinder may be made of an isolating ferromagnetic core, for allowing the magnets’ bar to form a changing magnetic flux.

Fig. 6 details a side view of the channel cylinder 228 with magnets arrangement 211, 211B and coils 231-238. The magnet parts 212 of the magnets arrangement can be in some distance from each other. There may be pairs and/or rows of magnets for closing a magnetic loop with changing flux, upon vertical movement. This formation allows having multiple magnetic loops, and forming induced AC voltages separately from each.
Fig. 7 details a top view of a cylinder with magnets arrangement and coils. Each pair of coils, such as the two coils 231 and 232, can be placed one above each other, to allow the magnets arrangement 211 and 211B slide therein using the rollers 218. The magnets arrangement’s shape can be adapted to the location of the coils pairs, so that maximal flux difference would be made as a result of the up-down movement.

Fig. 8 details a perspective view of kinetic energy absorber bar 219 with rollers 218. The bar and rollers can be adjusted to the location in which they are placed. It may be possible to have rollers at the top and bottom of the bar, so as not to interfere.

Fig. 9 details a mechanical setup of the vibration absorber / energy generator 2, for a vibration amplitude or stroke enhancement using a lever 19. The lever may be shaped to form a linear movement conversion ratio of R2/R1 thus allowing to set the torque, and easily adjust the vibration absorber to practical use. For example if there are only small vertical movements of the vehicle, then the lever 19 can be connected to the wheel of the vehicle moving/vibrating at an amplitude of about X, and move the bar within the cylinder at an amplitude of about Y. Stroke enhancement by the ratio \( Y = X \times (R2/R1) \) is achieved.

Fig. 10 details a mechanical setup for a vibration amplitude enhancement using hydraulic cylinders and pistons 191, 192 with a tube 196 therebetween arrangement. Thus, similarly to the mechanical setup of Fig. 9, an amplitude convergence of X to Y can be implemented, to match between actual vibrations and linear movement within the vibration absorber / energy generator. Stroke enhancement by the ratio \( Y = X \times (A192/A191) \) is achieved, where A192, A191 are the areas of pistons 192, 191 respectively. Alternately, the formula may use the Area times the Height value.

Benefits of utilizing this arrangement include, among others:

Hydraulic transformation and amplitude enhancement of the kinetic/vibrational energy will allow to place a type A aperture anywhere in the vehicle, possibly in various
positions. Cylinder 191 may be placed in an unoccupied area, such as the luggage compartment.

Fig. 11 details a mechanism with a sprocket cluster 194 connected to a moving chained column 193, for converting linear movement X to rotational movement Y. Optionally, an elongated and/or flexible shaft may be used for the rotational movement at point Y, allowing to locate the alternator in a remote/unused space.

An energy utilizing apparatus can be implemented by using an alternator using rotational energy, which is created by this mechanism - converting the linear X movement of vibrations to a rotational Y movement.

Fig. 12 details two bars arrangement one of coils 23 and another of magnets 21, adjacent to each other. The flux changes as a result vertical movement of either one of them. In a preferred embodiment, one bar is connected to the vehicle’s body and the second to the wheel or spring. In another preferred embodiment, a type B aperture may be used (for example connection to a spring).

Fig. 13 details magnets arrangement within the magnets bar 21. Induced voltages are provided from the coils L1-L6 (see Fig. 12), which can be connected to an electric circuit and to a battery.

The magnets can be placed in such a manner that there is high ferromagnetic isolation between them, and wherein their poles are placed in opposite orientations (South-North-South…) for creating maximal alternating flux through the coils L1-L6 and providing an induced AC voltages. The coils can be connected in a serial or parallel connection.

Using any one or more of the mentioned devices, the utilization of vehicle’s vibrations, such as vertical, rotational, side movements or any other unwanted movement or rotation
of the vehicle’s body caused as a result of the vehicle’s movement on the road for generating electricity, can be efficiently provided, such as an induced AC voltage. This voltage can be connected to an AC-DC converter, an optional regulator, then to a battery, such as the vehicle battery – for charging it. The energy thus saved can be used in operating the vehicle’s electric motor and/or other operational systems, such as lighting, air conditioning, steering, etc.

The abovementioned embodiments are compatible with the type A Apparatus, to be connected between the vehicle’s body (such as the chassis) and the axles, wheels and/or to various types of vibration absorbers or dampers. This apparatus can be used in any type of vehicle.

Moreover, these embodiments can also be adjusted for type B Apparatuses: to be connected between the vehicle’s body (such as the chassis) and a moving weight, such as a trunk, luggage, spare wheel etc, through a spring and/or any other form of vibration absorber. This apparatus can be used for any type of vehicle on road or craft at sea.

Thus, using any of these apparatuses, it is possible to utilize the kinetic energy caused by vibrations between two (or more) objects, to create an electric energy. The electric energy can be converted, such as from AC to DC, and can be stored by charging an electric battery.

