March 8, 1966 V. J. HUBER ETAL 3,238,889

PISTON DRIVE MECHANISM

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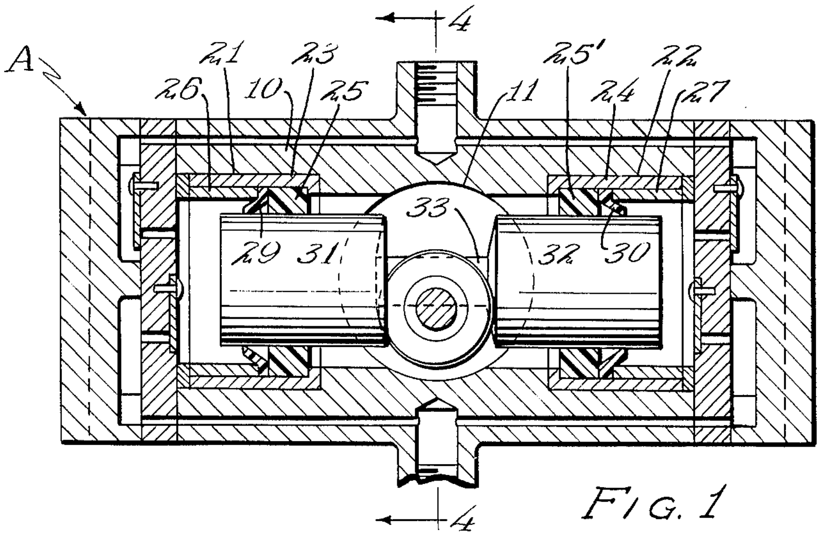

FIG. 1

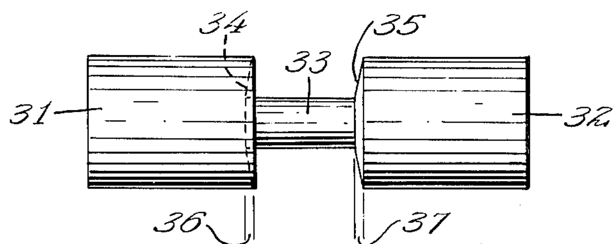

FIG. 2

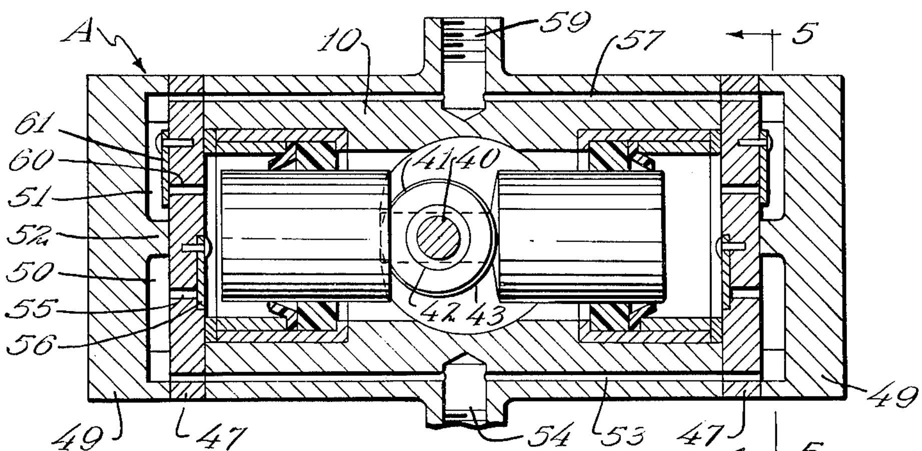

FIG. 3

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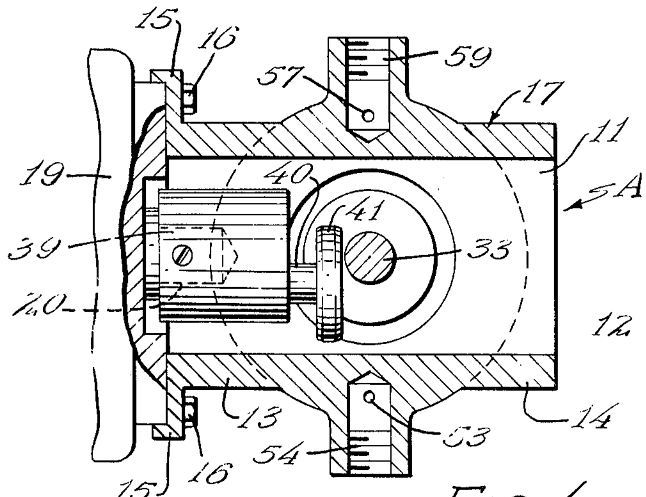

