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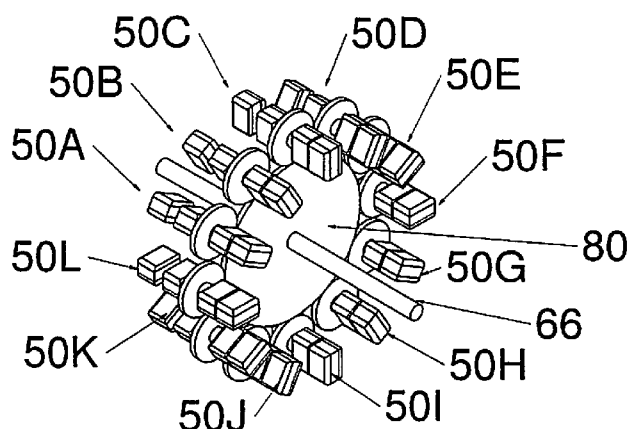
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CYCLIC DRIVE INPUT

Fig. 2A

(57) Abstract: A permanent magnet is rotated
about an axis extending between opposing
north and south poles. The magnetic field of
the rotated permanent magnet interacts with
magnetic fields of permanent magnets carried
by a shuttle for repelling and attracting the
fixed permanent magnets, and providing a lin-
ear reciprocating movement of the shuttle re-
sponsive to the favorable rotary motion of the
rotated permanent magnet where the force of
the linear motion is captured by an energy
storage device.

MAGNETIC REACTION APPARATUS, ASSEMBLY AND ASSOCIATED METHODS FOR OPTIMIZATION OF A CYCLIC DRIVE INPUT

Cross-Reference to Related Applications

[0001] This application is a continuation of 13/838,412 filed on March 15, 2013, which is a continuation-in-part of Application Serial No. 13/081,595, filed April 7, 2011, and claims the benefit of U.S. Provisional Application Nos. 61/378,984 filed September 1, 2010 for Magnetic Drive Motor Assembly and Method, and 61/416,405 filed November 23, 2010 for Magnetic Drive Motor Assembly and Associated Methods, the disclosures of which are hereby incorporated by reference herein in their entireties, and all commonly owned.

Field of the Invention

[0002] The present invention generally relates to apparatus, assembly, and methods employing magnetic fields to provide a driving force, and more particularly to a method of using permanent magnets for enhancing power from a cyclic drive input.

Background of the Invention

[0003] The use of a magnetic field to provide a driving force is well known. Reducing available sources of standard types of fuel and concerns for protecting the environment have led to increased efforts in developing alternative sources for supplying energy to drive power systems. One type of power system which eliminates the need for fuel and also eliminates the ecological drawbacks of fuel consumption is a system which utilizes magnetic motors. As described in US Patent No. 4,038,572 to Hanagan, it is desirable to have a prime mover which would not depend exclusively upon fossil fuels. The benefits of alternate forms of prime movers adapted to be utilized in motor vehicles, and the like, is well known in the art. The desirability of developing a prime mover for motor vehicles which would not be dependent on fossil fuels for its source of energy has

received a great deal of impetus. In response, Hanagan provides a magnetic clutch device described as a magnetically driven motor.

[0004] US Patent No. 3,899,703 to Kinnison for a Permanent Magnet Motion Conversion Means discloses a magnetic motor using stationary magnets arranged with inverse polarity and another permanent magnet alternately movable within the field of the stationary magnets by a diverter, such as a solenoid, to convert a rotational movement to a linear movement.

[0005] Indeed, several types of magnetic motors are known in which a rotating set of magnets is influenced by attractive and repulsive forces created by opposing magnets. US Patent No. 4,207,773 to Stahovic discloses arcuate shaped permanent magnets affixed to a moveable member on opposing sides of a rotatable magnet such that rotation of the rotatable magnet causes an alternating linear movement of the moveable member. US Patent No. 4,011,477 to Scholin discloses an apparatus for converting variations in magnetic force between magnets, one rotating and one non-rotating, into a reciprocating linear motion, the disclosure of which is incorporated by reference. US Pat. No. 3,703,653 to Tracy et al discloses a set of magnets mounted for rotation about an axis first attracted towards the corresponding stationary magnets. After the rotatable magnets are aligned with the stationary magnets, the magnetic fields of the stationary magnets are then altered so as to provide a repulsion force with respect to the rotatable magnets thereby causing the continued rotation of the rotatable magnets. In order to accomplish this effective inversion of the polarity of the stationary magnets, so as to alternately provide the attractive and repulsive forces, the stationary magnets are initially covered by magnetic plates as the rotatable magnets are approaching the position of the stationary magnets. These magnetic plates in effect cause the stationary magnets to provide attractive forces to the rotatable magnets. When the rotatable magnets are then in alignment with the stationary magnets, these magnetic plates are removed and the stationary magnets then provide a repulsion force to the rotatable magnets and thereby cause the continued movement of the rotatable magnets.

[0006] Yet further, rotary generators are well known and used to generate electric energy by movement of magnets within inductive coils. Typically, the rotary generator has a plurality of inductive coils, a plurality of magnets inserted into the respective

inductive coils and rotatable within the inductive coils, a mechanical assembly of magnets, and a motor generating and applying a movable force to the magnets through the mechanical assembly.

[0007] Attempts continue to provide magnetic motors which can be economically and efficiently operated for providing power. With such extensive use of magnetic fields to do work, there remains a need to provide an efficient means for enhancing operation of well-known machines using available magnetic forces for improving efficiency of power sources and enhancing power output from devices such as motors.

Summary of the Invention

[0008] The invention employs a rotatable permanent magnet having a north pole and an opposing south pole favorably rotatable about an axis and between the opposing poles. A shuttle confined to a linear movement generally parallel to the axis may include first and second fixed permanent magnets affixed to the shuttle, wherein the rotatable permanent magnet is carried there between. Each of the first and second fixed permanent magnets has a north pole and an opposing south pole with the axis extending there between. The permanent magnets are positioned such that rotation of the rotatable permanent magnet results in repelling and attracting of the first and second fixed permanent magnets, alternately, and thus a linear reciprocating movement of the shuttle is induced. This invention includes: a favorable rotation method achieving a reduced rotation torque; a progressively variable with angular position linear-to-rotational force converter; an energy storage device for capturing the cyclic energy impulse generated by the magnetic reaction; a novel method for increasing the output force of the linear magnetic reaction by focusing the magnetic flux field of the permanent magnets; and methods for harvesting the energy of the linear motion.

