

[72] Inventor Ernst Hatz
Ruhstorf, Germany
[21] Appl. No. 851,944
[22] Filed Aug. 21, 1969
[45] Patented Sept. 14, 1971
[73] Assignee Motorenfabrik Hatz KG
Ruhstorf, Germany
[32] Priority Sept. 12, 1968
[33] Germany
[31] P 17 76 054.2

1,774,087	8/1930	Dunn.....	123/56 (C) X
1,784,902	12/1930	Maurais.....	74/55
1,904,680	4/1933	Ferry.....	123/56 (C)
2,198,759	4/1940	Cadet.....	92/72 X
2,249,951	7/1941	Fulton.....	74/55

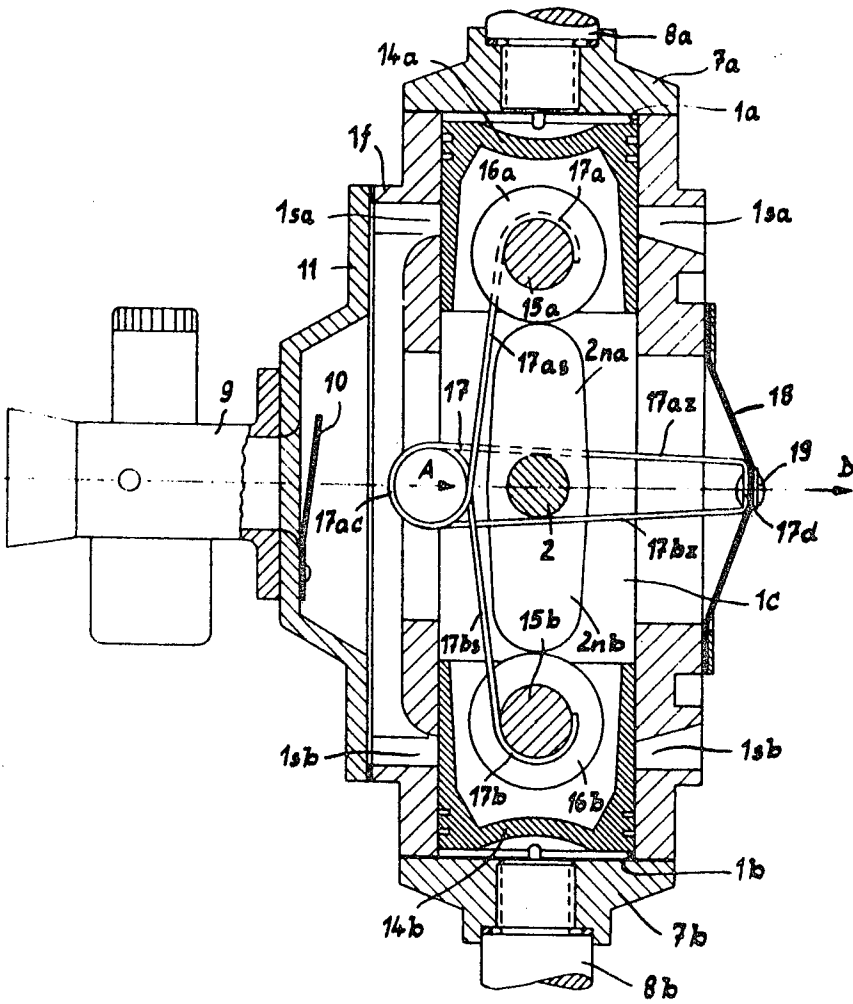
FOREIGN PATENTS

603,720	6/1948	Great Britain.....	123/56 (C)
20,518	1/1918	France.....	123/44 (E)
1,252,583	12/1960	France.....	92/73
826,839	1/1938	France.....	74/55
426,680	3/1926	Germany.....	123/56 (C)

Primary Examiner—Wendell E. Burns
Attorney—Larson, Taylor and Hinds

[54] PISTON MECHANISM
9 Claims, 8 Drawing Figs.
[52] U.S. Cl..... 123/56 C,
74/55, 92/72, 123/43 C, 123/197
[51] Int. Cl..... F02b 75/24,
F02b 75/32
[50] Field of Search..... 123/56 C,
44 E, 43 C, 197, 197 A; 92/72, 73; 74/55
[56] References Cited
UNITED STATES PATENTS
1,394,587 10/1921 Stewart 123/44 (E)

ABSTRACT: A piston mechanism having preferably one or two pairs of opposed cylinders with reciprocating pistons therein. A shaft located between the pistons includes diametrically opposed cams thereon for directly and drivingly engaging the pistons. Springs urge the pistons against the cam parts and the spring can also operate a scavage air feeder. Valves can be operated by further cams mounted on the shaft.



