PATENT: "ARTICULATED RHOMBIC PRISM PISTON FOR THERMAL MACHINES"

Filed in Italy on 18/11/2008 N° TO 2008 A 000847

Inventor: Vittorio Scialla - Nationality: italian - Resident: Via Cibrario 114, Torino (TO), Italy

vittorio.scialla@strumentiperleaziende.com

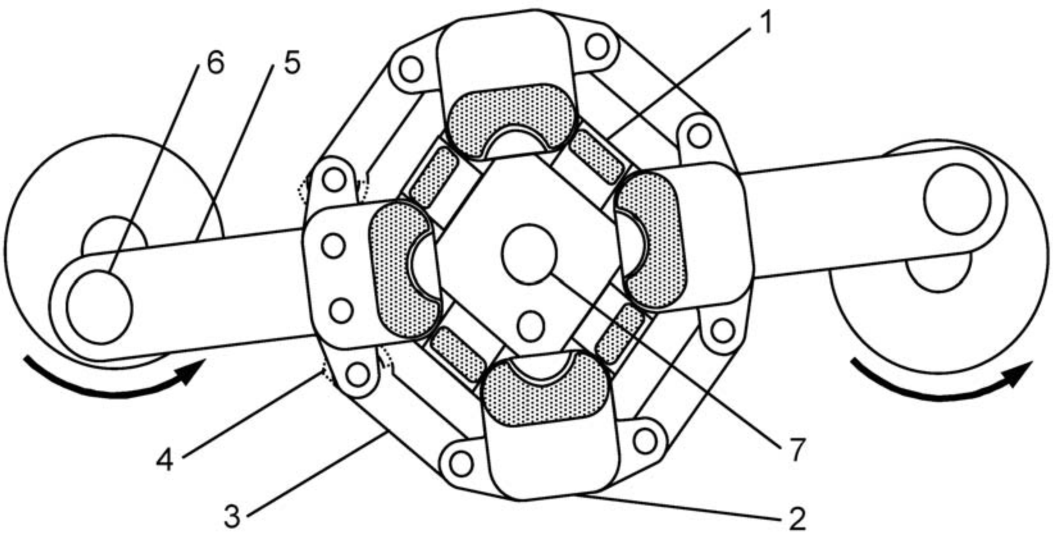
ABSTRACT

Articulated rhombic prism piston for thermal machines, provided with four movable sides (1), hinged to four links (2), so as to cooperate with two parallel planes inside a machine body, to form a variable geometry closed chamber, substantially shaped as a right rhombic prism, whose volume varies as the relative orientation of said four sides varies.

Two opposed articulated edges of said piston are provided with piston rods (5), linked to two cranks (6), which, by effect of a transmission system, rotate in the same direction, at the same speed and with a 180° phase-shift with each other, so that said articulated rhombic prism keeps itself always centred with intake and exhaust valves (7), placed in front of each other in said two parallel planes of said machine body.

Parallelism and alignment among said components of said piston are assured by means of auxiliary connecting rods (3) and gears (4).

Applications of said articulated rhombic prism piston include: internal combustion engines, closed cycle Stirling engines and inverted cycle Stirling heath pumps.



PATENT: "ARTICULATED RHOMBIC PRISM PISTON FOR THERMAL MACHINES"

Filed in Italy on 18/11/2008 N° TO 2008 A 000847

Inventor: Vittorio Scialla - Nationality: italian - Resident: Via Cibrario 114, Torino (TO), Italy

vittorio.scialla@strumentiperleaziende.com

DESCRIPTION

FIELD OF THE INVENTION

The present invention relates to articulated rhombic prism pistons and their application in thermal machines, including: internal combustion engines, closed cycle Stirling engines and inverted cycle Stirling heath pumps.

BACKGROUND OF THE INVENTION

Since their invention, internal combustion engines have been the object of continuous efforts, in order to improve their characteristics and to overcome the limitations of cylindrical piston engines. In the course of years, many progresses have been made, and many new concepts have been proposed. However, in spite of the numerous alternative solutions proposed, the only engine which had an appreciable success, is the rotary piston engine of Felix Wankel, US Patent 2988008 of 1961.

Besides, there is a rising demand for engines which can efficiently convert low intensity energy, like solar energy and residual energy from industrial processes and from heating boilers, for distributed electric power generation. Closed cycle Stirling machines, conceived by Robert Stirling, English patent 4081 of 1916, since operating at much lower pressure than internal combustion engines, require high precision machining of substantially larger cylinders, in order to assure a good sealing, and, in many cases, these factors limit their economical feasibility.

SCOPES OF THE INVENTION

A scope of the present invention is to realize internal combustion engines which are more efficient than cylindrical piston engines, and in particular with lower energy losses from vibration and friction.

A further scope of this invention is to realize internal combustion engines, whose specific power is higher than that of cylindrical piston engines.

A further scope of this invention is to realize internal combustion engines, which are more reliable and durable than cylindrical piston engines.

A further scope of this invention is to realize internal combustion engines, which are smaller than cylindrical piston engines.

A further scope of this invention is to realize Stirling engines and heath pumps, even of large size, which are less critical to manufacture than cylindrical piston Stirling engines and heath pumps.

SUMMARY OF THE INVENTION

The present invention, as will be better understood from the following description, consists of a variable geometry piston, provided with four hinged sides, arranged so as to form an articulated rhombic prism. The compressible working fluid is delimited within said four movable sides and two fixed parallel planes inside a machine body, between which said piston is placed. Force is transferred to or from the working fluid by two opposite edges of said articulated rhombic prism.

Parallelism and alignment among said elements of said piston are maintained by means of additional elements, like connecting rods and gears, which will be described in the detailed description.

A four-stroke articulated rhombic prism piston engine features numerous advantages over a cylindrical piston engine.

A first advantage is that, while a four-stroke cylindrical piston engine performs a complete cycle every two rotations of the drive shaft, an articulated rhombic prism piston engine performs a complete cycle in a single rotation, and, then, it outputs double power at the same rotational speed, or it outputs the same power at half rotational speed, reducing friction losses and wear by over 50%.

A second advantage is that, in an articulated rhombic prism piston, movable masses are divided in two equal parts moving in opposite directions, so that no linear vibration is generated, but only torque vibrations which, in an engine with four articulated rhombic prism pistons, tend to annul each other, substantially reducing vibration losses.

A third advantage is that, notwithstanding the total stroke length or an articulated rhombic prism piston is larger than that of a cylindrical piston of equal displacement, said stroke length is equally divided between two opposite cranks, so that the actual stroke length of each crank is about 80% that of a cylindrical piston and, at the same rotational speed, at double output power, accelerations are reduced by 20%, while at the same output power, at half rotational speed, said accelerations are reduced by 80%, further reducing vibration losses.

A fourth advantage is that, while a cylindrical piston pushes its crank for 180° out of 720°, equal to 25% of rotation, an articulated rhombic prism piston pushes for 107°-109° out of 360°, equal to 30% of rotation. In an engine with four articulated rhombic prism pistons, the torque produced by said pistons will overlap by 20%, and the output torque will be more levelled, similar to that of a five cylindrical piston engine.

A fifth advantage is that, while the connecting rod of a cylindrical piston continually varies its orientation with respect to said piston, producing lateral forces on the piston, an articulated rhombic prism piston always transmits force to its two cranks parallely to said two parallel planes of the engine body, avoiding any friction and wear by lateral forces on the piston.

Articulated rhombic prism pistons may be used to realize Stirling engines and heath pumps, even of large size, which are easier to manufacture than large cylindrical piston Stirling machines, and which can be optimized, at the design stage, for effective thermal exchange between the working fluid and said two parallel planes of the engine body, by varying the distance between said parallel planes.

BRIEF DESCRIPTION OF THE DRAWINGS

A detailed description of the present invention is hereinafter described, with specific reference being made to the drawings, wherein:

FIG. 1, 2, 3, 6, 8, 10, 11, 12, 15 and 17 are top views of basic embodiments of articulated rhombic prism pistons.

FIG. 4, 7, 9, 13, 16 and 18 are cross-sections respectively of pistons of FIG. 3, 6, 8, 12, 15 and 17.

FIG. 5 and 14 are front views, respectively of pistons of FIG. 3 and 12, placed between two parallel planes of a machine body, represented in cross-section.

FIG. 19, 20 and 21 are top views of an embodiment of an articulated rhombic prism piston, suitable for the realization of internal combustion engines.

FIG. 22 is a partial cross-section of the piston of FIG. 21.