Any one or more of several power transformation solutions can be implemented for utilizing the kinetic energy:

1. Direct mechanical connection – such as attaching a sprocket cluster to a chain.
2. Using hydraulic fluid or other piston device.
3. Using magnets arrangement – for converting the movement to flux.
4. Using electric circuit and/or electronic device, such as AC-DC adapters, using electric transformers, etc.
It may be possible to use one diode bridge rectifier for the entire coil array. It can also be possible to use a diode bridge rectifier for each of the coils, or for each of the bars.

Additional mechanical features may include stroke (travel) converter, for example up to 1:10 stroke converter may increase the magnet travel. Plastic bearings can be used for reducing friction (such as in addition or instead of the rollers).

The present invention may be used in various types of vehicles, practically everywhere:

a. crafts moving over/on/under water
b. motor vehicles on land - from private cars to trucks, buses, etc
c. aircraft, helicopters, etc.

Either a Type A or Type B system may be used, as appropriate.

The system thus provides the dual benefit of reducing undesired movements and vibrations, and also saving/recuperating energy in doing so.

It will be recognized that the foregoing is but one example of an apparatus and method within the scope of the present invention and that various modifications will occur to those skilled in the art upon reading the disclosure set forth hereinbefore.
Claims

1. An apparatus adapted for converting vibrations and/or undesired movements in a vehicle to an utilizable electric energy, wherein the apparatus is connected between a vehicle’s body and a vehicle’s wheel, and is utilizing the vibrations and/or movements created therein.

2. The apparatus according to claim 1, wherein the apparatus is placed so as to replace a shock absorber or damper in the vehicle.

3. The apparatus according to claim 1, wherein the apparatus is placed next to, or connected to a shock absorber, damper or a spring in the vehicle.

4. An apparatus adapted for converting vibrations and/or undesired movements in a vehicle or in a craft, to an electric energy, wherein the apparatus is connected between a vehicle’s body or a craft’s body and another object having a substantive weight within the vehicle or the craft, and is utilizing the vibrations created therein.

5. The Apparatus according to claim 4, wherein the substantive weight to which it is connected is an existing moving part, such as a trunk, luggage or a spare wheel.

6. The apparatus according to claim 4, wherein the apparatus comprises one or more magnets and one or more ferromagnetic cores, adapted to utilize the vibrations to an electric flux.

7. The apparatus according to claim 6, wherein the apparatus further comprising one or more coils adapted to create induced AC voltage from the electric flux, and electronic AC to DC converter.
9. The apparatus according to claim 6 or 7, wherein the magnets are placed along a bar, and wherein each two adjacent magnets are in an opposite polarity.

10. The apparatus according to claim 4, 5, 6, 7 or 8 wherein the apparatus further comprises amplitude enhancement device adapted to match between actual vibrations amplitude and the amplitude provided to the energy utilizing apparatus.

11. The apparatus according to claim 1, 2, 3, 4 or 5, wherein the apparatus is adapted to mechanically convert linear movement to rotational movement, and wherein the apparatus further comprises an alternator.

12. The apparatus according to claim 9 or 10, wherein the apparatus comprises one or more rollers, adapted to provide smooth movement with low friction of the energy utilizing apparatus’ moving parts.

13. An apparatus adapted for converting vibrations and/or undesired movements in a vehicle to an utilizable electric energy, substantially as disclosed in the present disclosure and drawings.
Documents considered to be relevant:

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| X,Y      | X: 1, 3, 7-10,  
|          | Y: 5, 6           | US 2003/0034697 A1  
|          |                    | Goldner et al. - Figures 4, 6 and 9-12B; Paragraphs [0228] and [0229] |
| X,Y      | X: 1, 3, 7-9,  
|          | Y: 5, 6           | US 2004/0206561 A1  
|          |                    | Song et al. - Figure 1; paragraphs [0010] and [0027] |
| X,Y      | X: 1, 4, 7-9,  
|          | Y: 5, 6           | US 2004/0119289 A1  
|          |                    | Zabramny - Figure 1; paragraphs [0012] and [0032] |
| X,Y      | X: 1, 4, 11,  
|          | Y: 5, 6           | US 4387781 A  
|          |                    | Ezell et al. - Figures 1, 4 and 6 |
| X,Y      | X: 1, 3, 11,  
|          | Y: 5, 6           | EP 0871577 A2  
|          |                    | Zenobi - Figure 2 |
| X,Y      | X: 1, 4, 11,  
|          | Y: 5, 6           | GB 2254301 A  
|          |                    | Gould - Whole document |
| Y        | 5, 6               | DE 10246837 A1  
|          |                    | Consens - Figures 1 and 2; WPI accession number 2003-494802 [47] |

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