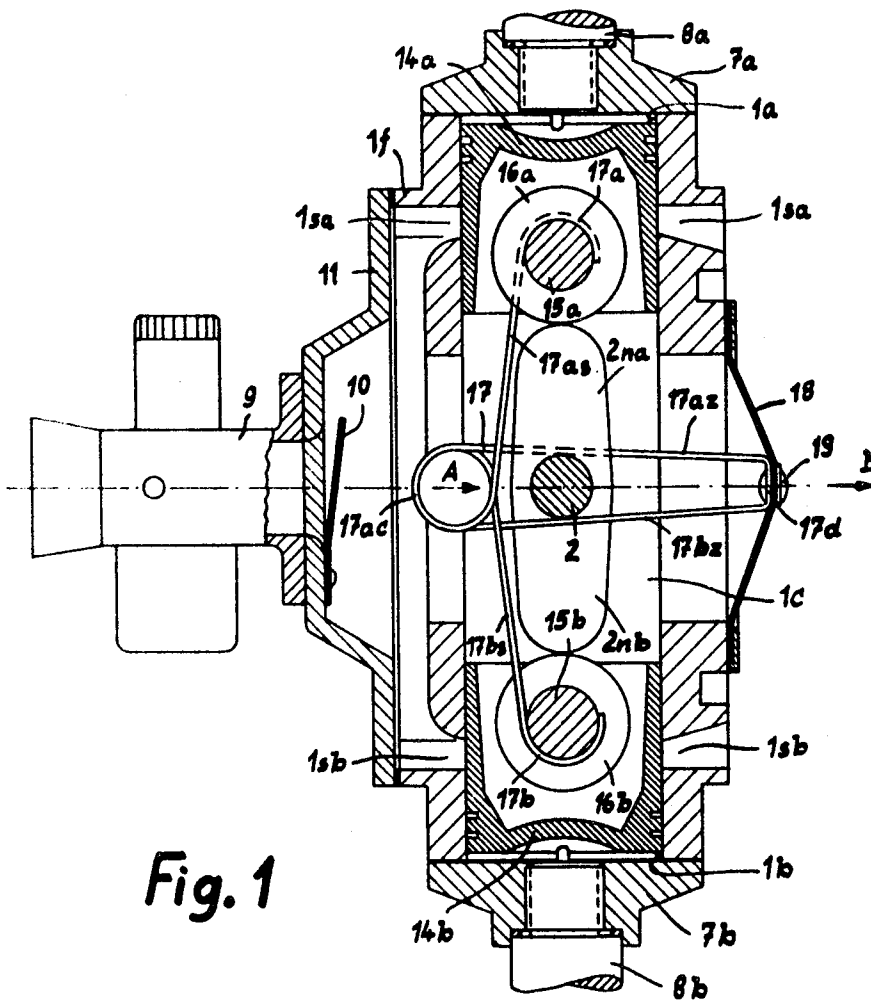
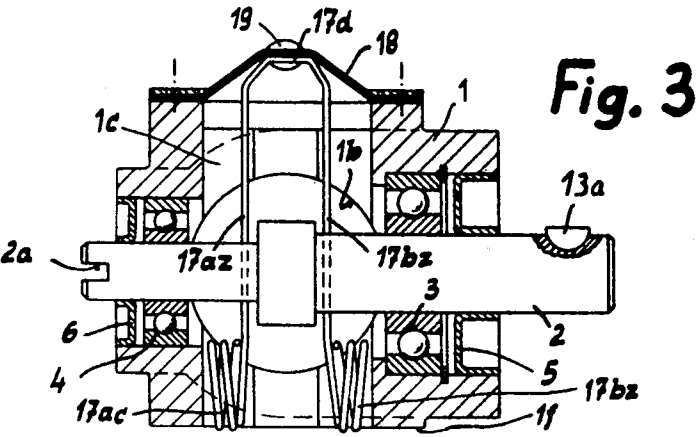
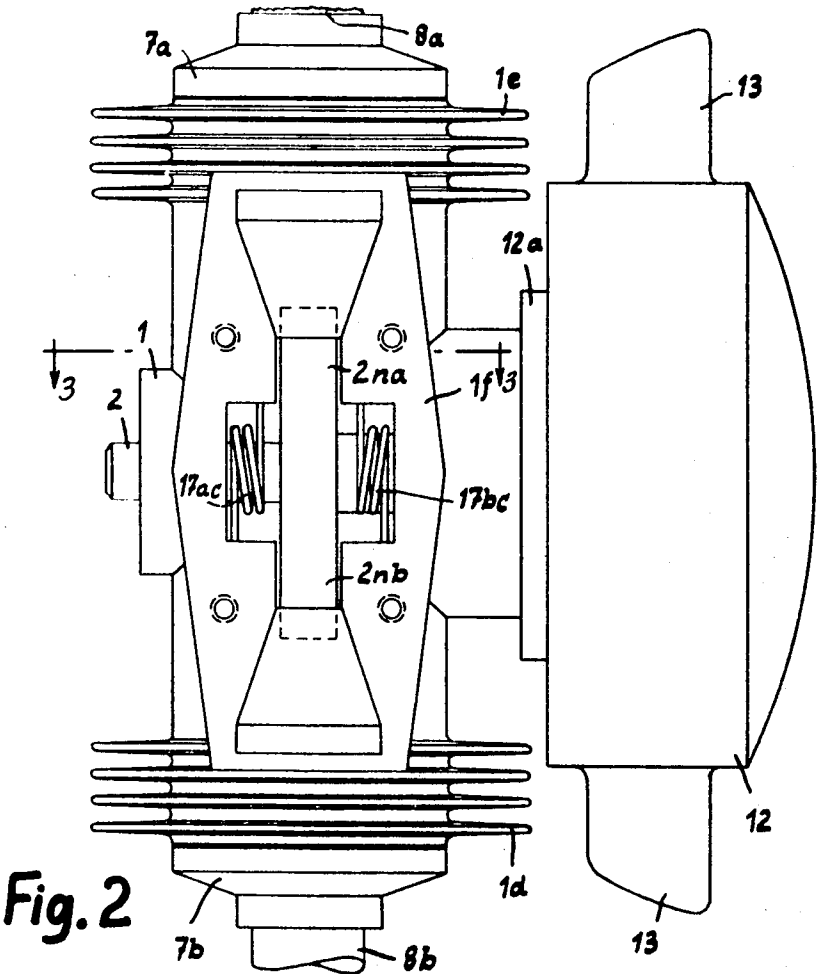


