Abstract: A mechanism for translating reciprocating-motion into rotary-motion has a reciprocatable member connected to a reciprocating input shaft, a rotatable member connected to a rotating output shaft, a separating element situated between the reciprocatable and the rotatable members and a mechanical diode that constrains the separating element to rotate in only one direction. The reciprocatable and the rotatable members have pairs of alternating-polarity, permanent-magnets, while the separating element has ferro-magnetic pole-pieces. In such an arrangement, whichever direction the reciprocating member moves, the rotatable member moves in the same direction.
Mechanism for Converting Reciprocating Motion into Rotary Motion

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Claim of Priority

This application claims priority to US Serial No. 61/543,426 filed on October 5th, 2011 by R. Rosser entitled "Mechanism for Converting Reciprocating Motion into Rotary Motion", and to US Serial No. 61/566,605 filed on December 3rd, 2011 by R. Rosser entitled "Magnetic Reciprocal-to-rotary (MR2R) Motion Convertor", the contents of both of which are hereby fully incorporated by reference.

Field of the Invention

This invention relates generally to mechanisms for converting reciprocating motion into rotary motion, and more specifically, for using a combination of magnetic gearing and a mechanical diode to convert reciprocating motion into rotary motion.

Background of the Invention

Currently, reciprocating motion is typically translated into rotary motion using cranks. A majority of automobiles, for instance, use four-stoke piston engines with crankshafts. The inefficiency of the crankshaft may be the primary reason that such engines are limited to only converting approximately 25% of the energy of a reciprocating piston to rotational energy.

The energy transfer from piston to output shaft in a reciprocating engine using a crankshaft is 0% at top dead center and only reaches a maximum of about 80% at about 80 degrees of crankshaft rotation. This mechanical inefficiency is compounded by the combustion pressure in a piston engine being at a maximum when the crankshaft is at "top dead center" and
that the combustion pressure decreases rapidly as the effective torque arm of the crankshaft increases. The combination of mechanical inefficiency and the pressure generation mismatch is an energy wasting arrangement that has been only been maintained because it is cheap, simple, and there has been no more efficient arrangement to replace it.

The present invention provides a simple combination of magnetic gears and one more mechanical diodes that efficiently convert reciprocating motion to rotary motion with a substantially constant torque arm that may be substantially 100%, and may therefore improve the efficiency of piston engines by as much as a factor of three.

The present invention relies, in part, on recent significant advances in magnetic gearing, particularly in the amount of torque that they may transmit, as discussed in detail in, for instance, WO/2009/087409 entitled "Drives for Sealed Systems" filed internationally on January 12, 2009 by Atallah et al. the contents of which are hereby incorporated in their entirety by reference.

The present invention also takes advantage of recent advances in mechanical diodes, the background of which is described in, for instance, US Patent no 6,16,024 issued to Rottino on September 12, 2000 entitled "Torque converter employing a mechanical diode" the contents of which are hereby incorporated in their entirety by reference.

The prior art of reciprocating to rotary motion includes:

**Summary of the Invention**

The present invention relates to mechanisms for translating reciprocating-motion into rotary-motion.
In a preferred embodiment, the mechanism for translating reciprocating-motion into rotary-motion may have a reciprocatable member that may be connected to a reciprocating input shaft, a rotatable member that may be connected to a rotating output shaft, a separating element situated between the reciprocatable member and the rotatable member, which may be the elements of a magnetic gear.

In addition to the typical components of a magnetic gear, a preferred embodiment of the present invention, there may be a mechanical diode that may constrain the separating element to be able to rotate in one direction but not the other.

The reciprocatable member and the rotatable member may each have a number of pairs of alternating-polarity, permanent-magnets, while the separating element may have a number of ferro-magnetic pole-pieces, i.e., the elements of a typical magnetic gear. However, for the arrangement to act as a magnetic the separating element must be held stationary. So when the reciprocatable member attempts to move the separating element in the rotational direction not allowed by the mechanical diode, the arrangement acts as a magnetic gear, with the output shaft being rotated in the opposite direction to the input shaft, a fundamental property of magnetic gears of this design. However, when the reciprocatable member moves in the opposite rotational direction, i.e., the rotational direction in which the mechanical diode allows the separating element to rotate, the arrangement no longer acts as a magnetic gear. Instead, both the separating element and the rotatable member are driven to rotate in the same direction as the reciprocatable member. In this way, whichever rotational direction the reciprocating member moves, the rotatable member, and hence the rotating output shaft move in the same direction, as will be described in more detail by reference to the following drawings.
Brief Description of the Drawings

Fig. 1 A shows a front view of a mechanism for translating reciprocating-motion into rotary-motion of the present invention.