[0009] These aspects of the invention, along with other additional aspects, embodiments, and features will be better understood by referring to the accompanying drawings and the Detailed Description of the Preferred Embodiments.

Brief Description of the Drawings

[0010] FIG. 1 is a perspective view of one embodiment of the invention;

[0011] Fig. 2 is a perspective view of a multi axis embodiment of the invention;

[0012] Fig. 2A is a partial perspective view of the ordered pairs of rotational and fixed permanent magnets of the apparatus of Fig. 2, with the bracket removed to show internal details;

[0013] Fig. 2B is a top view of an exemplary set of the ordered pairs of rotational and fixed permanent magnets of Fig. 2;

[0014] FIG. 3 is a partial enlarged perspective view illustrating the linear to rotary output apparatus of FIG. 2;

[0015] FIG. 4 is a partial enlarged perspective view illustrating the drive apparatus of FIG. 2;

[0016] Fig. 5 is a perspective view of a permanent magnet with shaped focusing plates;

[0017] FIG. 6 is a perspective view of a set of permanent magnets in a Halbach array;

[0018] FIG. 7 is a graph of the torque of rotation versus aspect ratio of an ordered pair of rotational and fixed permanent magnets of the apparatus of Fig. 2;

[0019] FIG. 8 is a graph of the torque of rotation versus the position of the shuttle of the apparatus of Fig. 2.

Detailed Description of the Preferred Embodiments

[0020] In the Summary above and in the Detailed Description of Preferred Embodiments, reference is made to particular features (including method steps) of the invention. Where a particular feature is disclosed in the context of a particular aspect or embodiment of the invention, that feature can also be used, to the extent possible, in combination with and/or in the context of other particular aspects and embodiments of the invention, and in the invention generally.

[0021] The term “comprises” is used herein to mean that other ingredients, features, steps, etc. are optionally present. When reference is made herein to a process comprising two or more defined steps, the steps can be carried in any order or simultaneously (except where the context excludes that possibility), and the process can include one or more steps which are carried out before any of the defined steps, between two of the defined steps, or after all of the defined steps (except where the context excludes that possibility).

[0022] The present invention will now be described more fully hereinafter with reference to the accompanying drawings, in which preferred embodiments of the invention are shown. This invention may, however, be embodied in many different forms and should not be construed as limited to the embodiments set forth herein. Rather, these embodiments are provided so that this disclosure will be thorough and complete, and will fully convey the scope of the invention to those skilled in the art. Like numbers refer to like elements throughout, and prime notation is used to indicate similar elements in alternate embodiments.

[0023] Referring initially to FIG. 1, one embodiment in keeping with the teachings of the present invention directed to motion conversion is herein described, by way of example, as an apparatus **10** comprising rotatable permanent magnets **12, 14** each having a north pole **15** and an opposing south pole **16** aligned within a plane **18**. The rotatable permanent magnets **12, 14** are rotatable about an axis **20** within the plane **18** and lying between the opposing poles **15, 16**. A shuttle **22** is confined to a linear reciprocating movement **24** generally parallel to the axis **20**. The rotatable permanent magnets **12, 14** are positioned between first and second fixed permanent magnets **26, 28** affixed to opposing first and second sides **30, 32** of the shuttle **22** forming a permanent magnet axis group **50**. Each of the first and second fixed permanent magnets **26, 28** has a north pole **34** and an opposing south pole **36**, wherein the axis **20** extends therebetween. The magnets are positioned such that rotation of the rotatable permanent magnets **12, 14** is coincident with a repelling and an attracting of the first

and second fixed permanent magnets **26, 28**, alternately, and the linear reciprocating movement **24** of the shuttle **22** is induced.

[0024] With continued reference to FIG. 1, while a single rotatable permanent magnet **12** may be employed, desirable improvements include at least two opposing rotatable permanent magnets **12, 14**. In other embodiments, the rotating permanent magnets **12, 14** are located on the first and second sides **30, 32** of shuttle **22** operable with drive **38** for rotation thereof with a single fixed permanent magnet **26** located between rotatable permanent magnets **12, 14** or a pair of fixed permanent magnets **26, 28** located between rotatable permanent magnets **12, 14**. Further, improved efficiency results when the poles **34, 36** of the first fixed permanent magnet **26** are 180 degrees out of phase with the poles **34, 36** of the second permanent magnet **28**.

[0025] While those of skill in the art will appreciate that converting a direction of motion may include converting a linear motion to a rotary motion and converting a rotary motion to a linear motion, by way of example, embodiments of the invention as herein described are directed to improving efficiencies when converting a rotary motion to a linear motion. More specifically, the rotatable permanent magnet illustrated and described with reference again to FIG. 1 is operable with a drive **38** for rotation thereof in affecting a linear movement **24** of the shuttle **22** as a result of the magnetic interaction between the fixed permanent magnets **26, 28** and the rotatable permanent magnets **12, 14**. With continued rotation of the rotatable magnets **12, 14** a reciprocating linear movement **24** of the shuttle **22** is created. The drive **38** input is magnetically coupled to the shuttle **22**. The linear movement **24** of the shuttle **22** is a function of the shuttle load and the input rate of the drive **38**. The rotating motion of the drive **38** may be continuous or cyclic. For the embodiment herein described, the drive **38** includes an electric motor not shown, but will be understood that other well known drives may be employed without departing from the teachings of the invention.

[0026] Efficiencies have been shown to increase when employing multiple permanent magnet axis groups **50**. One embodiment of a multiple permanent magnet axis groups

50 is illustrated with reference to FIG. 2 for an apparatus **100** for converting cyclic rotary motion provided by the drive **38** to the reciprocating linear motion **24** of the shuttle **22**.