Fig. 1

INVENTOR
ERNST HATZ

Larson and Dayles
ATTORNEYS



INVENTOR
ERNST HATZ

Sarsoy and Taylor
ATTORNEYS

Fig. 4

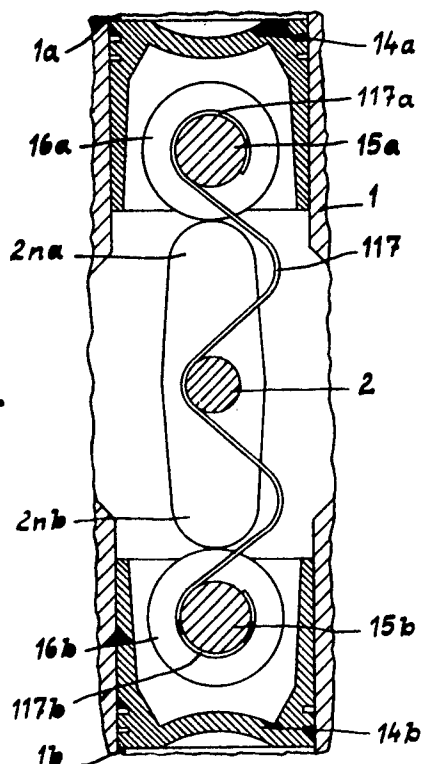
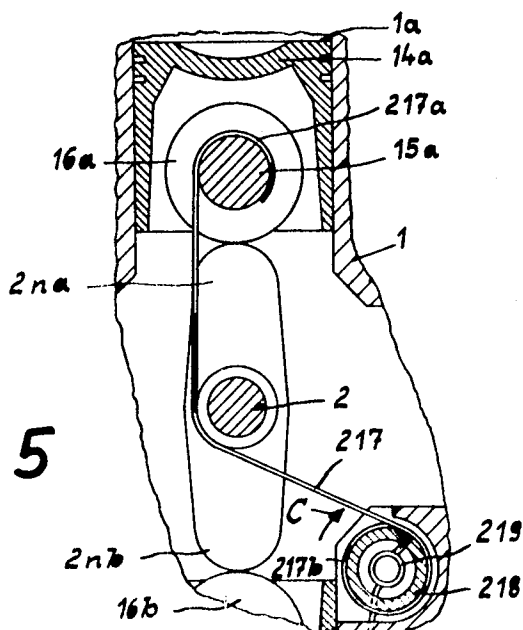