FIG. 4

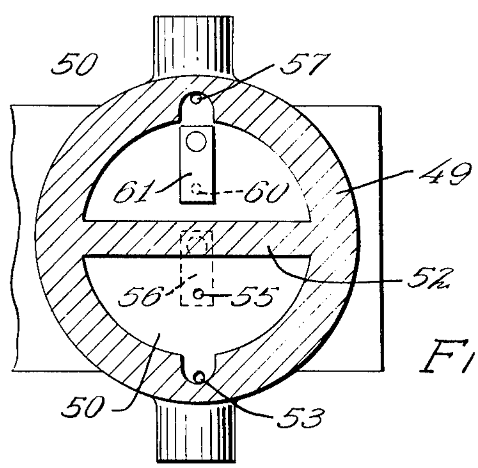

FIG. 5

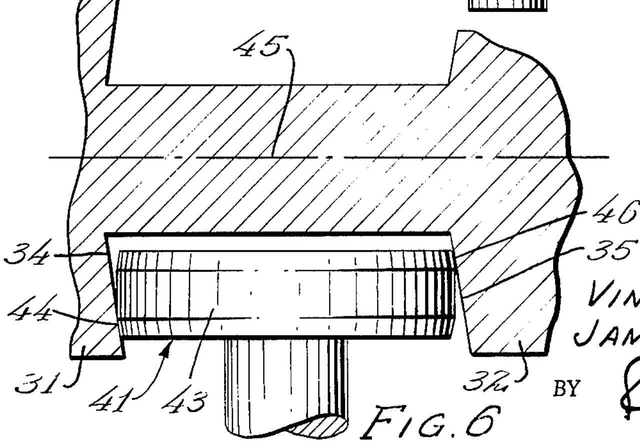

FIG. 6

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3,238,889

Patented Mar. 8, 1966

3,238,889
PISTON DRIVE MECHANISM

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Filed June 3, 1963, Ser. No. 285,125
10 Claims. (Cl. 103—171)

This invention relates to an improvement in piston drive mechanisms and deals particularly with a means of driving a reciprocable piston in such a manner that it will rotate about its axis as it is reciprocated.

Various types of piston mechanisms have been provided which are reciprocated by an eccentric mounted on a shaft having its axis intersecting the axis of the piston at right angles. Such pistons are usually provided with a piston rod of smaller diameter than the piston and including parallel shoulders which are spaced apart a distance substantially equal to the diameter of the eccentric roller or bearing. For example, compressors and vacuum pumps have been produced comprising an elongated cylinder having a pair of connected pistons reciprocable therein. The pistons are reciprocated in unison by an eccentric roller or bearing supported eccentrically upon a drive shaft, the axis of which intersects the axes of the pistons. During one hundred eighty degrees of rotation of the drive shaft, the pistons are urged in one direction, and during the remaining one hundred eighty degrees travel of the drive shaft, the pistons are moved in the opposite direction. Means are provided for admitting air into the cylinder ends during movement of the pistons away from the end, and permitting air to escape from the cylinder end during the compression stroke.

One of the difficulties which has been experienced with devices of this type lies in the fact that the eccentric roller or bearing engages the same areas of the pistons ends or abutments against which the eccentric roller engages, causing undue wear in this area. Furthermore, in the event any abrasive material enters the cylinder, this material may enter the small clearance between the piston and the cylinder and be moved longitudinally of the cylinder as the piston reciprocates, providing longitudinal groove in the wall of the cylinder, of the piston, or of both. In actual practice, some structures of this type have been actually worn out after a relatively few hours of continuous operation.

We have found that the life of a piston structure of this general type can be prolonged many times its normal life if the piston structure is rotated about its axis as it reciprocates. As the piston structure rotates about its axis, the eccentric cam or bearing continually engages a different point on the abutments against which the bearing engages. Furthermore, any abrasive particles which are accidentally entrapped between the piston structure and the wall of the cylinder also continually engage a different portion of the surface of the piston structure and cylinder, so that the tendency of such a particle to wear a longitudinal groove is eliminated.

We have found that by making the surface of the abutment on one side of the eccentric roller or bearing concave, and making the surface of the other abutments slightly convex, the piston structure will automatically rotate about its axis as it is reciprocated. It is believed that this is due to the fact that as the substantially cylindrical surface of the eccentric roller is forced against the concave surface of the abutment, the edge of the eccentric roller which is farthest from the axis of the piston shaft bears against this surface in a manner to create a moment arm tending to rotate the piston structure in one direction about its axis, while when the cam roller exerts its force in the opposite direction, the edge of the eccentric

roller which is nearest the axis of the piston structure exerts a force tending to rotate the piston structure in an opposite direction. However, due to the fact that the moment arm is considerably reduced when the eccentric roller engages the convex surface, an unbalanced force is created, and the rotation of the piston caused by the engagement of the eccentric roller with the concave surface overrides the tendency of the piston to rotate in the opposite direction.