[0027] The apparatus **100** is herein described as including a base **64** and the drive **38** affixed to the base. The drive **38** rotates a drive shaft **66** (see Fig. 2A) about its axis coincident with the axis **20**. A plurality of rotatable auxiliary shafts **68** are carried by a bracket **70** affixed to the base **64**. As herein described by way of example, twelve auxiliary shafts **68** are employed. Each of the auxiliary shafts has its ends **72**, **74** extending through first and second sides **76**, **78** of the bracket **70**. A gear assembly **80** (see Fig. 2A) is operable between the drive shaft **66** and the auxiliary shafts **68** for rotation. A plurality of rotatable permanent magnets **12**, **14** is attached to the plurality of auxiliary shafts **68**. Each of the rotatable permanent magnets **12**, **14** are carried at each of the ends **72**, **74** of the auxiliary shafts **68** for rotation by their respective auxiliary shafts **68**.

[0028] Turning to Figs. 2A and 2B, the plurality of rotatable magnets **12**, **14** located on the auxiliary shafts **68**, coincident with the plurality of fixed permanent magnets **26**, **28** are concentrically arranged with axis **20**. The magnetic field of the fixed magnet **26A** interacts with the magnetic field of rotatable magnet **12A**, the magnetic field of the fixed magnet **28A** interacts with the magnetic field of rotatable magnet **14A**; forming permanent magnet axis group **50A**. The magnetic field of the fixed magnet **26B** interacts with the magnetic field of rotatable magnet **12B**; the magnetic field of the fixed magnet **28B** interacts with the magnetic field of rotatable magnet **14B**, forming permanent magnet axis group **50B** and the like for the balance of the magnets used in the apparatus **100**. For efficiency of illustration, only group **50A** is shown in Figure 2B.

[0029] Returning to Fig. 2, The bearings **56** are attached to the base **64** and the shuttle **22** is slidably guided by the bearings for the linear movement **24** generally parallel to the axis **20**. A plurality of fixed permanent magnets **26**, **28** is affixed to the shuttle **22**,

wherein a fixed permanent magnet **26, 28** is positioned on the shuttle for interacting with a cooperating rotatable permanent magnet **12, 14** carried at the end of the auxiliary shafts **68**.

[0030] The apparatus **100** further comprises first and second shock absorbers **44A, 44B, and 46A, 46B** affixed to the base **64** on opposing sides of the bracket **70** with each of the shock absorbers operable for receiving an impact of the shuttle during the reciprocating movement **24** and each shock absorber absorbs an impact by overcoming an inertia provided by the shuttle and delivers a recoiling force to the shuttle **20**.

[0031] Refer to Fig. 3, a pair of opposite facing directional clutches **110A, 110B** receive the force from the shuttle linear motion **24** thereby receiving power from the shuttle as it moves in each direction. The directional clutches **110A, 110B** deliver the linear power received as input torque to the rotary shaft **112** that is connected through a gear system **130** to shaft **212** that supplies rotating torque to a rotary generator **250** and an energy storage fly wheel **200**. The attachment of the shuttle **22** to the directional clutch **110A** is by a bar link **102A**, and the attachment of the shuttle **22** to the directional clutch **110B** is by a bar link **102B** (not shown). Each of the directional clutches **110A, 110B** act over an arc to allow the shuttle to deliver its energy in an optimized method. In other embodiments mechanical devices such as rack and pinion gears may be used to deliver the linear power of the shuttle **22** to the pair of directional clutches **110A, 110B**.

[0032] The energy storage fly wheel **200** receives the cyclic impulse torque from shaft **212**, storing the energy and providing a continuously available flow of energy for conversion through the rotary generator **250** and the drive system **238** as shown in Fig. 4. The rotary generator **250** provides a variable energy load to system **100** allowing energy to be directed for desired usage as well as to prevent undesirable acceleration of the shuttle **22**.

[0033] Returning to Fig. 2, improved efficiencies of system **100** are realized for embodiments operating with the use of cyclic drive motion. The cyclic drive input is not

directly coupled to the linear motion **24** of the shuttle **22**. They are related by a function of the shuttle position, the load of the shuttle, and the point of engagement of the cyclic drive input to the plurality of rotating magnets **12,14**.

[0034] As illustrated with reference to Fig. 5 the magnetic fields of the permanent magnets **12, 14, 26, 28** are focused in a desired direction by a magnetic focusing shoe **86** placed onto each of the poles of the permanent magnets **12, 14, 26, 28**. The magnetic focusing shoes **86** are oriented to increase the magnetic flux between permanent magnet pairs **12, 26** and **14, 28**. The magnetic focusing shoes **86** are made of a magnetic material such as steel and contoured to increase the magnetic flux direction **87** (shown as an arrow). The installation of magnetic focusing shoes **86** has increased the force between the permanent magnets **12, 14, 26, 28** by more than 300%. The use of rotating magnets as herein described has resulted in a prolonged magnetic strength for all the permanent magnets.

[0035] Referring to Fig. 6, additional strength can be achieved between the permanent magnet pairs by using permanent magnets in a Halbach array **88**. Permanent magnets **84, 85, 89** are aligned where each magnets North orientation shown by arrow **87**. The Halbach configuration will increase the concentration of the magnetic field in the desired direction while minimizing the magnetic field in all other directions.

[0036] Turing to Figs. 5 and 7, the torque **300** required to rotate the rotatable permanent magnets **12, 14** when in the magnetic field of fixed permanent magnets **26, 28** varies with the aspect ratio **92** of the permanent magnets and the distance **93** between the magnets. Aspect ratio **92** is defined as the height of the permanent magnet **280** divided by the distance between the outermost sides **285** of the focused permanent magnet **90**.

[0037] Continuing with Fig. 7, the curves of the graph show that for a set distance between magnets of equal strength, a high aspect ratio magnet **92A** requires a higher peak torque for rotation, but provides a reduced torque passing through ninety degrees

of rotation **265**. The torque reduction is a result of the increase in the angular air gap **290** (not shown) between the fixed and the rotating magnets reducing their magnetic coupling. A permanent magnet set with square aspect ratio **92C** has a lower torque that peaks as the magnet rotates through ninety degrees **265**.