Fig. 5



INVENTOR
ERNST HATZ

Larson and Day
ATTORNEYS

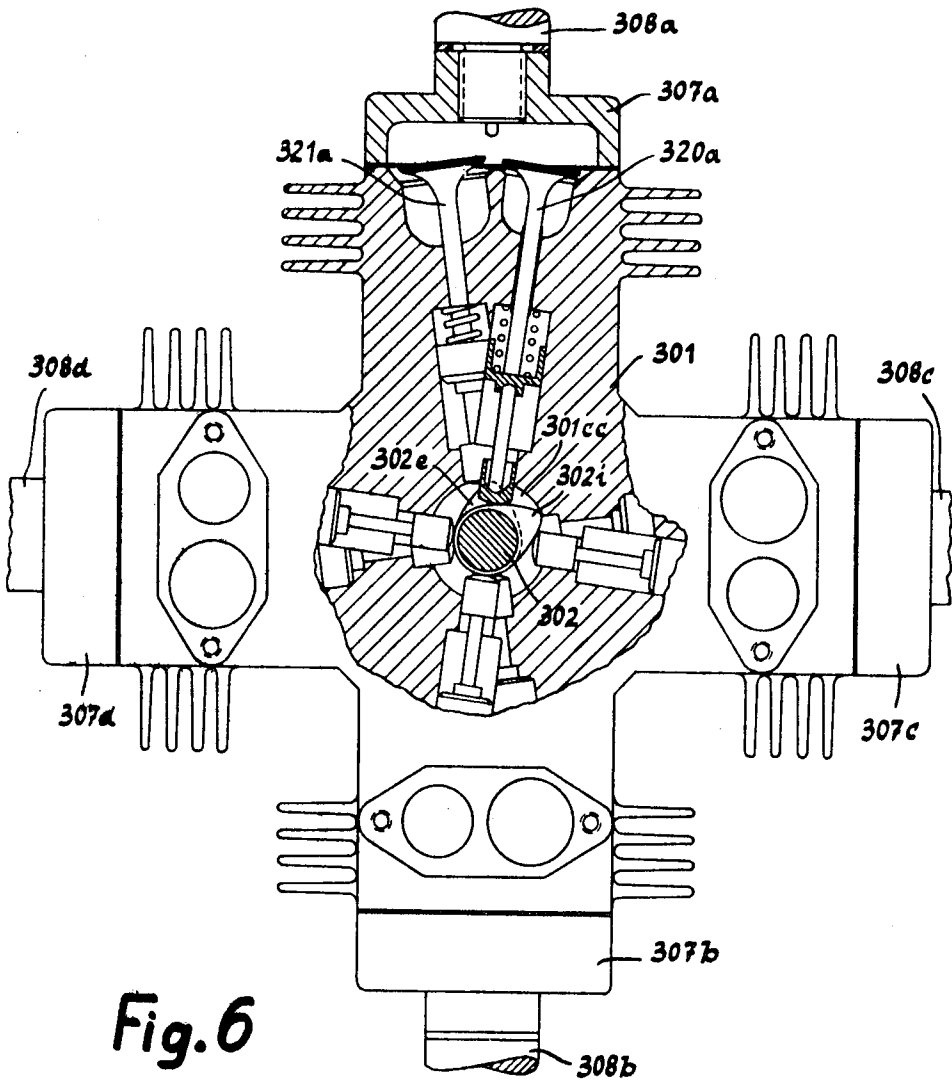
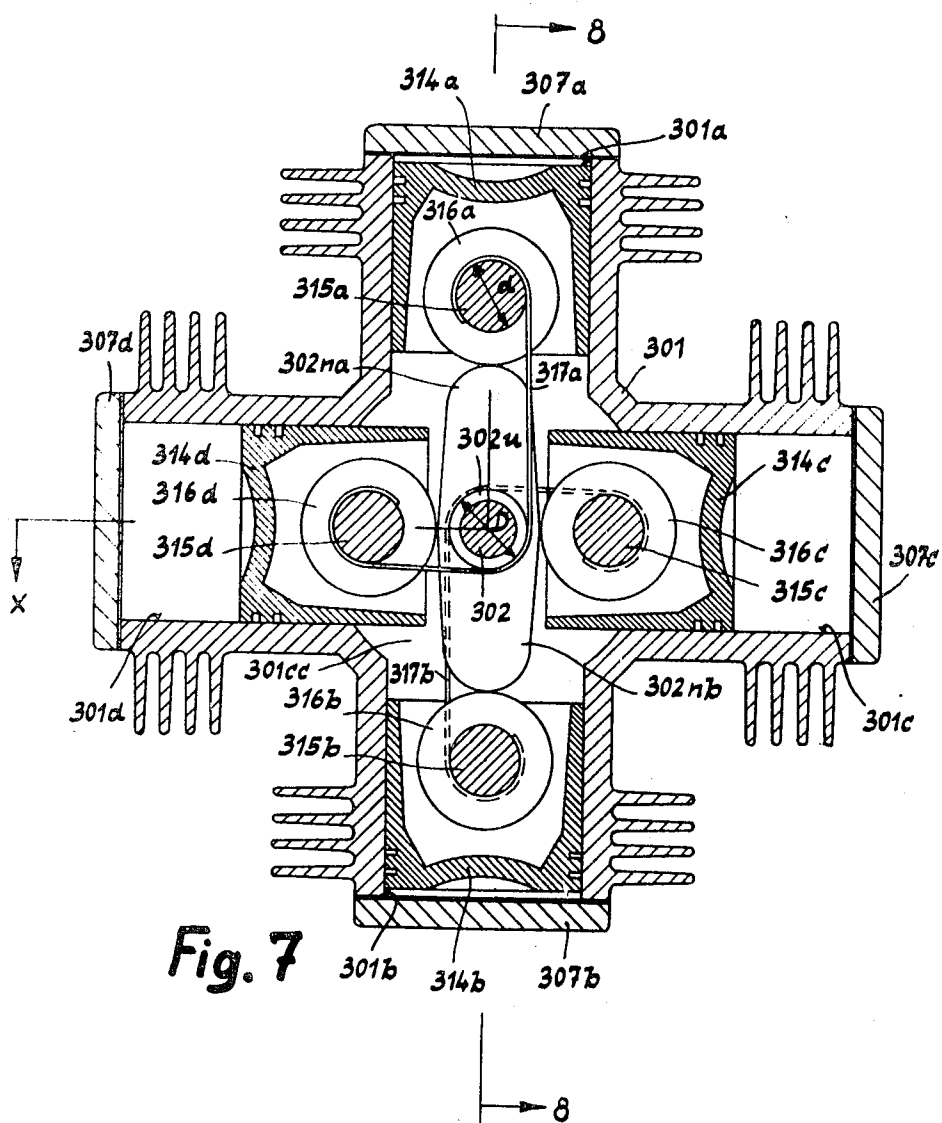