A further feature of the present invention resides in the fact that a somewhat similar result may be accomplished by arranging the axes of the piston and the drive shaft on a common plane with the axes thereof intersecting, but in locating the axis of the drive shaft of slightly more or less than ninety degrees from the axis of the piston. However, better results have been produced by having the surfaces of the abutments of frusto-conical form, one surface being slightly concave and the other surface being slightly convex.

These and other objects and novel features of the present invention will be more fully and clearly set forth in the following specification and claims.

In the drawings forming a part of the specification:

FIGURE 1 is a longitudinal sectional view through a double acting compressor or vacuum pump showing the general arrangement of parts therein.

FIGURE 2 is an elevational view of the piston used in the pump, the concavity and convexity of the piston ends being materially exaggerated to show the principle.

FIGURE 3 is a view similar to FIGURE 2 showing the piston structure at one end of its stroke.

FIGURE 4 is a transverse sectional view through the compressor, the position of the section being indicated by the line 4—4 of FIGURE 1.

FIGURE 5 is a transverse section on the line 5—5 of FIGURE 3.

FIGURE 6 is an enlarged view of a portion of the piston drive mechanism.

To simplify the description, the apparatus will be described as a compressor. However, by changing the arrangement of the ports, the same device can be used as a vacuum pump. The present structure has been found particularly advantageous in this type of device, but it should be understood that the same drive principle could be used in other types of piston structures where the piston is reciprocated by an eccentric roller or bearing movable between two abutments on a shaft coaxial with the piston.

The compressor A includes an elongated cylinder **10** which is intersected intermediate its ends with a transverse bore **11** extending through a pair of right angularly extending bosses **13** and **14**. The boss **13** is provided with a peripheral flange **15** through which angularly spaced bolts such as **16** may extend to secure the housing **17**, including the cylinder **10** and bosses **13** and **14** to a motor **19**. The motor **19** is provided with a drive shaft **20** which projects into the bore **12**, preferably in coaxial relation thereto.

In the particular arrangement illustrated, the end portions of the cylinder **10** are counter bored to a larger diameter than the central portion of the cylinder as indicated at **21** and **22**. Mounting rings **23** and **24** are provided in the counter bores **21** and **22** and support rings **24** made of low friction material such as resilient plastic material polytetrafluoroethylene known to the trade under the trademark "Teflon" also in the particular arrangement illustrated, the mounting sleeves **21** and **22** may support spacer rings **26** and **27** respectively which hold the Teflon rings **24** and **25**, as well as the angular wiper rings **29** and **30** in position.

The rings **24** and **25** and wiper rings **29** and **30** slidably support a double ended piston unit including a pair of pistons **31** and **32** connected by a connecting rod **33** which is coaxial with the pistons. In the arrangement illustrated, the inner opposed ends of the pistons **31** form the abutments against which the drive roller engages. The piston **31** is provided with a frusto-conical concave surface **34** while the piston **32** is provided with a frusto-conical convex surface **35**. The concave surface **34** is at an angle **36** to a plane normal to the axis of the pistons, while the convex frusto-conical surface **35** of the piston **32** is at an angle **37** to a plane normal to the axes of the pistons. The angles **36** and **37** are equal and are shown in greatly exaggerated form in FIGURE 2. In the structures produced, are about one or two degrees. This angle has proven sufficient to create rotation of the pistons about their axes as they are reciprocated. In structures of different dimensions, this angle may have to be increased or decreased.

As indicated in FIGURE 4 of the drawings, a sleeve **39** is secured to the motor shaft **20** to rotate in unison therewith, and this sleeve supports a pivot pin **40** which is arranged with its axis offset from the axis of the sleeve. As indicated in FIGURE 3 of the drawings, the pivot shaft or stud **40** supports a ball bearing **41** having an inner race **42** and an outer race **43**. The diameter of the outer race **43** is approximately equal to the distance between the abutment surfaces **34** and **35**, the bearing fitting between the surfaces so that it will only contact one of the surfaces at a time, but so that there is no particular waste space. As a result, as the motor drive shaft **20** rotates in a clockwise direction as viewed in FIGURES 1 and 3 of the drawings, the bearing **41** will engage the concave piston surface **34** as the piston structure moves to the left, and will engage the convex piston **35** as the motor shaft completes each revolution. As indicated in the greatly enlarged section of FIGURE 6, when the pistons are moving to the left, the outer race **43** of the bearing **41** engages an area **44** of the concave surface **34** of the piston **31** which is located relatively far away from the axis of the pistons, this axis being represented by the broken line **45** in FIGURE 6. At the same time, during the movement of the piston structure to the right as viewed in this figure, the bearing race **43** will engage the convex surface **35** along an area **46** which is materially closer to the axis **45**.