FIG. 23 is an axonometric view of the piston of FIG. 20.
FIG. 24 is an exploded view of the piston of FIG. 20.
FIG. 25, 26, 27 and 28 are top views of a four stroke sequence of the articulated rhombic prism piston of FIG. 20, linked to two cranks.
FIG. 29 is a top view of a transmission system for the two cranks of the piston of FIG. 20.
FIG. 30 is a lateral view of the piston of FIG. 28, placed between two parallel planes of a machine body, represented in cross-section.
FIG. 31 is a top view of a layout of an internal combustion engine with four articulated rhombic prism pistons, of the type illustrated in FIG. 26.
FIG. 32 is a top view of a layout of an internal combustion engine with eight articulated rhombic prism pistons, of the type illustrated in FIG. 26.
FIG. 33, 34 and 37 are top views of basic embodiments of an articulated rhombic prism pistons.
FIG. 35 and 38 are cross-sections respectively of pistons of FIG. 34 and 37.
FIG. 36 and 39 are front views respectively of the pistons of FIG. 34 and 37, placed between two parallel planes of a machine body, represented in cross-section.
FIG. 40 and 41 are top views of an embodiment of an articulated rhombic prism piston, suitable for the realization of closed cycle Stirling thermal machines.
FIG. 42 is an exploded axonometric view of two sides of an articulated rhombic prism piston, of the type illustrated in FIG. 40, but provided with sealing platelets.
FIG. 43 is an axonometric view of the piston of FIG. 40.
FIG. 44 is a top view of a layout of a Stirling machine with two articulated rhombic prism pistons, of the type illustrated in FIG. 40.

DETAILED DESCRIPTION OF THE INVENTION

The foregoing detailed description is given, by way of illustration and example only, of some significant embodiments of the present invention and is not intended to limit the scope of the claims in any manner, the spirit and scope of the present invention being limited solely by said claims.
FIG. 1, 2, 3, 4 and 5 illustrate basic embodiment of an articulated rhombic prism piston, composed of four sides 201, of equal length and height, linked to each other by means of four links 202, and eight cylindrical pins 203, forming a closed chain.
Said piston is contained between two parallel planes 501, 502 of a mchine body, so as to form a variable geometry closed chamber, substantially having the form of a right rhombic prism, whose volume can vary from a maximum, when the angles between adjacent sides are equal to 90°, 90°, 90°, 90°, as illustrated in FIG. 2, to a minimum, when said angles are equal to the limit values of 0°, 180°, 0°, 180°, as illustrated in FIG. 1, or 180°, 0°, 180°, 0°, as illustrated in FIG. 3.
Said sides 201 of said piston feature a central part 503, whose length is 506, provided with holes for pins 508, and two parts, upper 504 and lower 505, whose length 507 is shorter, which form two slots, wherein are hinged said links 509, which are provided too with holes for pins 508.
Said sides 201 of said piston, at their ends, are provided with cylindrical coupling surfaces 401, 301, and said links 202 too, at their ends, are provided with cylindrical coupling surfaces 302.
The function of said coupling surfaces is to always get a quasi-contact among said sides of said piston

and said links, as their relative orientation varies, in order to delimit the working fluid in a substantially closed volume. In order to get a good sealing of said piston, the machining of said coupling surfaces should be kept within established tolerance limits.

Force is transferred from or to said piston, by means of links 202, 204, placed at two opposed articulated edges of said rhombic prism.

FIG. 6 and 7 illustrate a variant of the embodiment illustrated in FIG. 1, 2, 3, 4, and 5, wherein sides 601 of said articulated rhombic prism piston are provided with flat coupling surfaces 602, instead of cylindrical ones.

FIG. 8 and 9 illustrate a variant of the embodiment illustrated in FIG. 1, 2, 3, 4, and 5, wherein sides 801 of said articulated rhombic prism piston are provided with coupling surfaces partly flat 802 and partly concave cylindrical 803.

FIG. 10, 11, 12, 13 and 14 illustrate a variant of the embodiment illustrated in FIG. 1, 2, 3, 4 and 5, wherein links 1102 are placed in the central part 1401 of said piston. Sides 1101 of said piston, at their ends, are provided with cylindrical coupling surfaces 1201, 1301, and links 1102 as well, at their ends, are provided with cylindrical coupling surfaces 1302.

FIG. 15 and 16 illustrate a variant of the embodiment illustrated in FIG. 10, 11, 12, 13, and 14, wherein sides 1601 of said articulated rhombic prism piston are provided with flat coupling surfaces 1602, instead of cylindrical ones.

FIG. 17 and 18 illustrate a variant of the embodiment illustrated in FIG. 10, 11, 12, 13, and 14, wherein sides 1801 of said articulated rhombic prism piston are provided with coupling surfaces partly flat 1802 and partly concave cylindrical 1803.

Figures 19, 20, 21, 22, 23 and 24 illustrate an embodiment of an articulated rhombic prism piston 191, of the type illustrated in FIG. 6 and 7, suitable for the realization of internal combustion engines.

Sides 2008, 2009, 2010, 2011 of said piston, better illustrated in the detail 2404 of FIG. 24, both in the shown face and in the bottom one, not shown, are provided with shaped niches, better illustrated in the detail 2405 of FIG. 24, within which are slidably coupled sealing platelets 2012, evidenced in grey, better illustrated in the detail 2406 of FIG. 24, which are pressed, by underlying springs 2411 against said two parallel planes of the engine body, between which said piston is placed.

Link 2001 is integrated with piston rod 2005 and link 2002 is integrated with piston rod 2006.

Top links 2001, 2002, 2003, 2004 are single pieces with bottom links, not shown, as better illustrated in the detail 2401 of FIG. 24.

Said links 2001, 2002, 2003, 2004, both in the shown face and in the bottom one, not shown, are provided with shaped niches, better illustrated in the detail 2402 of FIG. 24, within which are slidably coupled sealing platelets 2007, evidenced in grey and better illustrated in the detail 2403 of FIG. 24, which are pressed, by underlying springs 2410 against said two parallel planes of the engine body, between which said piston is placed.

Said links 2001, 2002, 2003, 2004, are provided with supports 2105, better illustrated in the detail 2407 di FIG. 24, whereto are hinged, by means of pins inserted in holes 2106, four connecting rods 2101, 2102, 2103, 2104, which, at their ends, are provided with holes 2106, 2107, whose holes spacing is equal to that of sides 2008, 2009, 2010, 2011 of said piston. Holes 2106 of said supports

2105, are so positioned that, when said links 2001, 2002, 2003, 2004 are oriented at 90° with respect to each other, as illustrated in FIG. 19, 20 and 21, said connecting rods 2101, 2102, 2103, 2104 are parallel respectively to said sides 2008, 2009, 2010, 2011 of said piston, in order to form four articulated parallelograms. Said articulated parallelograms force said links 2001, 2002, 2003, 2004, to always keep themselves oriented at 90° with respect to each other, and piston rods 2005, 2006 to keep themselves always parallel to each other, independently from the orientation of said sides 2008, 2009, 2010, 2011 of said piston.

Inner ends of said connecting rods 2103, 2104 are provided with sectors of gears 2108, 2109, better illustrated in the details 2201, 2202 of FIG. 22, which are geared to each other by means of two intermediate toothed wheels 2203, 2204, in order to force said connecting rods 2103, 2104, and consequently said sides 2010, 2011 of said piston, to be always symmetrically oriented, with respect to the axis of piston rod 2006. The system of parallelograms described in the preceding paragraph, forces as well sides 2008, 2009 of said piston to be always symmetrically oriented, with respect to the axis of piston rod 2005. Consequently, piston rods 2005, 2006 are forced to keep their axes always aligned with each other.

Note that the pressure of ignition itself forces said sides of said piston to assume a maximum allowed volume rhombic arrangement, so that said sectors of gear 2201, 2202, and said intermediate toothed wheels 2203, 2204, are not subject to excessive stress.

Links 2003, 2004, both in the shown face and in the bottom one, not shown, are provided with shaped niches 2013, better illustrated in the detail 2408 of FIG. 24, within which, when said piston is in the position illustrated in FIG. 25, an exhaust valve and an intake valve can respectively extend themselves from said two parallel planes of said engine body. Since on ignition, illustrated in FIG. 27, a considerable pressure is exerted on said niches 2408, inner faces of said links 2003, 2004, are provided with bottom niches 2409, mirroring niches 2408. If the structural strength of said links 2003, 2004 is sufficient to withstand said pressure, said mirror niches 2409 can be omitted.

Said links 2001, 2002 can be provided as well with shaped niches, similar to niches 2408, 2409, although not needed in the normal operation of said piston, since both valves are closed when, on ignition, said piston is in the position illustrated in FIG. 27 and said links 2001, 2002 are placed thereunder; however, said niches avoid damages to the engine, in the case a valve may not retract itself in its seat, and is particularly opportune in the case of electrically, hydraulically or pneumatically operated valves, since these kinds of valves may be more subject to this kind of failure.