Fig. 6

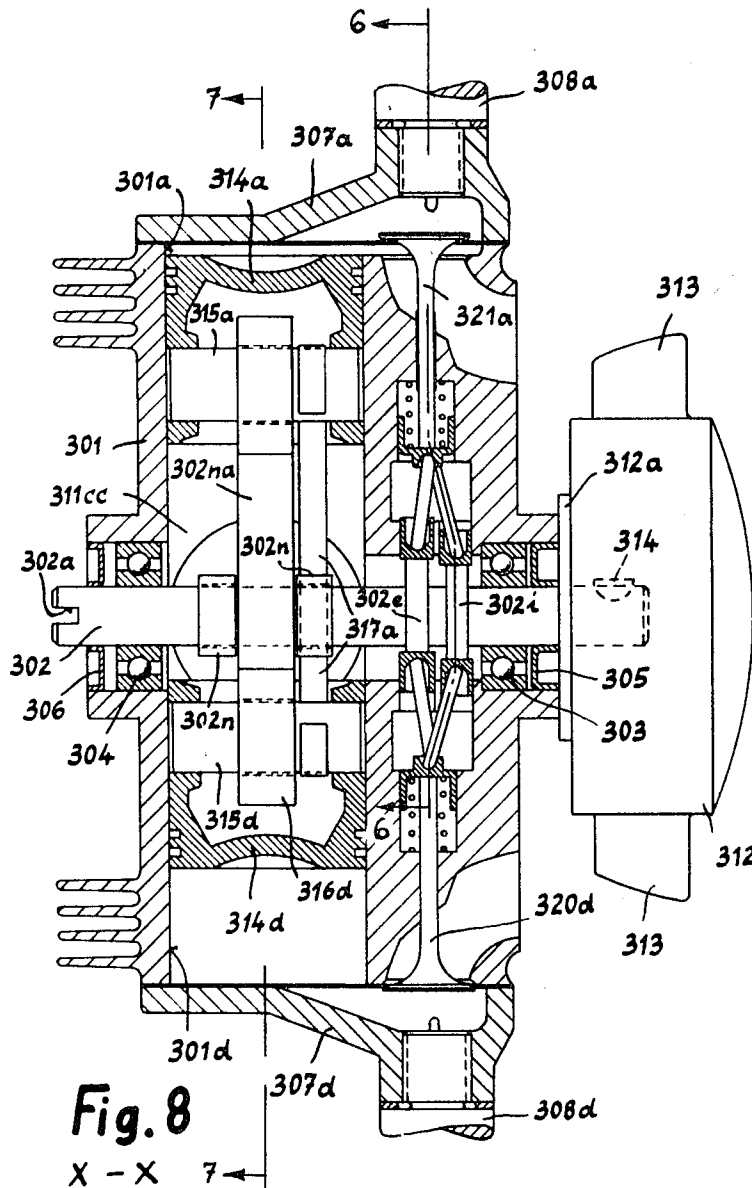
INVENTOR
ERNST HATZ

Sarsoy and Taylor
ATTORNEYS



INVENTOR
ERNST HATZ

Taxson *Jayler*
ATTORNEYS



INVENTOR
ERNST HATZ

Farson and Taylor
ATTORNEYS

PISTON MECHANISM

BACKGROUND OF THE INVENTION

This invention relates to piston mechanisms of the type including at least one pair of opposed pistons and cylinders and including a central shaft drivingly engageable with the pistons.

In piston mechanisms of the present type, particularly in internal combustion engines, the coupling between the pistons and the central shaft is usually characterized by a connecting rod system. However, this conventional connecting rod system has several disadvantages. It is a comparatively complicated structure and requires substantial space for its operation. In addition, this arrangement has the further disadvantage that the coupling elements are normally fairly large and thus produce large oscillations as they constantly change their direction during the operation of the engine. These oscillations thereby result in undesirable vibrations and moreover they lead to excessive wear of the engine parts and excessive loading of the bearings.

SUMMARY OF THE INVENTION

It is a purpose of the present invention to provide a piston mechanism such as an internal combustion engine or the like wherein the above described disadvantages are eliminated. It is thus a further purpose of this invention to provide a mechanism of the type described which is substantially free from vibrations and which is compact in size and which operates without overloading the bearings.

This purpose is achieved in accordance with the present invention by providing at least one and possibly more pairs of diametrically opposed piston and cylinder units located on opposite sides of a rotating shaft and providing on the shaft a cam comprising cam parts mounted on diametrically opposite sides of the shaft axis for rotation with the shaft. In accordance with a feature of the present invention, the driving force is transferred between the pistons and the cams by direct engagement of these members, either through sliding surface contact or rolling surface contact wherein the driving force is exerted in a direction generally parallel to the direction of reciprocation of the pistons. Thus, conventional crank shafts, connecting rods, etc., are completely eliminated.

In a preferred embodiment of the invention, resilient means are provided for urging the pistons against the cam parts. This resilient means may comprise a wire-type spring member grasping the pistons at its two ends and having its central part located in the central space between the pistons in the vicinity of the shaft. For convenience the wire-type spring may be at least partially wound about the shaft.

When applying the present invention to a two-stroke internal combustion engine, the spring need only ensure movement of the pistons against the cams when the engine is stopped and upon starting of the engine. Consequently, in this environment the spring need not be very powerful. In the case of a four-stroke internal combustion engine, however, the spring must also assure contact between the piston and the cam parts during a particular operating phase, and in this case the spring will have to be more powerful.

In accordance with a further feature of the invention, the resilient means may comprise a steel strip or the like connected to one piston at one end and connected at its other end to a separate resilient means or to another part of the engine which is moveable through a cycle opposite from that to which the said strip is attached. For example, in an embodiment having two pairs of pistons arranged at right angles to each other, the strip may be attached at its two ends to one piston of each pair, the intermediate part of the strip being wound about the shaft.

In accordance with a further feature of the invention, in the case of a two-stroke internal combustion engine, the spring may be arranged to facilitate feeding of scavaging air into the cylinders. In this case the moveable part of the spring may be made to act against a resilient member such as a diaphragm or

the like to cause pumping of air into the cylinders concurrent with reciprocating movement of the piston.