[0038] The peak torque required for rotation of a given aspect ratio **92** is at its lowest value as the distance between the magnets **12, 26** and **14, 28** are approximately equal. This should be near the center of the shuttle **22** motion **24**. Referring to Fig. 8, the curve of torque **300** shows that this minimum torque **300B** is offset from the center point **275** due to the difference in the attract versus the repel forces of the magnets **12, 26** and **14, 28**. This offset will cycle to opposing sides of the center point **275** as the rotatable magnets rotate and change the direction of attract and repel of the permanent magnet axis groups **50**.

[0039] The input torque required to rotate the rotatable permanent magnets is minimized by the use of high aspect ratio magnets and initiating the cyclic drive to begin rotation as the shuttle passes near the center point of the shuttle **22** motion **24**. The cyclic drive input control is a position based function where a variable start command is needed for optimization. In the current embodiment, this control function is supplied by a programmable controller receiving a signal of the position of the shuttle. The programmable controller commands the clutch of drive **238** to initiate a rotation cycle and deliver torque **300** from flywheel **200** to the shaft **66**. One skilled in the art will understand that a mechanical control system using cams and rate sensors may be used to provide the desired control. In other embodiments a servo drive system provides the cyclic drive input to rotate the rotatable permanent magnets.

[0040] A motor **240** is affixed to the base **64** and provides torque through overrunning clutch **202** for establishing rotation of the energy storage device **200** during start up of the system **100** and may provide additional energy to the system **100** for continuous operation. Rotary generator **250** is operable with the shuttle **22** for generating electrical power resulting from the linear movement **24** of the shuttle when the cyclic drive **238** is

being cycled and the motor **240** when it is delivering torque **300** to shaft **212** through overrunning clutch **202**.

[0041] When using the electric motor **240**, it is appropriate to measure the electrical power output **60** from the rotary generator **250** and compare it to the electrical power input **62** of the electric motor as a measure of efficiency for the apparatus **100** when the cyclic drive **238** input is being cycled. When the cyclic drive **238** input is not being cycled; it is appropriate to measure the electrical power output **60** from the rotary generator **250** and compare it to the electrical power input **62** of the electric motor as measure of efficiency of the generator **250**.

[0042] Many modifications and other embodiments of the invention will come to the mind of one skilled in the art having the benefit of the teachings presented in the foregoing descriptions and the associated drawings. Therefore, it is understood that the invention is not to be limited to the specific embodiments disclosed, and that modifications and embodiments are intended to be included within the scope of the appended claims.

THAT WHICH IS CLAIMED IS:

1. An apparatus comprising:

a frame;

a shuttle carried by the frame;

a rotatable permanent magnet carried by the frame and having a north pole and an opposing south pole aligned with a plane, the rotatable permanent magnet rotatable about an axis within the plane and between the opposing poles;

means confining the shuttle to a linear reciprocating movement generally parallel to the axis;

first and second fixed permanent magnets fitted to the shuttle with the rotatable permanent magnet positioned between the first and second fixed permanent magnets, and with each of the first and second fixed permanent magnets having a north pole and an opposing south pole with an axis extending therebetween; and wherein

the fixed permanent magnets are positioned on the shuttle such that rotation of the rotatable permanent magnet is coincident with a repelling force and an attracting force of the first and second fixed permanent magnets to effectuate the linear reciprocating movement of the shuttle.

2. The apparatus according to Claim 1, further comprising a drive operable with the rotatable permanent magnet for providing a rotation thereto about the axis thereof.

3. The apparatus according to Claim 2, where the drive provides a cyclic input motion.

4. The apparatus according to Claim 3, where cyclic input motion is based on the shuttle position.

5. The apparatus according to Claim 3, where the input motion is less than 360 degrees.

6. The apparatus according to Claim 3, where the input motion is bi-directional.

7. The apparatus according to Claim 1, further comprising first and second shock absorbers affixed on opposing sides of the shuttle and each operable for receiving an impact of the shuttle during the reciprocating movement thereof, wherein each of the first and second shock absorbers operates with the shuttle for overcoming an inertia provided thereby and for delivering a recoiling force thereto.

8. The apparatus according to Claim 1, further comprising a linear to rotary converter for bidirectional capturing of the linear motion.

9. The apparatus of claim 8, where the linear to rotary converter provides a progressive variable rate.

10. The apparatus of claim 1, further comprising an energy storage device.

11. The apparatus of claim 8, further comprising a rotary generator for generating electrical power.

12. The apparatus of claim 8, further comprising a fly wheel as an energy storage device.

13. The apparatus according to Claim 1, wherein opposing faces of the rotatable and fixed permanent magnets are in a spaced relation during reciprocating

movement of the shuttle, and wherein a gap formed thereby has a dimension ranging from 0.045 inches at a first extreme position of the shuttle to 1.5 inches at a second opposing extreme position during the reciprocating movement.

14. The apparatus according to Claim 1, further comprising a guide slidably receiving the shuttle for maintaining an alignment of the linear movement parallel to the axis of the drive shaft.

15. The apparatus according to Claim 1, wherein the poles of the first fixed permanent magnet are 180 degrees out of phase with the poles of the second fixed permanent magnet.

16. An apparatus comprising:
a drive operable for rotating a first shaft about a first axis thereof;
a plurality of second shafts, each rotatable about a respective second axis;
a coupling operable between the first shaft and the plurality of second shafts for rotation thereof each about their respective second axis;
a plurality of rotatable permanent magnets operable with the plurality of second shafts, wherein each of the rotatable permanent magnets is defined by a north pole and an opposing south pole, and wherein each of the rotatable permanent magnets is rotated by a respective one of the second shafts about its respective second axis extending between the north and south poles;
a shuttle slidably carried for linear movement generally parallel to the first axis;
and
a plurality of fixed permanent magnets affixed to the shuttle,
wherein opposing fixed permanent magnets are positioned on the shuttle for interacting with respective opposing rotatable permanent magnets carried by each of the second shafts,
wherein each of the fixed permanent magnets is defined by a north pole and an opposing south pole,

wherein the rotatable permanent magnets and the fixed permanent magnets are aligned along the respective second axes; and

wherein rotation of each of the rotatable permanent magnets about their respective second axis results in a repelling and an attracting of the fixed permanent magnets affixed to the shuttle, thus providing a linear reciprocating movement to the shuttle.