FIG. 25, 26, 27 and 28 illustrate the operation of an articulated rhombic prism piston 251 linked to two cranks 2503, 2504, of drive shafts 2602, 2603, and the operation of valves, injector and spark plug, during the four strokes of a direct injection Otto cycle.

Said cranks 2503, 2504 are forced to rotate in the same counterclockwise direction, at the same speed, and with a 180° phase-shift with each other, by a transmission system, illustrated in FIG. 29, composed of two toothed wheels 2901, 2903, of equal diameter and connected to said drive shafts 2602, 2603, and by a third toothed wheel 2902, geared to said toothed wheels 2901, 2903.

Intake and exhaust valves are placed in two seats, in front of each other, in two parallel planes of an engine body, in position 2501, and an injector and a spark plug are placed in two holes, in front of

each other, in said two parallel planes of the engine body, in position 2502.
FIG. 25 illustrates said articulated rhombic prism piston 251 at the beginning of an intake stroke, and intake valve 2501, evidenced in grey, opens.
In FIG. 26, said articulated rhombic prism piston 251, at the end of said intake stroke, is at its maximum volume, with its four sides perpendicular to each other, at the beginning of a compression stroke, and injector 2601 is operated.
In FIG. 27, said articulated rhombic prism piston 251 is at its maximum compression, and spark plug 2701 sparks.
In FIG. 28, said articulated rhombic prism piston 251, after completion of an expansion stroke, is at its maximum volume, at the beginning of an exhaust stroke, and exhaust valve 2801 opens.
The holes wherein said injector and said spark plug are placed, in position 2502, overlap the shaped sealing platelet 2505, and the sealing platelet in the opposite side of said piston, not shown, only during intake and exhaust strokes, as illustrated in FIG. 25. Since the diameter of said holes 2502 is smaller than the width of said sealing platelets 2505, sealing of said piston is always assured.
Note, in FIG. 25, 26, 27 and 28, that an articulated rhombic prism piston performs a four strokes cycle in a single rotation of the drive shafts, instead of two rotations needed to a cylindrical piston, an that, at the same rotational speed, it outputs double power, and it outputs the same power at half rotational speed, reducing friction losses and wear by over 50%.
Note, in FIG. 25, 26, 27 and 28, that, in an articulated rhombic prism piston, movable masses are divided in two equal parts moving in opposite directions, so that no linear vibration is generated.
Note, in FIG. 25, 26, 27 and 28, that the total stroke length of an articulated rhombic prism piston is equally divided between two opposite cranks, so that the actual stroke length of each crank is about 80% that of a cylindrical piston and then, at the same rotational speed, i.e. double output power, accelerations of moving masses are reduced by 20%, while at the same output power, i.e. half rotational speed, said accelerations are reduced by 80%, further reducing vibration losses.
Note, in FIG. 25, 26, 27 and 28, that an articulated rhombic prism piston always transmits force to its two cranks parallely to said two parallel planes of the engine body, avoiding any friction and wear by lateral forces on the piston.
Note that an articulated rhombic prism piston, like that illustrated in FIG. 25, 26, 27, 28, can be utilized to realize Otto cycle internal combustion engines, with direct injection, indirect injection or carburetor, and Diesel cycle engines.
FIG. 30 illustrates a cross-section of two parallel planes 3001, 3002 of an engine body, between which is placed an articulated rhombic prism piston 301, arranged as illustrated in FIG. 28, and illustrated in lateral view. An exhaust valve 3003, placed in its seat 3005, is open and extends itself into the combustion chamber, constituted of said four sides of said piston 301 and by said two parallel planes 3001, 3002, while an intake valve 3004, is closed and coupled to its seat 3006.
Said valves 3003, 3004 can be mechanically operated by two cams, connected respectively to shafts 3007 or 3009 and to shafts 3008 o 3010, or be electrically, hydraulically or pneumatically operated.
FIG. 31 illustrates a layout of an internal combustion engine with four articulated rhombic prism pistons 311, 312, 313, 314, linked to four cranks 3101, 3102, 3103, 3104, which are forced to rotate in the

same counterclockwise direction, at the same speed, and with a 180° phase-shift, by a transmission system, constituted by four toothed wheels of equal diameter, 3105, 3106, 3107, 3108, geared to a fifth toothed wheel 3109.

Note, in FIG. 28, that an articulated rhombic prism piston pushes for 108° out of 360°, equal to 30% of rotation, so that in an engine with four articulated rhombic prism pistons, like that of FIG. 31, the torque produced by said pistons will overlap by 20%, and the output torque will be more levelled, similar to that of a five cylindrical piston engine.

Note that, by virtue of the double specific power of an articulated rhombic prism piston and of its overlapping power strokes, it may be possible to realize internal combustion engines, whose pistons can be switched into an 8-stroke cycle, constituted by four regular strokes, followed by four additional strokes without fuel injection, wherein the residual heath of the combustion chamber is recovered, and eventually further heath is recovered from exhaust, with the additional advantage that a cooling circuit is no more needed.

Note that an engine with four articulated rhombic prism pistons, like that illustrated in FIG. 31, does not generate significant linear vibration, since its main movable masses are counterbalanced by equal masses moving in opposite direction, and does not generate significant torque vibration, since vibrations generated by pistons 311, 312, are substantially annulled by opposite vibrations generated by pistons 313, 314, so that no rotating counterweights are required and vibration dampers and noise insulations can be substantially simplified.

Note that in an engine with four articulated rhombic prism pistons, like that illustrated in FIG. 31, intake and exhaust valves 3111 of said four pistons can be operated, by only two cams placed on both sides of transmission shaft 3110, since the direction of rotation of said shaft corresponds to the sequence of operation of valves of said pistons, which is a significant simplification with respect to the two camshafts and related transmission components, as toothed wheels, roller chains or belt and pulleys, commonly used in cylindrical piston engines.

Note that an engine with four articulated rhombic prism pistons, like that illustrated in FIG. 31, is provided with five shafts of toothed wheels 3105, 3106, 3107, 3108, 3109, which, if prolonged outside the engine body, can be utilized, other than for the main power transmission, for directly operating alternator, pumps, compressor or other devices, without additional transmission components, as toothed wheels or belts and pulleys.

Note that an engine with four articulated rhombic prism pistons, like that illustrated in FIG. 31, features an optimal occupation of space and a limited size, and that the position of intake and exhaust valves 3111 and of injectors and spark plugs 3112, correspond to spaces not occupied by transmission wheels 3105, 3106, 3107, 3108, 3109, so that the overall thickness of said engine is limited too.

FIG. 32 illustrates a layout of an internal combustion engine with eight articulated rhombic prism pistons, constituted of two groups of four pistons. The first group, constituted by pistons 321, 322, 323, 324, is analogous to that of FIG. 31, and is characterized by the fact that toothed wheels 3201, 3202, 3203, 3204 rotate counterclockwise. The second group, constituted by pistons 325, 326, 327, 328, is analogous to that of FIG. 31, and is characterized by the fact that toothed wheels 3206, 3207, 3208, 3209 rotate clockwise, being said toothed wheels 3206 and 3209 respectively geared to toothed wheels 3202, 3203 of said first group of pistons. Crank 3212 is specularly 45° out of phase with crank 3211, so that there will be an ignition every 45°, with the following sequence of pistons: 324, shown at the moment of ignition, 328, 321, 327, 322, 326, 323, 325.

Note that an engine with eight articulated rhombic prism pistons, like that illustrated in FIG. 32, features a very limited thickness, and allows to design racing cars having a lower barycentre than cars provided with cylindrical piston engines.

The following description will address applications of articulated rhombic prism pistons in the realization of closed cycle Stirling thermal machines. Articulated rhombic prism pistons of the types illustrated in figures 1 to 24 can be utilized for this purpose. However, since a Stirling machine operates in a two-stroke mode, simplified embodiments can preferably be used, like those illustrated in FIG. 33 to 44, whose movable sides can rotate by 45° instead of 90°.

FIG. 33, 34, 35 and 36 illustrate an embodiment of an articulated rhombic prism piston, composed of four sides 3301, 3302, 3303, 3304, of equal length and equal height, hinged to each other by means of four cylindrical pins 3305, in order to form a closed chain.

Said piston is contained between two parallel planes 3601, 3602, in order to form a variable geometry closed chamber, substantially having the form of a right rhombic prism, whose volume can vary from a maximum, when the angles between adjacent sides are equal to 90°, 90°, 90°, 90°, as illustrated in FIG. 33, to a minimum, when said angles are equal to the limit values of 180°, 0°, 180°, 0°, as illustrated in FIG. 34.