In accordance with another feature of the invention, the same driving shaft may have additional cams mounted thereon for controlling the fluid relative to the cylinders. For example, the cams may operate valves, injection nozzles or the like for controlling the flow of fuel and or air to and from the cylinders.

Thus, it is a purpose of this invention to provide a new and improved piston mechanism.

It is another object of this invention to provide a new and improved piston mechanism which is substantially vibration free and which is relatively compact.

It is another object of this invention to provide a new and improved piston mechanism having diametrically opposed cylinders with reciprocating pistons therein which are drivingly engageable with cam parts mounted on and rotatable with a shaft located between the pistons.

It is another object of this invention to provide a new and improved piston mechanism having opposed pistons drivingly engaging a shaft through cams mounted on the shaft and including novel arrangements of resilient means for assuring contact between the pistons and the cams.

Other objects and the attendant advantages of the present invention will become apparent from the detailed description to follow together with the accompanying drawings. BRIEF DESCRIPTION OF THE DRAWINGS

There follows a detailed description of preferred embodiments to be read together with accompanying drawings. It is to be understood, however, that the description and the drawings are provided merely to illustrate and describe preferred embodiments of the invention.

FIG. 1 is a sectional view of a piston mechanism constructed in accordance with the features of the present invention.

FIG. 2 is a side elevational view taken from the left-hand side of FIG. 1.

FIG. 3 is a horizontal sectional view taken along line 3—3 of FIG. 2.

FIG. 4 is a partial cross-sectional view similar to FIG. 1 but showing a modification of the invention.

FIG. 5 is a partial cross sectional view similar to FIG. 1 but showing another modification of the invention.

FIG. 6 is a side elevational view of another embodiment with a portion shown in section and taken through line 6—6 of FIG. 8.

FIG. 7 is a sectional view taken through line 7—7 of FIG. 8.

FIG. 8 is a sectional view taken through line 8—8 of FIG. 7. DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENTS

In the description to follow, like numerals represent like elements throughout the several views. Further, in FIGS. 4 and 5, certain elements similar to those in FIG. 1 are increased by 100 and 200, respectively. Further, in the embodiment of FIGS. 6 through 8, elements similar to those in FIGS. 1 through 4 are raised by 300.

Referring to FIGS. 1-3, there is shown a two-cylinder two-stroke internal combustion engine. It comprises a cylinder block 1 in which are formed two diametrically opposed cylinders 1a, 1b with an inner chamber 1c between them. A driving shaft 2 is mounted and axially centered in the unit through the agency of bearings 3, 4 and has a clutch slot 2a for positive engagement with any unit (not shown) to be driven. 5 and 6 depict seals for sealing the inner chamber 1c from the exterior. The cylinders are provided at their peripheries with cooling fins 1d, 1e, and a cylinder head 7a, 7b respectively, is fastened to the block 1 at the respective ends of the cylinders. Spark plugs 8a, 8b of conventional form are secured in each cylinder head. A cover 11 is secured to one narrow side 1f of block 1 by screws, this cover carrying carburetter 9 and suction flap valve 10. The driving shaft 2 also drives the rotary part 12 of an electromagnetic spark distributor, which has a number of blades 13 additionally carried at the periphery thereof serving as an air blower for cooling parts 1d, 1e. The fixed or immobile

part 12a of the distributor is secured to the engine block 1. The drive transmission from shaft 2 to the rotary part 12 may for example be implemented by a key 13a.

Also provided in cylinder block 1, in the vicinity of cylinders 1a, 1b are apertures 1sa, 1sb which conduct the flow of scavaging air through the cylinders. Arranged in each cylinder is a piston 14a, 14b which is reciprocable in the direction towards the axial center of the unit. The coupling between pistons 14 and driving shaft 2 is, however, not in the traditional manner through a connecting rod but as follows:

Transversely mounted in each of the pistons 14a, 14b is a roller pintle 15a, 15b on which is rotatably mounted, preferably through the agency of needle bearings (not shown), a roller 16a, 16b respectively. Each of these rollers is engaged by a cam comprising cam parts 2na, 2nb mounted on shaft 2. These cam parts may be in one piece with the shaft or may be made separately and then firmly fastened thereto. Cam parts 2na, 2nb are disposed diametrically opposite from one another relative to the shaft axis so that they cooperate alternately with the rollers 16a, 16b of the pistons when shaft 2 rotates.

A return spring 17 of resilient wire form is disposed in the inner chamber 1c and has ends 17a, 17b curved and each engaging and thus held to one of the pintles 15a, 15b. The resilient limb 17as of this spring is shaped to provide a central multiturn section 17ac in the vicinity of shaft 2, with limbs 17az extending therefrom transversely through the inner chamber 1c and united at 17d with the other spring part 17bz which is similarly shaped and arranged at the other side of cams 2na, 2nb. Spring 17 is connected at 17d to a resilient diaphragm 18 by means of a rivet 19 or the like. With the arrangement of spring 17 described above, when piston 14a moves outwardly, that is, into its upper dead center position "OT," limbs 17as and 17bs are distended so that the central limb portions 17az, 17bz move in the direction of the arrow A in FIG. 1. At the same time the part 17d makes a movement in the same sense in the direction of arrow B, wherefore diaphragm 18 is pushed out to the right (FIG. 2). When piston 14 moves inwardly, that is to say into the lower dead center position "UT," limbs 17as, 17bs draw together under the effect of the resilience of spring 17 and the spring portion 17ac, 17bc, 17d now perform a movement in the reverse direction to the left (FIG. 1). During this phase diaphragm 18 is pulled in again. This motion of diaphragm 18 in synchronism with the inward movement of the pistons is used for a pumping action, whereby the parts 17d and 18 act as a charging pump or blower. This increases the volume of suction and scavaging air and the suction or scavaging air inside chamber 1c is subjected to a useful precompression (in other constructions a feed pump or the like can be connected to the spring portion 17d, in place of diaphragm 18, for the purpose indicated above).