Fig. 1 B shows a side view, looking along "A" of a mechanism for translating reciprocating-motion into rotary-motion of the present invention.

Fig. 1 C shows a side view, looking along "B" of a mechanism for translating reciprocating-motion into rotary-motion of the present invention.

Fig. 1 D shows a top view, looking along "C" of a mechanism for translating reciprocating-motion into rotary-motion of the present invention.

Fig. 2 A shows a front view of a reciprocatable member of the present invention.

Fig. 2 B shows a front view of a separating element constrained by a mechanical diode of the present invention.

Fig. 2 C shows a front view of a rotatable member of the present invention.

Fig. 3 A shows a close up of one element of a mechanical diode in free mode.

Fig. 3 B shows a close up of one element of a mechanical diode in locked mode.

Description of the Preferred Embodiments

The preferred embodiments of the present invention will now be described with reference to the drawings. Identical elements in the various figures are identified with the same reference numerals.
Reference will now be made in detail to embodiment of the present invention. Such embodiments are provided by way of explanation of the present invention, which is not intended to be limited thereto. In fact, those of ordinary skill in the art may appreciate upon reading the present specification and viewing the present drawings that various modifications and variations can be made thereto.

Figures 1A, 1B, 1C and 1D show views of a mechanism for translating reciprocating-motion into rotary-motion of the present invention.

In a preferred embodiment, the mechanism 100 for translating reciprocating-motion into rotary-motion may include four main elements: a reciprocatable member 105 that may fixedly connected to a reciprocating input shaft 106; a rotatable member 130 that may be fixedly connected to a rotating output shaft 132; a separating element 145; and a mechanical diode 160 that may constrain the separating element 145 to rotate in only one rotational direction.

The reciprocatable member 105 may, for instance, be a disk having a number of pairs of alternating-polarity, permanent-magnets 110 fixedly attached to it. The disk may, for instance, be made of a suitably strong, stiff, non-magnetic material such as, but not limited to, a non-ferrous metal, a suitably strong plastic, aluminum, a suitably strong wood or some combination thereof. The pairs of alternating-polarity, permanent-magnets 110 may, for instance, be a suitably strong permanent magnet such as, but not limited to, a rare-earth magnet, including neodymium or samarium/cobalt magnets or some combination thereof.

The rotatable member 130 may, for instance, also be a disk having a number of pairs of alternating-polarity, permanent-magnets 110 fixedly attached to it, with both the disk and the magnets made of the materials described above.
The separating element 145 may be a disk having a number of ferro-magnetic pole-pieces 150 rigidly attached to it.

The mechanical diode 160 may have an outer ring 205 separated from an inner ring 210 by a number of wedge elements 215. The components of the mechanical diode 160 may all be made of suitably wearing non-magnetic materials, including those describe above, and may be chosen with due allowance for maintaining low friction between the wedge elements 215 and the inner ring 210.

In a preferred embodiment of the mechanism 100 for translating reciprocating-motion into rotary-motion, both the reciprocatable member 105 and the rotatable member 130 may be held in place, but allowed to rotate or reciprocate, by a suitable thrust bearing 220 acting against a side support member 225. The side support member 225 and the separating element 145 may all be rigidly attached to, and supported by, a suitable base 230.

Figure 2 A shows a front view of a reciprocatable member 105 of the present invention.

The reciprocatable member 105 may be a disk 235 to which one or more pairs of alternating-polarity, permanent-magnets 110 may be fixedly attached. The up-ward hatched magnets 240 may, for instance, represent the north pole of a magnet; while the down-ward hatched magnets 245 may, for instance, represent the south pole of a magnet.

As shown in Figure 2 A, the reciprocatable member 105 may have a number, "pi" of identical pairs of alternating-polarity, permanent- magnets 110 of a standardized physical size, that are fixedly arranged in a rotationally symmetric pattern 115 about the reciprocatable member's 105 axis of rotation 120.