Sides 3301, 3303 of said piston feature a central part 3603, of length 3606, provided with holes for pins 3610, and two parts, upper 3604 and lower 3605, of shorter length 3607. Sides 3302, 3304 feature two parts, upper 3604 and lower 3605, of length 3608 equal to 3606, provided with holes for pins 3610, and a central part 3603, of length 3609 equal to 3607.

Said sides 3301, 3302, 3303, 3304 of said piston, at their longer ends, are provided with cylindrical coupling surfaces 3401, 3402, 3501, 3502 and, at their shorter ends, are provided with flat coupling surfaces 3403, 3404, 3503, 3504, or, alternatively, with coupling surfaces partly flat and partly concave cylindrical, similar to those of FIG. 8.

The function of said coupling surfaces is to form always a quasi-contact among said sides of said piston, as their relative orientation varies, in order to delimit the working fluid in a substantially closed volume. In order to get a good sealing of said piston, the machining of said coupling surfaces should be kept within established tolerance limits.

Force is transferred from or to said piston, by means of two opposite articulated edges 3305, 3306 of said rhombic prism.

FIG. 37, 38 and 39 illustrate a variant of the embodiment illustrated in FIG. 33, 34, 35 and 36, wherein sides 3701, 3702, 3703, 3704 of said articulated rhombic prism piston, at one end, in their central part 3902, are provided with a prolongation 3904, and at the other end, in the upper part 3901 and in the lower part 3903, are provided with two prolongations 3905; said prolongations are provided with holes for pins 3906.

Said sides 3701, 3702, 3703, 3704, at their longer ends, are provided with cylindrical coupling surfaces 3705, 3801, and at their shorter ends, are provided with flat coupling surfaces 3706, 3802, or,

alternatively, coupling surfaces partly flat and partly concave cylindrical, similar to those of FIG. 8.
FIG. 40, 41, 42 and 43 illustrate an embodiment of an articulated rhombic prism piston 401, suitable for the realization of closed cycle Stirling thermal machines, constituted by four sides 4001, 4002, 4003, 4004, of the type illustrated in FIG. 33.
Two opposed articulated edges of said rhombic prism piston, are respectively hinged to a machine body, by means of pin 4005, and to a piston rod 4007, by means of pin 4006.
Said piston rod 4007 is provided with two more holes for pins 4101, 4102, whereto two connecting rods 4103, 4104 are hinged at one of their ends.
The second end of said connecting rods 4103, 4104 is hinged to one end of two auxiliary links 4107, 4108, by means of two pins 4110, 4111.
The second end of said auxiliary links 4107, 4108 is hinged to the two lateral articulated edges of said piston, by means of two pins 4105, 4106.
The hole spacing of connecting rods 4103, 4104 is equal to that of said sides 4002, 4003 of said piston, and the hole spacing of connecting rods 4107, 4108 is equal to that of the holes of pins 4101-4109 and 4102-4109, in order to form two articulated parallelograms.
The inner ends of said connecting rods 4103, 4104 are provided with sectors of gears 4112, better illustrated in the detail 4301 of FIG. 43, which are geared to each other, in order to assure that said connecting rods 4103, 4104, and consequently said sides 4002, 4003 of said piston, are always symmetrically oriented, with respect to the axis of piston rod 4007 and, consequently, pin 4005, by means of which said articulated rhombic prism piston is hinged to said machine body, is always kept on the axis of piston rod 4007.
Since a Stirling thermal machine may not be subjected to large thermal shocks, and since its operating pressure is moderate, a Stirling thermal machine with articulated rhombic prism pistons of the type illustrated in FIG. 40, 41, 42 and 43 may not be provided with sealing platelets, as long as its machine body and the sides of its pistons are made of materials having equal coefficient of thermal expansion and as long as the machining of said elements is kept within established tolerance limits, so that friction losses of said machine would be very low.
In the case of large Stirling machines, or of large thermal shocks, it may be necessary to provide said sides 4001, 4002, 4003, 4004 of said piston, both in the shown face and in the bottom one, with shaped niches 4201, within which are slidably coupled sealing platelets 4202, illustrated in grey, which are pressed, by underlying springs 4203 against said two parallel planes of said engine body.
FIG. 44 illustrates a layout of a Stirling engine with two articulated rhombic prism pistons 441, 442, hinged, by means of pins 4401, 4402, between two parallel planes of an engine body, and linked to a crank 4403 of a drive shaft 4404, rotating clockwise.
During the rotation of said drive shaft 4404, the working fluid contained in said two articulated rhombic prism pistons 441, 442 is cyclically transferred from each other piston, trough a pipe 4407, which connects ports 4405, 4406, evidenced in grey, placed in one or both parallel planes of said engine body, within which said pistons 441, 442 are placed.
The body of the Stirling engine illustrated in FIG. 44 is made of two parts, rigidly connected to each other, but thermically insulated from each other, which are kept at different temperatures: the two

parallel planes, between which piston 441 is placed, are heated by an external heath source, while the two parallel planes, within which piston 442 is placed, are cooled by means of a heath exchanger.
The working fluid, when is transferred into the articulated rhombic prism piston 441, is heated by contact with hot surfaces of said piston and of said two parallel planes containing it, generates a pressure which tends to dilate said piston and produces a force on crank 4403. The working fluid, when is transferred into the articulated rhombic prism piston 442, is cooled back by contact with cold surfaces of said piston and of said two parallel planes containing it. In the course of this cycle, the Stirling engine illustrated in FIG. 44 subtracts thermal energy from the hot piston 441, converts a part of it into mechanical energy, and transfers the residual thermal energy to the cold piston 442.
Since, as known, a Stirling engine is a reversible thermal machine, a Stirling engine like that illustrated in Fig. 44, can be operated as a heath pump, to transfer thermal energy from piston 441 to piston 442, by applying an external energy source to keep its drive shaft 4404 rotating.
Note that articulated rhombic prism pistons like those illustrated in FIG. 40, 41, 42 and 43 may be used to realize Stirling thermal machines, even of large size, without the manufacturing criticalities due to difficulties in keeping tight tolerances in the machining of large cylinders.
Note, in FIG. 44, that an articulated rhombic prism piston transmits torque to its crank parallely to the two parallel planes of an engine body, avoiding any friction and wear by lateral forces on the piston.
Note that a Stirling thermal machine with articulated rhombic prism pistons, like that illustrated in Fig. 44, can be optimized, at the design stage, for effective thermal exchange between the working fluid and said two parallel planes of the body engine, by varying the distance between said parallel planes.
The above description should not be intended to give a comprehensive list of all the possible variations of the present invention. While only some preferred embodiments of the present invention have been shown and described, it will be understood that various modifications and changes could be made thereunto, without departing the spirit and scope of the invention disclosed.

PATENT: "ARTICULATED RHOMBIC PRISM PISTON FOR THERMAL MACHINES"

Filed in Italy on 18/11/2008 N° TO 2008 A 000847

Inventor: Vittorio Scialla - Nationality: italian - Resident: Via Cibrario 114, Torino (TO), Italy

vittorio.scialla@strumentiperleaziende.com

CLAIMS

1. A piston for thermal machines, provided with four movable sides which cooperate with two parallel planes inside a machine body, to form a variable geometry closed chamber, substantially shaped as an articulated right rhombic prism, whose height is equal to the fixed distance between said parallel planes, and whose volume varies as a function of the relative orientation among said four sides.

2. An articulated rhombic prism piston for thermal machines, according to claim 1, wherein:

said articulated rhombic prism is composed of four sides of equal length and of equal height, four links, interposed between said four sides, and eight cylindrical pins hinging the ends of said sides to the ends of said links;

each of the two ends of said sides is provided with a cylindrical hole, parallel to said end, for one of said pins, and is provided with at least one zone of shorter length, which forms at least one slot of rectangular layout, so shaped as to precisely hinge to one end of one of said links;

each of the two ends of said links is provided with a cylindrical hole, parallel to said end, for one of said pins, and has a convex cylindrical surface, concentric with said hole, so that said end is always in quasi-contact with the corresponding coupling surface of said at least one slot of one of said sides, as their relative orientation varies;

each of said slots of said sides, in the coupling zone with one of said cylindrical ends of one of said links, is provided with a coupling surface, whose generatrix, parallel to said holes, always lays externally to the body of said link and, at least in one point, is in quasi-contact with said cylindrical end;

each of said two ends of said sides has a convex cylindrical surface, concentric with said hole of said end, so that said ends of said sides are always in quasi-contact with each other, as their relative orientation varies;

transmission of force from or to the compressible working fluid contained in said articulated rhombic prism piston is performed by at least one opposed couple of said links.