The ends of the cylinder **10** are closed by end plates **47**, and manifold plates **49** abut against the end plates **47**. The manifold plates **49** are provided with a pair of generally semi-cylindrical recesses **50** and **51** separated by a partition **52**. The chambers **50** are connected by suitable passages **53** to an air inlet **54**, and these chambers **50** communicate with the interior of the cylinder through passages **55**. Check valves **56** permit air to enter the end of a cylinder from which the piston is moving.

The chambers **51** are connected by passages **57** to the outlet **59**, and these chambers **51** also communicate with the interior of the cylinder **10** through ports **60**. Check valves **61** close the ports **60** when the pistons are moving away from the cylinder end, and open as the piston moves on its compression stroke to force air through the outlet **59**.

The operation of the device as a compression pump or as a vacuum pump is believed obvious from the foregoing description. During the reciprocation of the piston unit, air is drawn into the end of the cylinder away from which the piston unit is moving, and air is forced from the end of the cylinder toward which the piston unit is moving.

Insofar as the operation of the means of rotating the piston is concerned, it is extremely difficult to state with complete accuracy just what takes place. However, it is noted that where the outer race **43** of the bearing such as **41** operates between a pair of abutments which are normal to the axis of the pistons, there seems to be some tendency for the piston to rotate about its axis in one direction as the piston is being moved in one direction, and to rotate in the opposite direction as the piston moves in the opposite direction. However, the forces against the two abutments are approximately the same, and as a result no rotation of the piston unit takes place. It should be remembered that when the pump is in operation, the piston unit may reciprocate at a relatively high speed so that the two tendencies are equalized.

It is theorized that when the bearing engages the concave surface **34** of the piston **31**, it engages the surface along the area **44** which is at a considerable distance from the piston axis **45**. During the return stroke of the piston unit, the bearing or roller **41** engages the convex surface **35** along the area **46** which is materially closer to the piston axis **45**. As a result, the force tending to rotate the pistons about their axes in one direction greatly exceeds the tendency to rotate the pistons in the opposite direction, and the piston unit maintains a constant rotation.

Whether or not this theory of operation is a complete explanation of the operation or not is not known. When the piston unit acts as a compressor or a vacuum pump, the pressures involved within the cylinder increase very materially as the piston moves along its compression stroke. This might have some effect on the operation, when combined with the fact that the point of engagement between the eccentric roller and the frusto-conical surfaces varies in radius from the piston axis as the eccentric rotates. It is known that the speed of rotation of the piston assembly about its axis increases as the load against which the piston assembly increases. This fact is also important, as when the apparatus is not operating under a load, the need for rotating the piston decreases. In any event, it is known that as the piston reciprocates, it also rotates about its axis where the abutments are frusto-conical and formed in the manner described. Thus it is known that the structure being described and claimed accomplishes the desired result.

Some advantageous results have also been accomplished by locating the axis of the motor shaft **20** on a plane with the axis of the pistons **31** and **32** and wherein the axis of the motor shaft is slightly out of right angular relation to the piston axes. When this is done, and when the faces of the abutments are parallel and normal to the axes of the pistons, the edge of the outer bearing race most remote from the piston axis will engage one abutment during the movement of the piston unit in one direction, and a portion of the bearing which is relatively closer to the piston axes would engage the other abutment during the return stroke. This arrangement does not appear to function as well as the preferred structure, described, but the fact that it functions seems to bear out the applicants' description of the operation.

If means are provided for carrying the eccentric past dead center position, the apparatus may also operate in reverse. If fluid is alternately directed to opposite ends of the cylinder **10**, the piston assembly may function to rotate the eccentric in its orbital path. The shaft **20** could be provided with a flywheel, or two angularly arranged pistons could be connected by the shaft **20**, each serving to move the eccentric of the other unit past dead center position. In such an event, the piston assemblies would still rotate about their axes upon reciprocation.

In accordance with the patent statutes, we have described the principles of construction and operation of our improvement in piston drive mechanisms, and while we have endeavored to set forth the best embodiment thereof, we desire to have it understood that changes may be made within the scope of the following claims without departing from the spirit of our invention.