17. The apparatus according to Claim 16, further comprising a drive operable with the rotatable permanent magnet for providing a rotation thereto about the axis thereof.

18. The apparatus according to Claim 17, where the drive provides a cyclic input motion.

19. The apparatus according to Claim 18, where cyclic input motion is based on the shuttle position.

20. The apparatus according to Claim 18, where the input motion is less than 360 degrees.

21. The apparatus according to Claim 18, where the input motion is bi directional.

22. The apparatus according to Claim 16, further comprising first and second shock absorbers affixed on opposing sides of the shuttle and each operable for receiving an impact of the shuttle during the reciprocating movement thereof, wherein each of the first and second shock absorbers operates with the shuttle for overcoming an inertia provided thereby and for delivering a recoiling force thereto.

23. The apparatus according to Claim 16, further comprising a linear to rotary converter for bidirectional capturing of the linear motion.

24. The apparatus of claim 23, where the linear to rotary converter provides a progressive variable rate.

25. The apparatus of claim 16, further comprising an energy storage device.

26. The apparatus of claim 23, further comprising a rotary generator for generating electrical power.

27. The apparatus according to Claim 16, wherein opposing faces of the rotatable and fixed permanent magnets are in a spaced relation during reciprocating movement of the shuttle, and wherein a gap formed thereby has a dimension ranging from 0.045 inches at a first extreme position of the shuttle to 1.5 inches at a second opposing extreme position during the reciprocating movement.

28. The apparatus according to Claim 16, further comprising a guide slidably receiving the shuttle for maintaining an alignment of the linear movement parallel to the axis of the drive shaft.

29. The apparatus according to Claim 16, wherein the poles of the first fixed permanent magnet are 180 degrees out of phase with the poles of the second fixed permanent magnet.

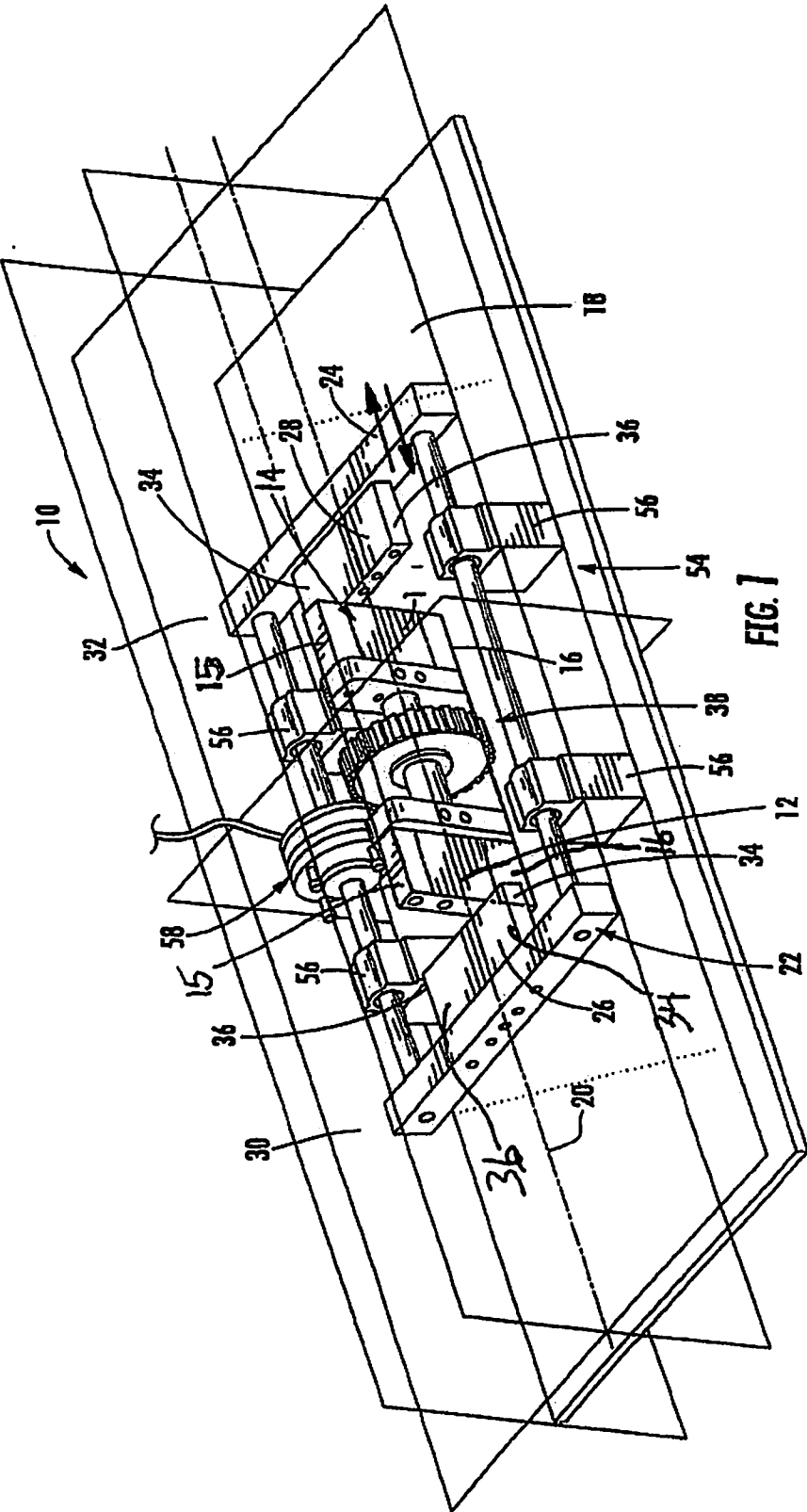
30. A method for converting magnetic energy into a linear reciprocating movement, comprising the steps of:

providing a frame;

mounting a shuttle to the frame and confining the shuttle to a linear reciprocating movement;

fitting a rotatable permanent magnet to the frame such that the rotatable permanent magnet rotates about an axis generally parallel to a direction of linear reciprocating movement of the shuttle;

fitting first and second fixed permanent magnets to the shuttle with the rotatable permanent magnet carried between the first and second fixed permanent magnets; and positioning the first and second fixed permanent magnets such that rotation of the rotatable permanent is coincident with a repelling force and an attracting force of the first and second fixed permanent magnets in order to effectuate the linear reciprocating movement of the shuttle.