3. An articulated rhombic prism piston for thermal machines, according to claim 2, wherein:

parallel to the external surface of each side of said articulated rhombic prism, and always externally to the body of said side, at least a connecting rod is hinged to the same two links whereto said side is hinged, by means of two pins, placed in two cylindrical holes, parallel to said pins of said sides;

the position of said holes in said links and in said connecting rods is such as, when each of said links is oriented at 90° with respect to adjacent links, the centres of said holes of said sides and the centres of said holes of said connecting rods lay at the vertexes of four articulated parallelograms, which always keep each of said links oriented at 90° with respect to said adjacent links;

at least two of said connecting rods, adjacent to each other, at their ends hinged to the same link, are provided with sectors of toothed wheels, geared to each other by means of two intermediate toothed wheels, rotationally coupled to said link, so that the orientation of said connecting rods is always kept symmetrical with respect to the axis of said link, and consequently the axes of opposed couples of said links are always aligned with each other.

4. An articulated rhombic prism piston for thermal machines, according to claim 2 or 3, wherein said sides of said articulated rhombic prism and said links, in both edges facing said two parallel planes of said machine body, are provided with niches, within wich are slidably coupled sealing platelets, which are pressed against said two parallel planes by at least one underlying spring;

5. An articulated rhombic prism piston for thermal machines, according to claim 4, wherein an opposed couple of said links is provided with piston rods of equal length, aligned with the axes of said links, and whose ends are rotationally linked to two cranks, rotationally coupled with said machine body and geared to each other by a transmission system, which forces them to rotate in the same direction, at the same speed and with a 180° phase-shift; the combined rotation of said two cranks always keeps the centre of said articulated rhombic prism in a fixed position.

6. An articulated rhombic prism piston for internal combustion engines, according to claim 5, wherein at least one opposed couple of said links, in both edges facing said two parallel planes of said engine body, are provided with niches, within which an exhaust valve and an intake valve can extend themselves, being said valves placed in front of each other in said two parallel planes, and centred with said fixed centre of said articulated rhombic prism.

7. An articulated rhombic prism piston for thermal machines, according to claim 1, wherein:

said articulated rhombic prism is composed of four sides, of equal length and equal eight, and four cylindrical pins, which hinge the ends of said sides;

each of said sides is provided with a right end and an angled end, oriented towards the adjacent side, and such as to overlap with the angled end of said adjacent side;

each of said two ends of said sides is provided with a cylindrical hole, parallel to said end, for one of said pins, and is provided with at least one zone of shorter length, which forms at least one slot of rectangular layout, so shaped as to precisely hinge to one end of said adjacent sides;

each of said two ends of said sides has a convex cylindrical surface, concentric with said cylindrical hole of said end, so that said ends of said sides are always in quasi-contact with the corresponding coupling surfaces of adjacent sides, as their relative orientation varies;

each of said slots of said sides, in the coupling zone with one of said cylindrical ends of one of said adjacent sides, is provided with a coupling surface, whose generatrix, parallel to said cylindrical holes, always lays externally to the body of said adjacent side and, at least in one point, is in quasi-contact with said cylindrical end of said adjacent side;

transmission of force from or to the compressible working fluid contained in said articulated rhombic prism piston is performed by at least one opposed couple of said pins, denominated push pins.

8. An articulated rhombic prism piston for closed cycle Stirling thermal machines, according to claim 7, wherein:

one of said two push pins hinges the corresponding articulated edge of said rhombic prism piston to said machine body;

the second of said two push pins hinges the corresponding articulated edge of said rhombic prism piston to one end of a piston rod, which is provided with a cylindrical hole for said pin, and has a convex cylindrical surface, concentric with said hole;

at least one of the two sides of said articulated rhombic prism piston, hinged to said second push pin, is provided with at least one zone of shorter length, which forms at least one slot of rectangular layout, so shaped as to precisely hinge to said cylindrical end of said piston rod, and provided with a coupling surface, whose generatrix, parallel to said pin, always lays externally to the body of said piston rod and, at least in one point, is in quasi-contact with said cylindrical end of said piston rod;
each of the two lateral pins of said articulated rhombic prism piston hinges the corresponding articulated edge of said rhombic prism to one end of at least one auxiliary link, which is provided with a cylindrical hole for said pin, and has a convex cylindrical surface, concentric with said hole;
at least one of the two sides of said articulated rhombic prism piston, hinged to each of said two lateral pins, is provided with at least one zone of shorter length, which forms at least one slot of rectangular layout, so shaped as to precisely hinge to said cylindrical end of said at least one auxiliary link, and provided with a coupling surface, whose generatrix, parallel to said pin, always lays externally to the body of said at least one auxiliary link and, at least in one point, is in quasi-contact with said cylindrical end of said at least one auxiliary link;
parallel to the external surface of each of the two sides of said articulated rhombic prism piston, hinged to said piston rod, and always externally to the body of said side, at least one connecting rod is hinged, respectively to said piston rod and to said at least one auxiliary link hinged to said side, by means of two cylindrical pins, placed in two cylindrical holes, parallel to said pins;
the position of pin holes in said piston rod, in said auxiliary links and in said connecting rods, is such that, when said piston rod is aligned with the axis of said articulated rhombic prism piston, the centres of said holes lay at the vertexes of two articulated parallelograms, which keep said connecting rods always parallel to the respective sides of said articulated rhombic prism piston;
said connecting rods, at their ends hinged to said piston rod, are provided with sectors of toothed wheels, geared to each other, so that said connecting rods, and consequently said sides of said articulated rhombic prism piston, are always symmetrically oriented, with respect to the axis of said piston rod;
the second end of said piston rod is rotationally linked to a crank of a drive shaft.
9. An articulated rhombic prism piston for closed cycle Stirling thermal machines, according to claim 7 or 8, wherein said sides of said articulated rhombic prism piston, in both edges facing said two parallel planes of said machine body, are provided with niches, within which are slidably coupled sealing platelets, which are pressed against said two parallel planes by at least one underlying spring,.