We claim:

1. A piston drive means for use in reciprocating a piston assembly and simultaneously rotating the assembly about its axis and including a piston assembly, a piston rod on said piston assembly and coaxial with respect thereto, means providing a pair of shoulder abutments on said piston rod, a drive shaft means supporting said drive shaft with its axis intersecting the axis of said piston assembly, a roller eccentrically supported by said drive shaft to move in an orbital path upon rotation of said piston said roller having a generally cylindrical outer surface, the cylindrical surface being somewhat inclined, relative to the surfaces of said abutments so that the edge of the cylindrical surface most remote from the axis of the piston assembly engages one abutment and the edge of the cylindrical surface closest to the piston assembly axis engages the other abutment when the piston assembly moves in the opposite direction the distance between the abutments being slightly in excess of the outer diameter of said roller, and a cylinder slidably supporting said piston assembly.

2. The structure of claim **1** and in which the axis of said drive shaft intersects the axis of the piston assembly at right angles, and in which said abutments are frusto-conical, one abutment being concave and the other convex the two surfaces being parallel.

3. The structure of claim **1** and in which said piston assembly includes a pair of pistons connected by a coaxial connecting rod.

4. The structure of claim **3** and in which the inner opposed ends of the pistons form the said abutments.

5. A piston drive means for use in reciprocating a piston assembly axially within a cylinder and simultaneously rotating said piston assembly about its axis, including a piston rod on said piston assembly and coaxial with respect thereto, means providing a pair of spaced parallel shoulders encircling said rod, a shaft rotatably supported on an axis intersecting the axis of said piston assembly and at substantially ninety degrees thereto, a roller supported by said shaft on an axis parallel to said shaft axis and eccentric with respect thereto, said roller being supported between said shoulders and engageable therewith to reciprocate said piston assembly upon rotation of said shaft, one said shoulder having a frusto-conical slightly concave surface, the engagement of said roller with said surfaces acting to rotate said piston assembly about its axis as it reciprocates.

6. The structure of claim **1** and in which said surfaces are at an angle of about one degree from a plane normal to the piston assembly axis.

7. A piston drive means for use in reciprocating a piston assembly axially within a cylinder and simultaneously rotating said piston assembly about its axis, including a piston rod on said piston assembly and coaxial with respect thereto, means providing a pair of spaced parallel shoulders encircling said rod, a shaft rotatably supported on an axis intersecting the axis of said piston assembly, said shaft and piston assembly axes being in a common plane and at an angle of about one degree less than ninety degrees apart, a roller supported by said shaft on an axis parallel to said shaft axis and eccentric with respect thereto, said roller being supported between said shoulders and engageable therewith to reciprocate said piston assembly upon rotation of said shaft the angular relation between the axes of said shaft and said piston assembly imparting a rotative force to said piston assembly upon rotation of said shaft.

8. An apparatus including a housing having an aligned cylinder chamber at each end, a piston assembly in said housing including a piston in each chamber and a connecting rod of smaller transverse dimension than the diameter of the piston connecting said pistons and drive means for axially reciprocating said pistons and cooperable surfaces on said drive means and the inner opposed ends of said pistons for rotating said piston assembly about its axis.

9. A pump unit including a cylinder, a piston unit reciprocably slidable in said cylinder, said piston unit including a pair of spaced pistons and a connecting member of reduced diameter connecting said pistons for moving the same in unison, piston reciprocating means including a rotatable shaft having its axis intersecting the axis of said piston unit and at substantially ninety degrees thereto, a roller supported by said shaft on an axis parallel to said shaft axis and eccentric with respect thereto, means on said piston unit defining spaced parallel shoulders between which said roller is supported, one said opposed shoulder having a frusto-conical concave surface, and the other said shoulder having a frusto-conical convex surface, and valved passages communicating with the ends of said cylinder to control the flow of fluid to and from said cylinder ends.

10. A drive mechanism for use in rotating a piston as it reciprocates including a cylinder, a piston assembly slidable axially of said cylinder, a piston rod connected to said piston assembly and coaxial therewith, a shaft arranged with its axis intersecting the piston axis, means providing a pair of spaced abutments on said rod and encircling the same, an eccentric roller mounted on said shaft on an axis parallel to and spaced from, the shaft axis, the diameter of said roller being substantially equal to the distance between said spaced abutments, said roller having a generally cylindrical outer surface, said surface being somewhat inclined relative to the surfaces of said abutments so that the edge of said roller most distant from said piston axis engages one abutment as the piston assembly moves in one direction and the edge of said roller nearest said piston axis engages the other said abutment upon movement of said piston assembly in the opposite direction.

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