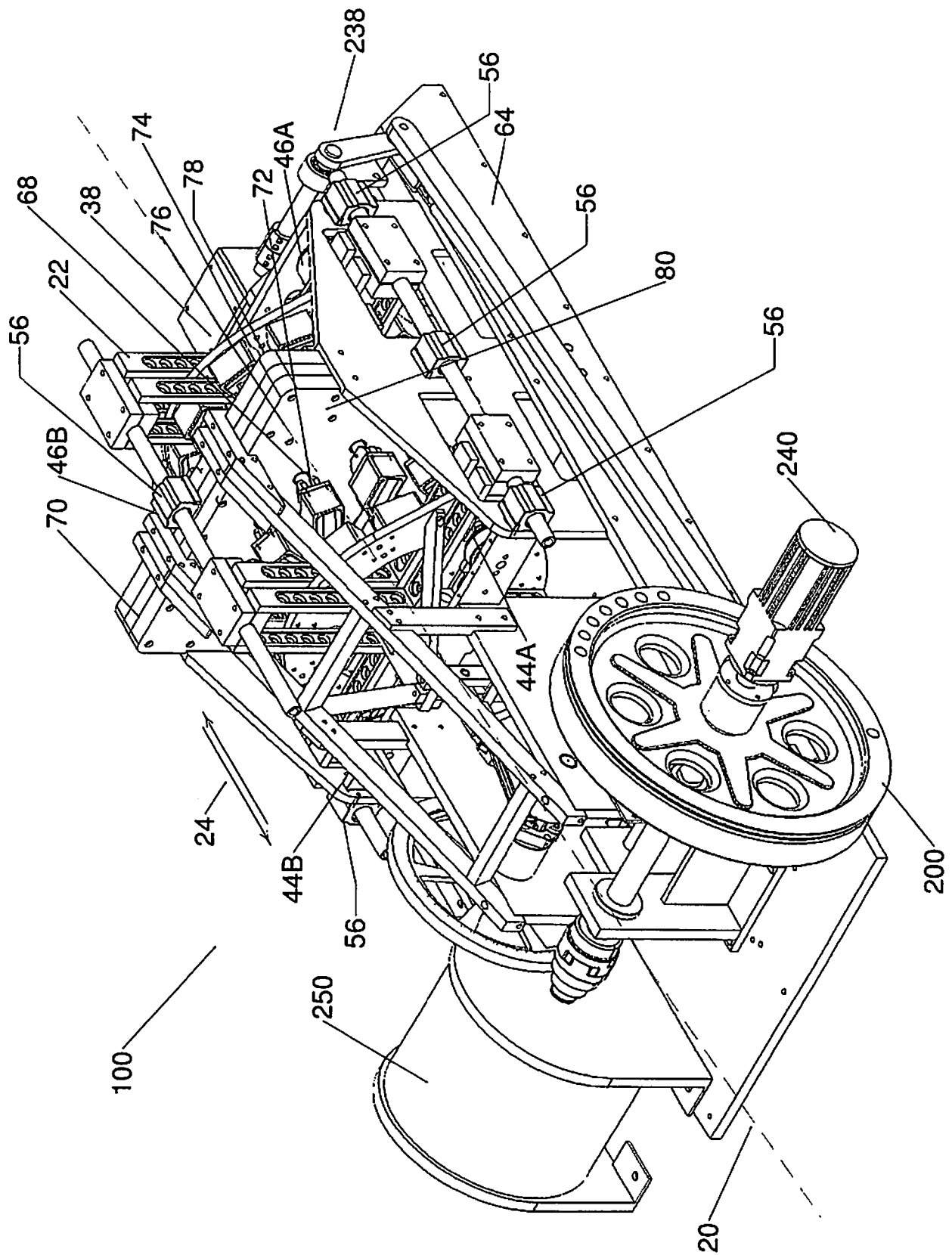


Fig. 2

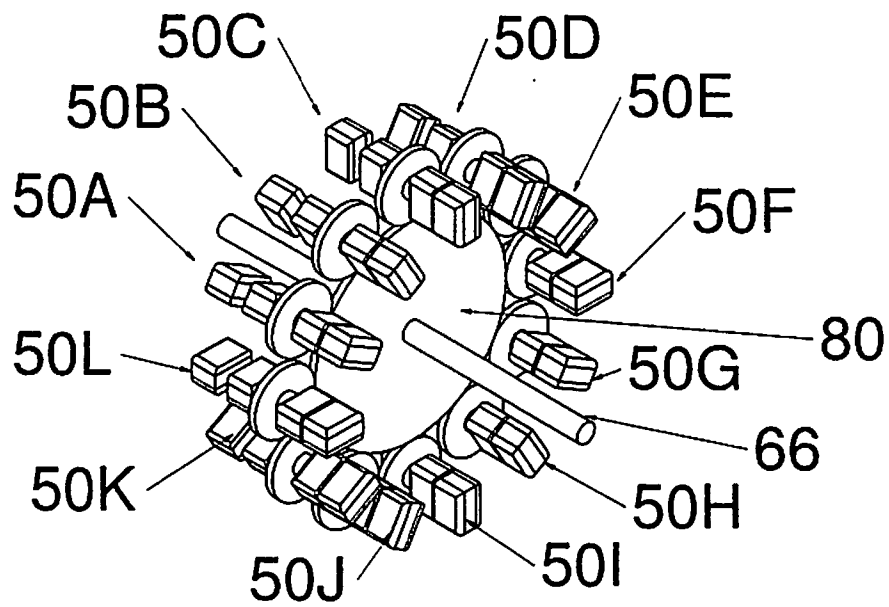


Fig. 2A