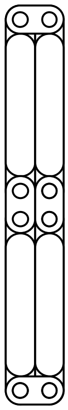


Fig. 1

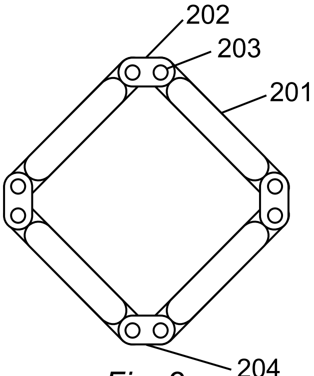


Fig. 2

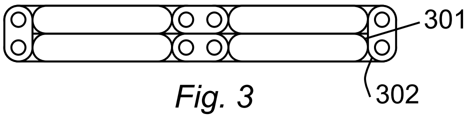


Fig. 3

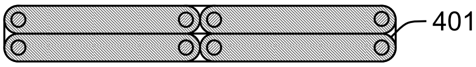


Fig. 4

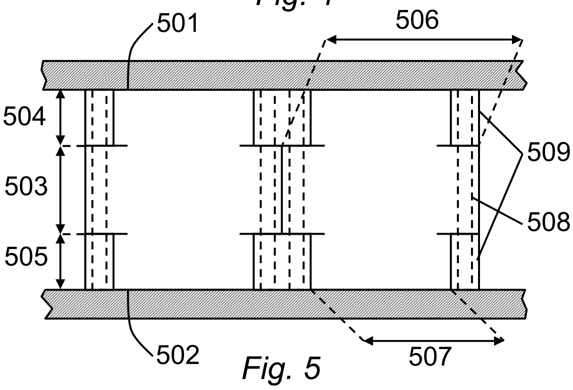


Fig. 5

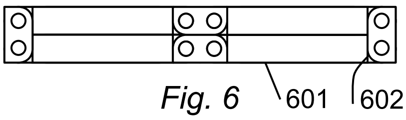


Fig. 6

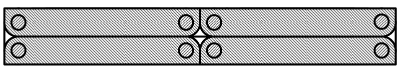


Fig. 7

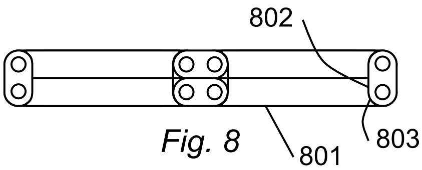


Fig. 8

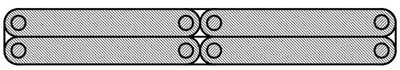


Fig. 9

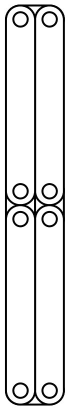


Fig. 10

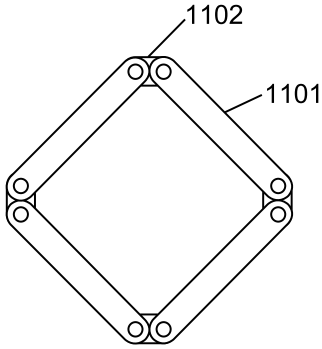


Fig. 11

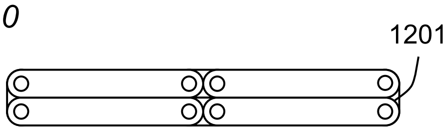


Fig. 12

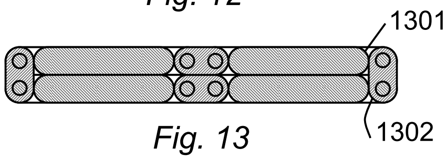


Fig. 13

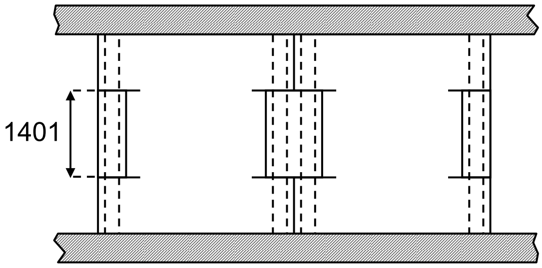


Fig. 14

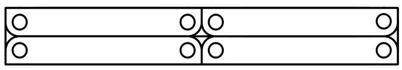


Fig. 15

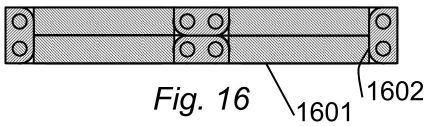