The operation of the arrangement described simulates that of a known two-stroke engine with an extraneous ignition, and thus it is unnecessary to explain further the functioning in a two-stroke cycle of this nature. A difference is to be found, however, in the fact that the two pistons operate with a simultaneous stroke, that is to say they simultaneously move outward and reach the OT position or inward reach the UT position. They also differ in that in the present arrangement the force between the shaft 2 and the pistons 14a, 14b is transmitted through cams 2na, 2nb only. Engagement between elements 14a, 14b on the one hand the elements 2na and 2nb on the other is ensured at any moment in the two strokes (up to a certain number of rotations), by either the pressure of the cam or the counter pressure within the cylinders acting on each piston.

An optimum driving coupling is ensured when the forces acting on a piston are equal to or less than the pressure exerted on the piston from the combustion chamber. In the example illustrated it will be assumed that the performance curve of each piston, which is calculated from the diameter of the drive rollers, the outside diameter of the cam and the curvature of the entry and exit flanks of the cam and the base circle of the latter is a true sine curve. Thus a satisfactory drive coupling is ensured as long as the formula

$$P = n\omega^2 r \sin \alpha$$

is adhered to, the factors of the above being as follows:

= pressure on the pistons.

n = twice the rate of rotation of the driving shaft

ω = twice the angular speed of the driving shaft.

r = half the height of the cams.

α = twice the angle of rotation of the driving shaft.

The pistons 14a, 14b are accelerated during the upward motion (from UT to OT) up to half the stroke, that is to say at least as long as the openings 1sa, 1sb are open. As soon as these openings are covered by the pistons a counterpressure is developed in each cylinder 1a, 1b which augments the pressure of the pistons 14a, 14b through the rollers 16a, 16b against the associated cams 2na, 2nb. As soon as the travel exceeds the half stroke the movement of the piston is slowed down, but the counterpressure at this point is already greater than the forces imposing the delay, so that even at this phase of the upward movement the power transmission is continuously maintained. The maximum delaying forces act on the piston in the OT position. At this instant, however, the counter forces exerted from the cylinder are at a maximum.

As regards the downward movement of the pistons (from OT to UT) conditions analogous to those referred to above in relation to the upward movement will apply. Thus a power coupling between the piston and the cams continuously prevails even during the downward movement.

As has been explained in the foregoing, the forces and counter forces which act on each piston in the embodiment being described are so related to one another that without more a nonpositive coupling is continuously applied between the pistons and cams, until a critical rate of rotation is achieved. The tension spring 17 is thus not per se necessary during the running of the engine. Its only function is to assist the starting of the stationary internal combustion engine in cases where both pistons may by chance come to rest in position OT. In such instances, when starting up the spring must move the two pistons towards position UT on movement of the cams to ensure engagement between the cooperating parts. In such instances the spring has merely to overcome the friction between the pistons and cylinders and the relatively small pressure in chamber 1c, and in some instances the weight of the pistons (in the event that the internal combustion engine is arranged so that the axis of the pistons are vertical). The spring forces required here are however very small, so that spring 17 need not be very strong.

When the return spring does not have to operate a scavaging air charging device, the form of this spring can be even more simple than that illustrated in FIG. 1, as shown by the example illustrated in FIG. 4. In this case a relatively weak spring 117 is arranged at each side of the cams 2na, 2nb. With this means, not only is the return of the pistons 14 ensured, but the pistons will also be held in their correct running positions relative to cams 2na, 2nb by the action of the two springs 117 on pintles 15a and 15b. Instead of using a return spring, each piston can be connected with one end of at least one steel strip 217 as indicated in FIG. 5, the other end being anchored to a part which is movable in a cycle opposed to that of the piston, for example to a fixedly mounted rotational roller 218 which is turned in the direction of arrow C by means of a helical spring 219. As a result, during the movement of the piston 14a to position UT the strip 217 will be rolled around roller 218 under the action of spring 219 and will roll off roller 218 again when the piston moves towards OT in opposition to spring 219. Alternatively, a steel wire or a chain may be used for the same purpose in place of a steel strip in this type of return of the piston.

The features illustrated in FIGS. 1 to 5 could be used also in similar form in a single cylinder internal combustion engine if for example the piston 14b is not subject to the pressure in a combustion chamber 1b but is merely urged, through its roller 16b against its associated cam 2nb or 2na under the action of a correspondingly powerful spring. This piston 14b would then merely have the function of a member for returning working piston 14a.

The embodiment of the invention illustrated in FIGS. 6 to 8 relates to a four-stroke internal combustion engine with extraneous ignition. In contrast to the embodiment of FIGS. 1 to 3, this embodiment has pairs of pistons offset at 90° to one another. The power transmission, without connecting rods, between the driving shaft and the pistons is here the same as in the first embodiment, so that a further description of this phase of the operation need not be repeated here.