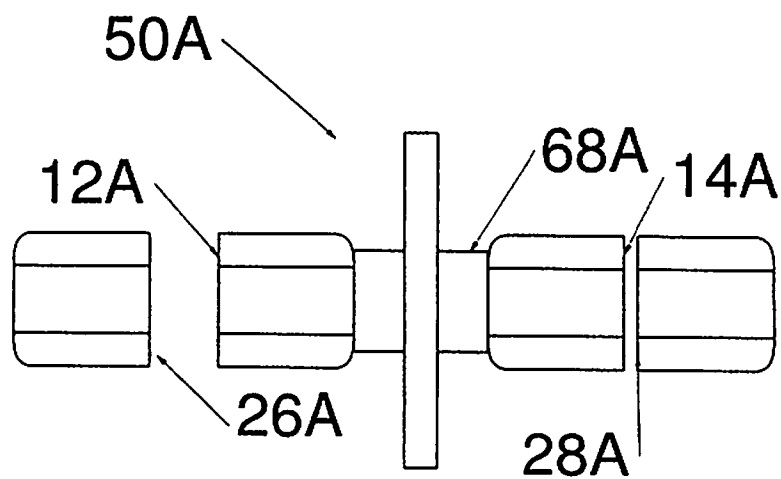
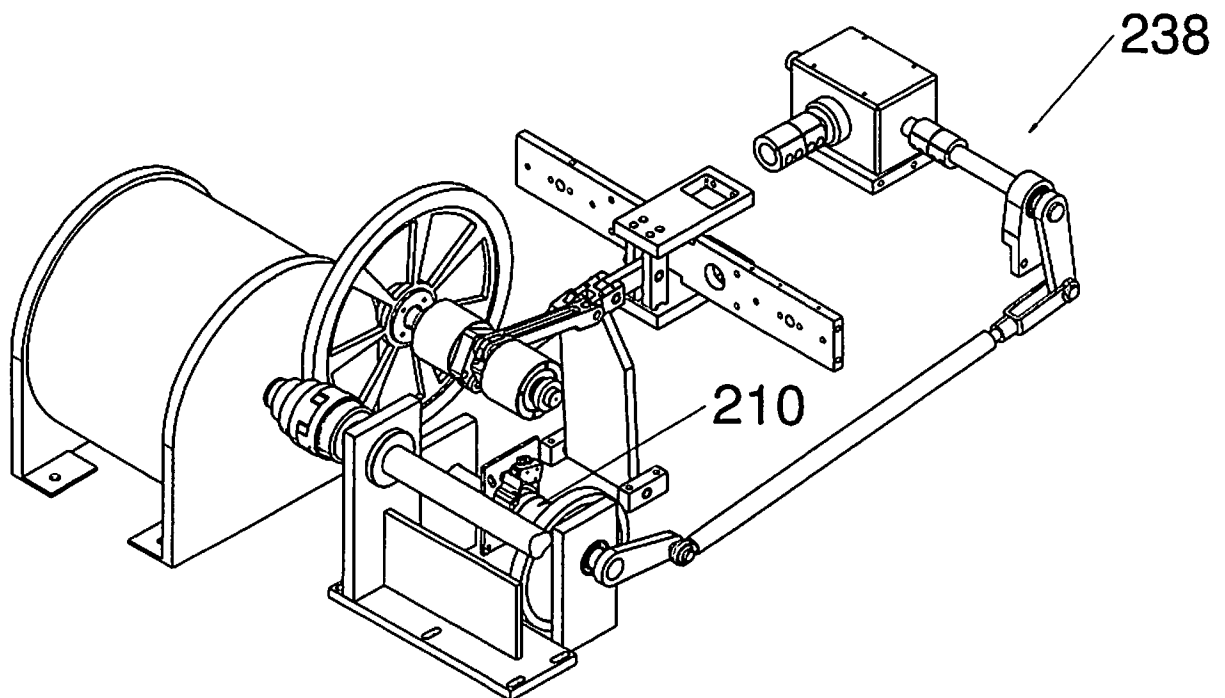
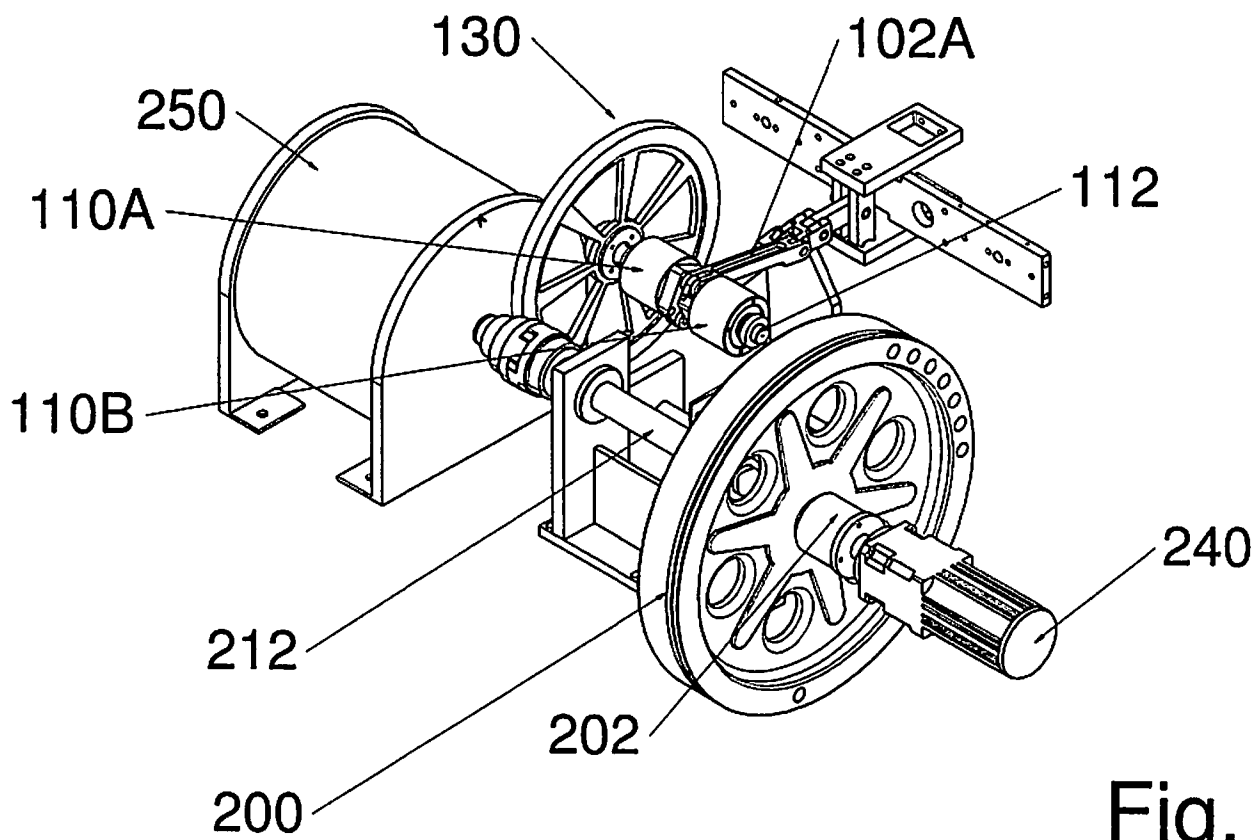