Fig. 16

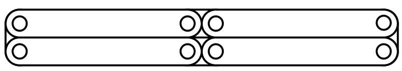


Fig. 17

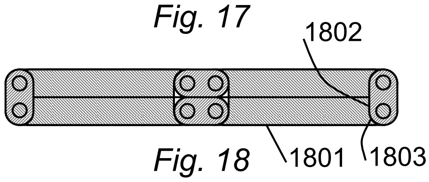


Fig. 18

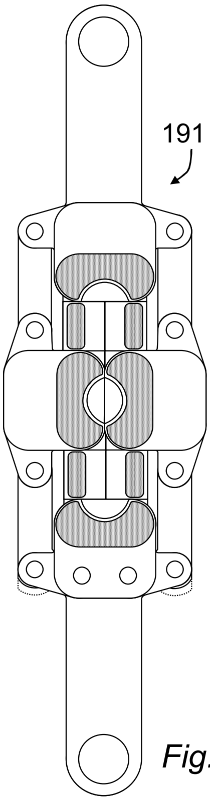


Fig. 19

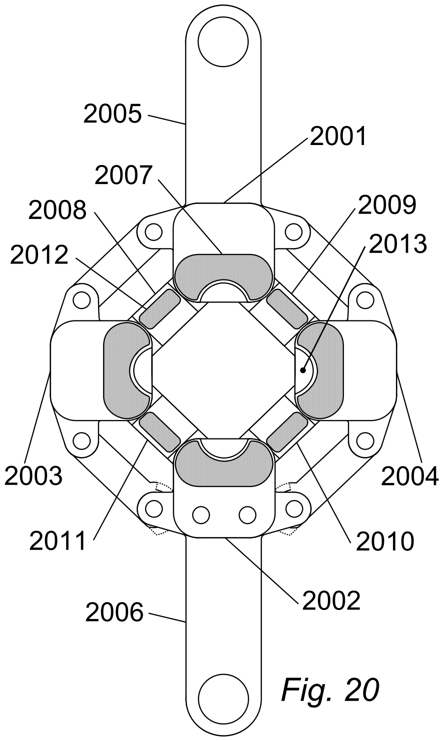


Fig. 20

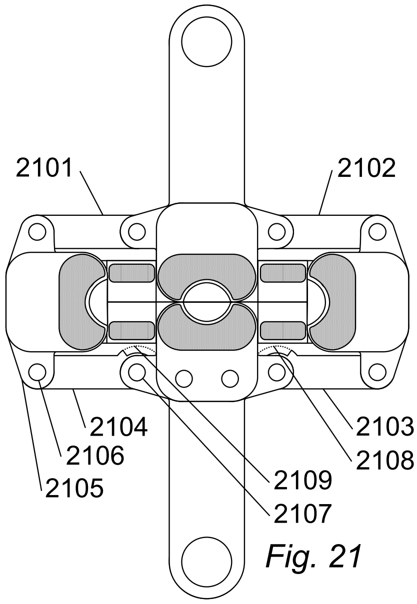


Fig. 21

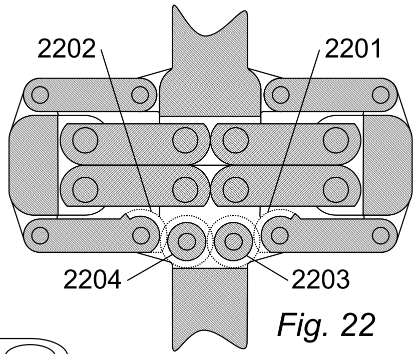


Fig. 22

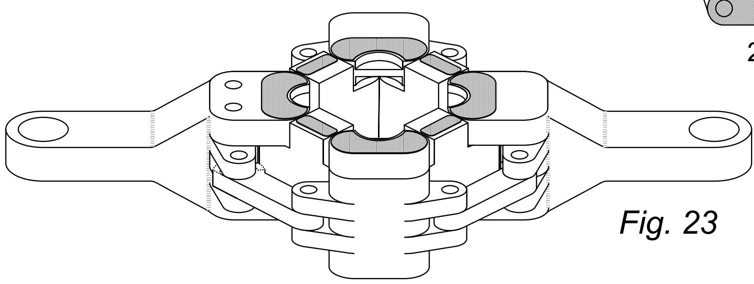


Fig. 23

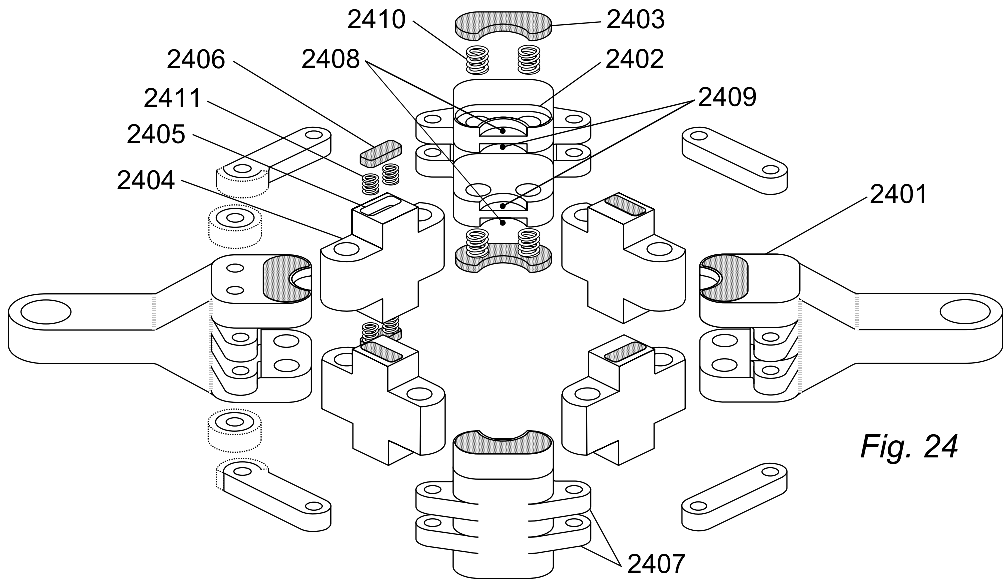


Fig. 24

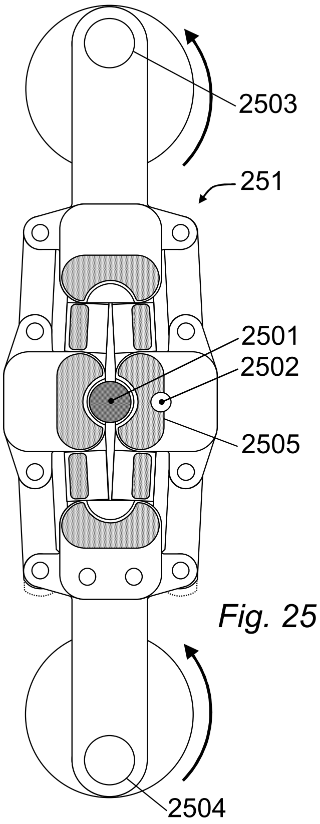


Fig. 25

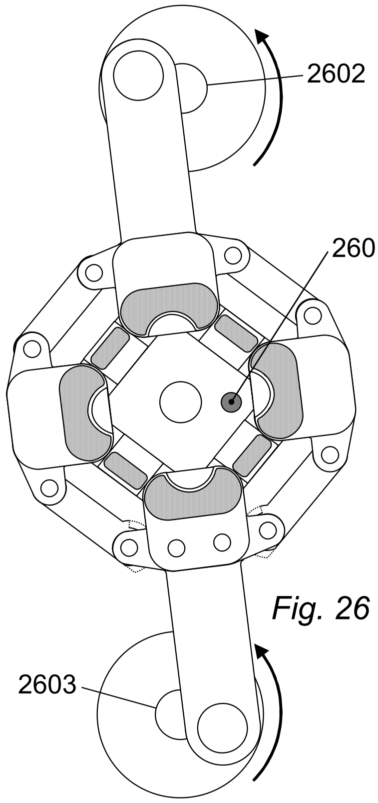


Fig. 26

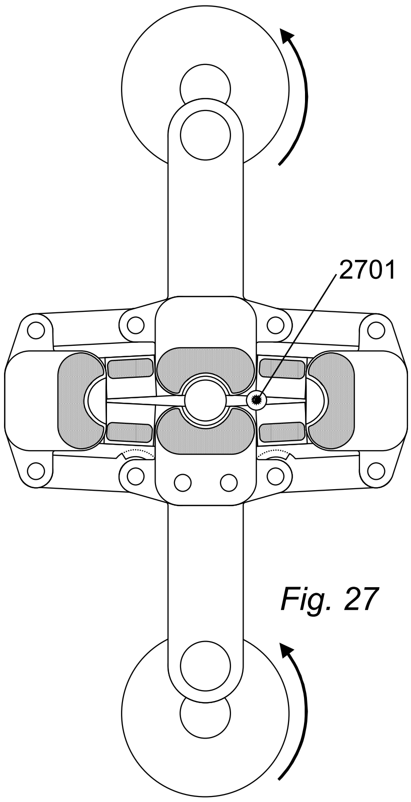


Fig. 27

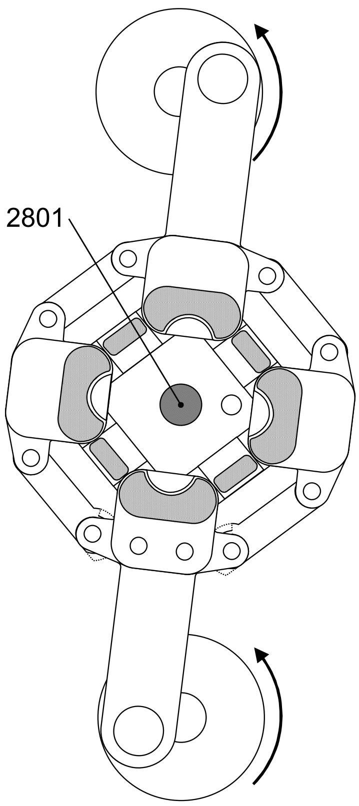


Fig. 28

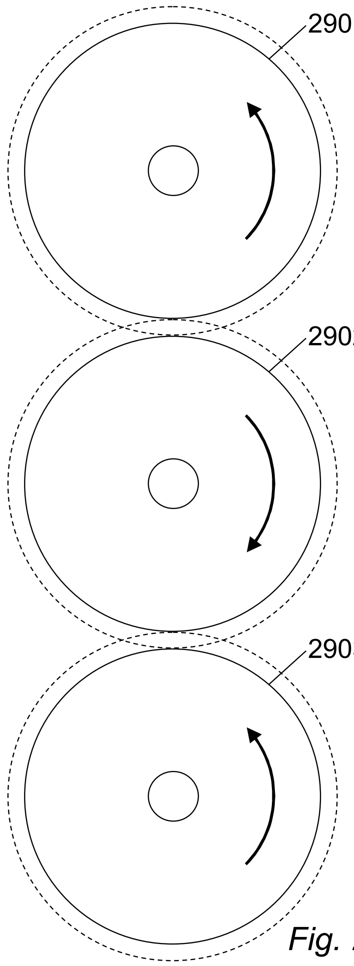


Fig. 29

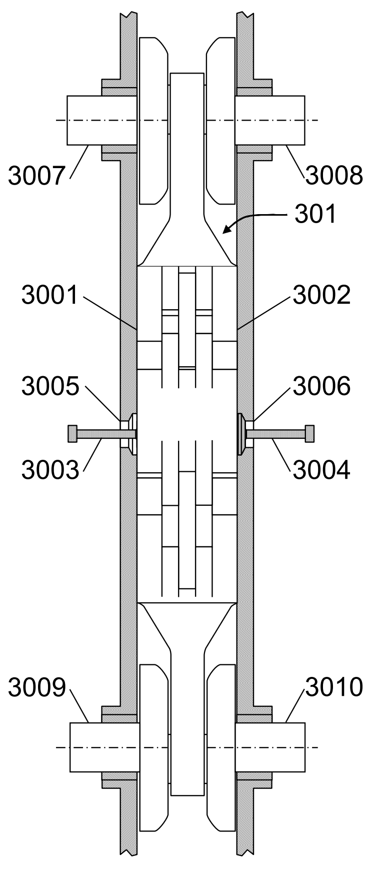


Fig. 30

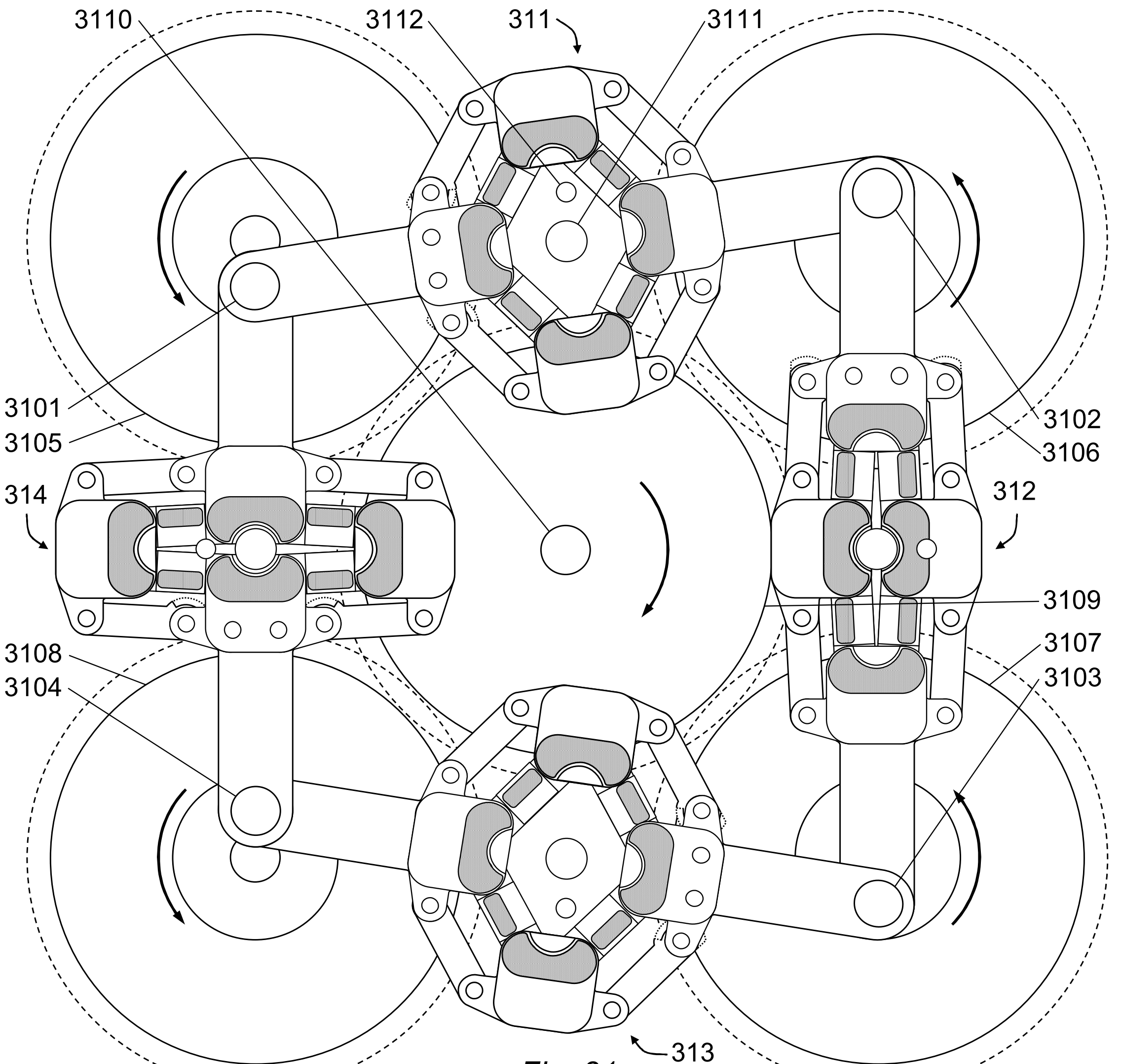

3110
3112
311
3111
3101
3105
3102
3106