The center of mass 125 of each of the permanent magnets may also be situated equidistant from the axis of rotation 120.
Fig. 2 B shows a front view of a separating element 145 constrained by a mechanical diode 160 of the present invention.

The separating element 145 may have a number, "wl", of identical, ferro-magnetic pole-pieces 150 arranged in a rotationally symmetric pattern 155 about the axis of rotation 120.

The center of mass 125 of the pole pieces may all be equidistant from the axis of rotation 120.

The mechanical diode 160 may have a diode axis of rotation 165 that is coincident with the axis of rotation 120. The mechanical diode 160 may constrain the separating element to rotate in a one rotational direction 170, but not in a rotational direction opposite 175 to said first rotational direction.

Figure 2 C shows a front view of a rotatable member of the present invention, a rotatable member 130 having a number "p2" of identical pairs of alternating-polarity, permanent-magnets 135 of a second physical size that may be fixedly arranged in a rotationally symmetric pattern 140 about the axis of rotation 120. The pairs of alternating-polarity, permanent-magnets 135 may have a center of mass 125 of each of permanent magnet that may be equidistant from the axis of rotation 120.

As one of ordinary skill in the art of magnetic gears will appreciate, the numberwl of ferro-magnetic pole-pieces 150 may be equal to pi, the number of pairs of alternating-polarity, permanent-magnets 110 of the reciprocatable member 105 plus p2, the number of pairs of alternating-polarity, permanent-magnets 110 of the rotatable member 130. Furthermore pi should not be equal to p2, else the device will not function as a magnet gear.

Figure 3 A shows a close up of one element of a mechanical diode in free mode and Figure 3 B shows a close up of one element of a mechanical diode in locked mode.
The wedge elements 215 may have both an upper curved surface 255 of wedge elements and a lower curved surface 260 of wedge elements. The curvatures may be chosen so that the upper curved surface 255 of wedge elements matches the lower curved surface 270 of outer ring while the lower curved surface 260 of wedge elements may match the upper curved surface 265 of inner ring.

Although this invention has been described with a certain degree of particularity, it is to be understood that the present disclosure has been made only by way of illustration and that numerous changes in the details of construction and arrangement of parts may be resorted to without departing from the spirit and the scope of the invention.

**Industrial Use**

The present invention should have considerable industrial applicability wherever internal combustion engines are used such as, but not limited to, the automobile industry, the emergency electrical power industry, the power equipment industry and the recreational power boating industry.
What is claimed:

Claim 1: A mechanism 100 for translating reciprocating-motion into rotary-motion, comprising:

- a reciprocatable member 105, fixedly connected to a reciprocating input shaft 106, said reciprocatable member 105 having a first plurality, numbering "pi", of identical pairs of alternating-polarity, permanent-magnets 110 of a first physical size, fixedly arranged in a first rotationally symmetric pattern 115 about a first axis of rotation 120, with a center of mass 125 of each of said permanent magnets of said first physical size, situated equidistant from said first axis of rotation;

- a rotatable member 130, fixedly connected to a rotating output shaft 132, said rotatable member 130 having a second plurality, numbering "p2", where "p2" is not equal to "pi", of identical pairs of alternating-polarity, permanent-magnets 135 of a second physical size, fixedly arranged in a second rotationally symmetric pattern 140 about said first axis of rotation, with a center of mass of each of said permanent magnets of said second physical size, situated equidistant from said first axis of rotation, and wherein said rotatable member is located in proximity to, but separated from, said first plurality of permanent magnets;

- a separating element 145 situated between said reciprocatable member and said rotatable member, and having a third plurality, numbering "wl", where "wl" is equal in number to "pi" plus "p2", of identical, ferro-magnetic pole-pieces 150 arranged in a third rotationally symmetric pattern 155 about said first axis of rotation, with a center of mass of said pole pieces being equidistant from said first axis of rotation; and

- a mechanical diode 160 having a diode axis of rotation 165 coincident with said first axis of rotation, and situated to constrain said separating element to rotate in a first rotational direction 170, but not in a rotational direction opposite 175 to said first rotational direction.