Fig. 2B



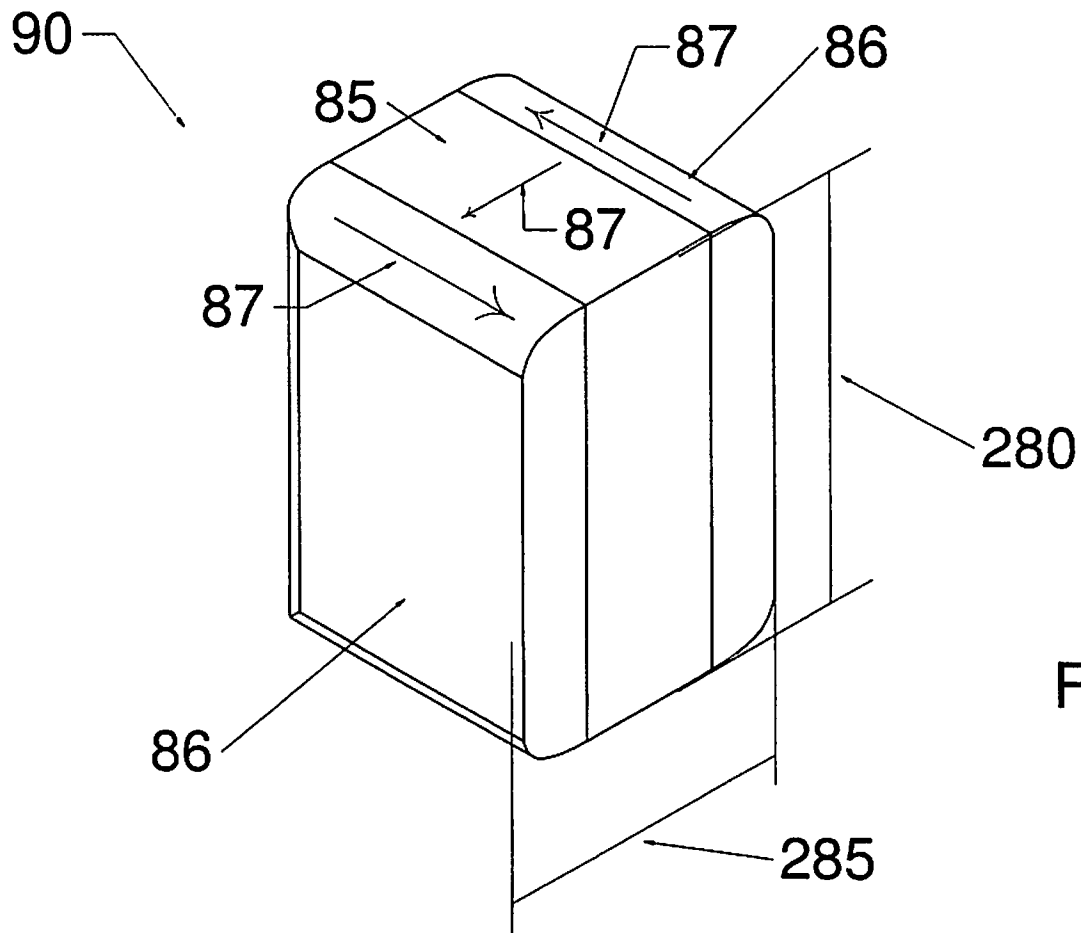


Fig. 5

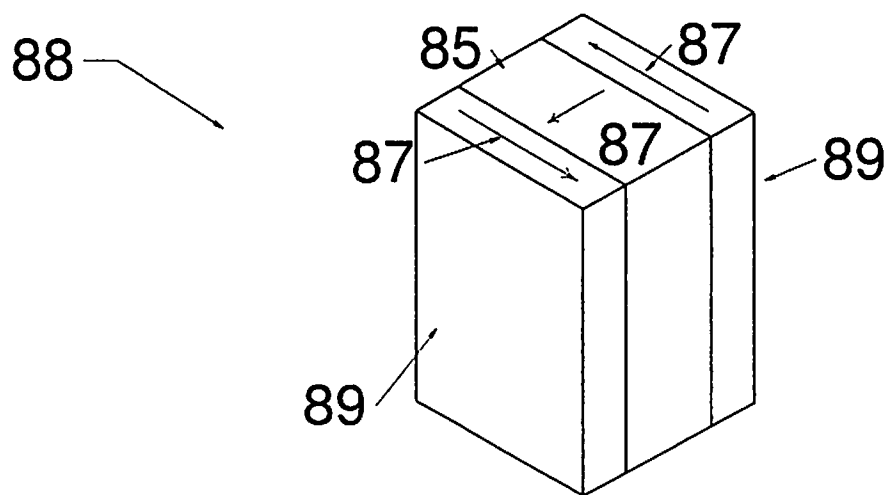


Fig. 6