314
312
3109
3108
3104
3107
3103
313

Fig. 31

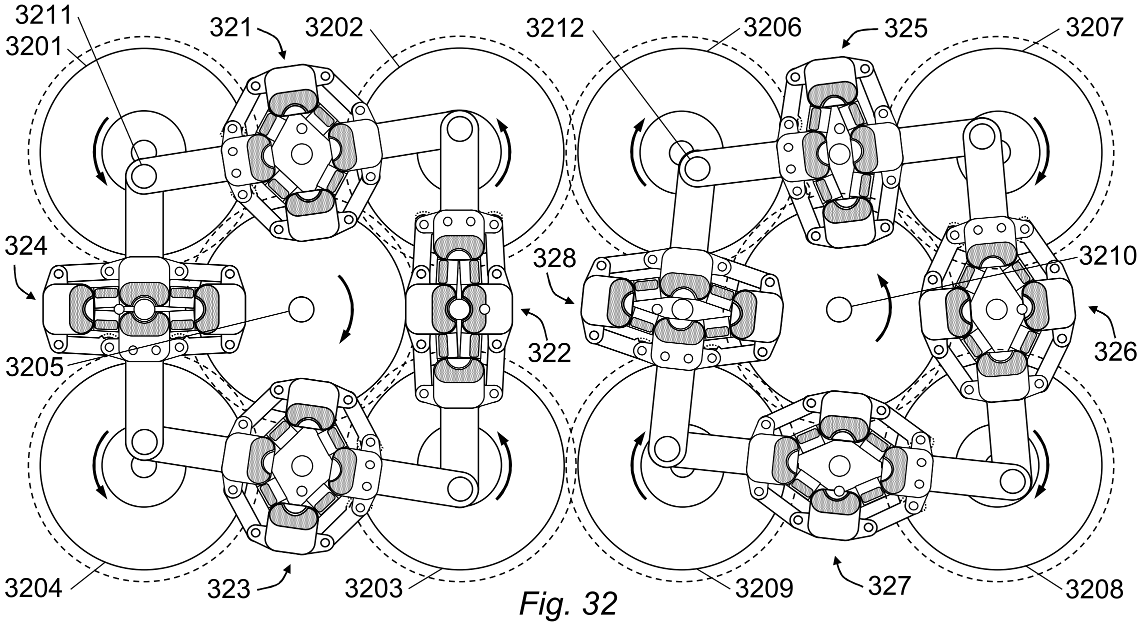

3211
3201
321
3202
3212
3206
325
3207
324
3205
328
322
3210
326
3204
323
3203
3209
327
3208

Fig. 32

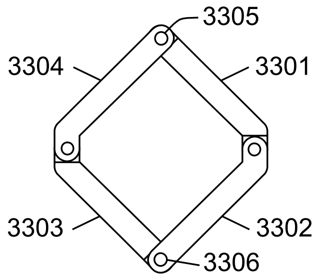


Fig. 33

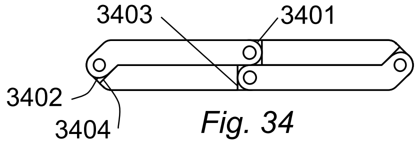


Fig. 34

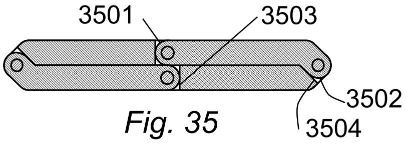


Fig. 35

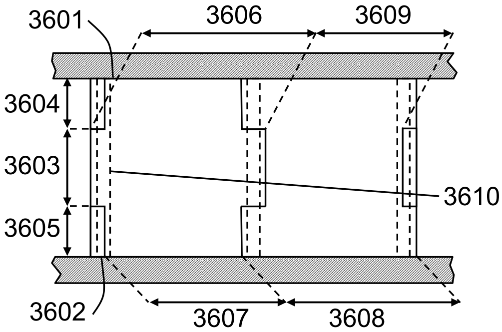


Fig. 36

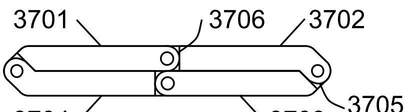


Fig. 37

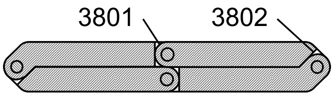


Fig. 38

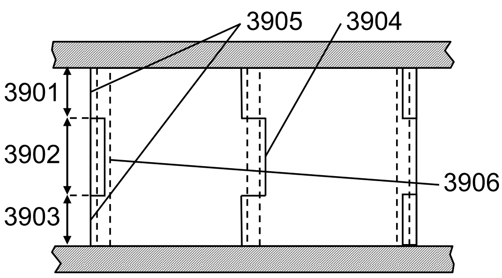


Fig. 39

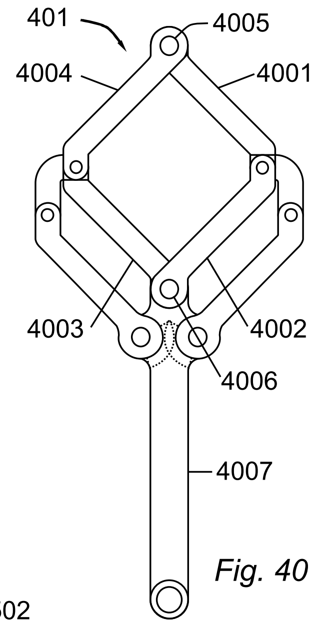


Fig. 40

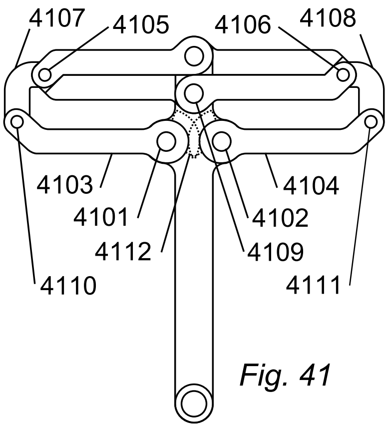


Fig. 41

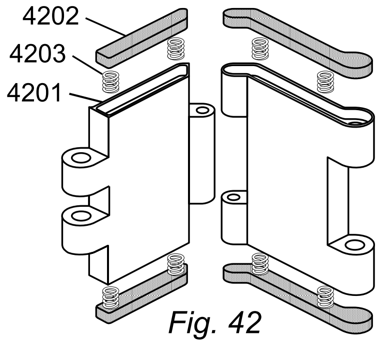


Fig. 42

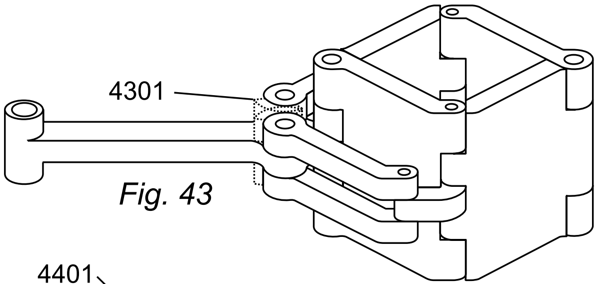


Fig. 43

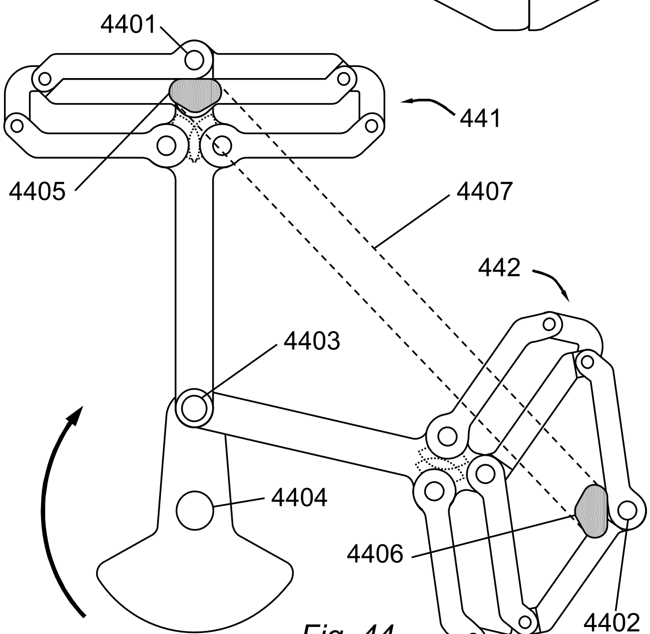


Fig. 44