The elements in this embodiment are again devised so that the cam rise follows a sine curve. Since in the case of a rapidly running four-stroke engine inertial forces are heavy and, on the other hand, the pressures or counter pressures applied against each piston from the cylinder are very small, or even slightly negative (suction stroke) in certain operating phases, an expedient dictating a positive return movement is necessary for each piston to ensure engagement between the piston and cam. A preferred return means designed for this purpose is a spring steel strip 317a which is connected to the piston 314a of one pair, passes around shaft 302 at 302u and is then connected to piston 314c of the other pair. A second strip 317b is similarly arranged between the other two pistons 314b and 314d. Since the two strip-connected pistons operate in opposed cycles, the strip length always remains the same (assuming $D=d$).

When the diameter D of the relevant portion of the shaft must be greater than the diameter d , the resultant comparative motions of pistons 314a and 314c may be balanced by an appropriate slight modification of the rising or falling flanks of cams 302na, 302nb, with the base circle and the top circles of these cams remaining the same.

A spring steel wire or a chain or the like may be used in place of the spring steel strip referred to. Moreover two connecting elements of the kind referred to could be connected in symmetrical fashion to a single piston, should it be found necessary to do so, for example for parallel guidance of the piston or its roller relative to the cam.

Two further control cams 302i and 302e are provided on drive shaft 302 alongside cam 302n for operating the inlet valves 320a, 320b, 320c, 320d or the exhaust valves 321a, 321b, 321c, 321d through interposed transmission elements of known type.

In the case of engines having self-coupling (Diesel engines) a third control cam, may be provided on shaft 302, for example for controlling injection nozzles.

In this embodiment use is made of one control cam only for a specific group of control elements, so that the firing sequence is a, b, c, d . Where use is made of a number of control cams for one group, for example for inlet valves, the firing sequence may however, be varied very simply in any appropriate way.

In all the embodiments of the invention described, no lateral and no continuously alternating torques are applied to the driving shaft, to that the occurrence of detrimental oscillations in the drive is inhibited. Moreover the transmission forces between the pistons and cams are always normal to the cams and alternate in the same cycle at both sides so that no, or only very minimal bending forces are applied to the shaft. The latter therefore need not be very robust and can be mounted in small main bearings only. Stated differently, the load on the bearings is relatively small. More importantly, the number and form of the driving cams on the shaft can be suited to the transmission ratio required. That is, instead of using the ratio 1:2 in the example illustrated, a reduction ratio 1:3 or 1:4 can be used.

the elements (pistons, shaft, cams, valves etc.) which are required to construct the piston engine in accordance with the present invention have the conventional form, so that they can be made by prior manufacturing means or methods, and for example even by a series manufacturing process, and be

economically assembled.

Moreover, in view of the omission of the connecting rods in the piston equipment, the height of the engine can be substantially reduced and a compact piston engine construction achieved.

Although the invention has been described in considerable detail with respect to preferred embodiments thereof, it should be apparent that the invention is capable of numerous modifications and variations apparent to those skilled in the art without departing from the spirit or scope of the invention. For example, the number of pistons is not limited to the number illustrated, and the device may be applied to different types of piston mechanisms such as a pump wherein the shaft drives the pistons.

I claim:

1. A piston mechanism comprising at least one pair of diametrically opposed cylinders, a reciprocating piston in each cylinder, a shaft located between said pistons, and driving means for placing said pistons and said shaft into driving relationship with each other, said driving means comprising at least one pair of cam parts mounted on diametrically opposite sides of the axis of the said shaft for rotation with said shaft, said cam parts being engageable with said pistons such that the driving force between the pistons and the shaft is transmitted through contact between said cam parts and said pistons in a direction generally parallel to the direction of movement of the pistons and including resilient means having a movable part, said resilient means continuously acting on the pistons for urging the pistons against the cam parts, wherein said piston mechanism is a two-stroke internal combustion engine including pumping means for pumping scavenging air to said cylinders, the last said means being operated by said resilient means as the movable of said resilient means moves with the pistons during the reciprocation of the pistons.

2. A piston mechanism according to claim 1 wherein the cam parts are nonpositively connected to said pistons such that the pistons and the cam parts can be moved independently of each other.

3. A piston mechanism according to claim 1 wherein the cam parts engage the pistons directly such that said contact is sliding contact.

4. A piston mechanism according to claim 1 wherein the pistons include rolling elements reciprocating therewith and wherein the cam parts engage the rolling elements whereby said contact is rolling contact.

5. A piston mechanism according to claim 1 including guide means for preventing rotary movement of each piston within its respective cylinder.

6. A piston mechanism according to claim 1 including further cams mounted on said shaft for rotation therewith for controlling the flow of fluids in said mechanism relative to said cylinders.

7. A piston mechanism according to claim 6 including control valves for controlling the flow of fluids into and out of said cylinders, movement of said valves being controlled by said further cams.

8. A piston mechanism according to claim 1, wherein said resilient means comprises at least one spring member having its central part located between the pistons and having one opposite end engaging each of the opposed pistons to urge the same in the direction towards the cam part, the movable part of said spring member reciprocating with said pistons operably engaging a movable part of said pumping means to feed said scavenging air into the cylinders.

9. A piston mechanism according to claim 8, said movable part of said pumping means being a diaphragm, wherein when the pistons move toward said shaft the diaphragm is moved by said spring member to cause scavenging air to be fed into the cylinders.