United States Patent [19]

Mills

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[45] **Nov. 20, 1973**

[54] **FLUID TORQUE OPERATOR**

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[22] Filed: **June 28, 1972**

[21] Appl. No.: **267,016**

Related U.S. Application Data

[63] Continuation-in-part of Ser. No. 168,674, Aug. 3, 1971, abandoned.

[52] **U.S. Cl.** ..... **92/66,** 92/117 R

[51] **Int. Cl.** **F01b 15/02**

[58] **Field of Search** ..... 92/66, 68, 71, 70, 92/76, 117, 117 A

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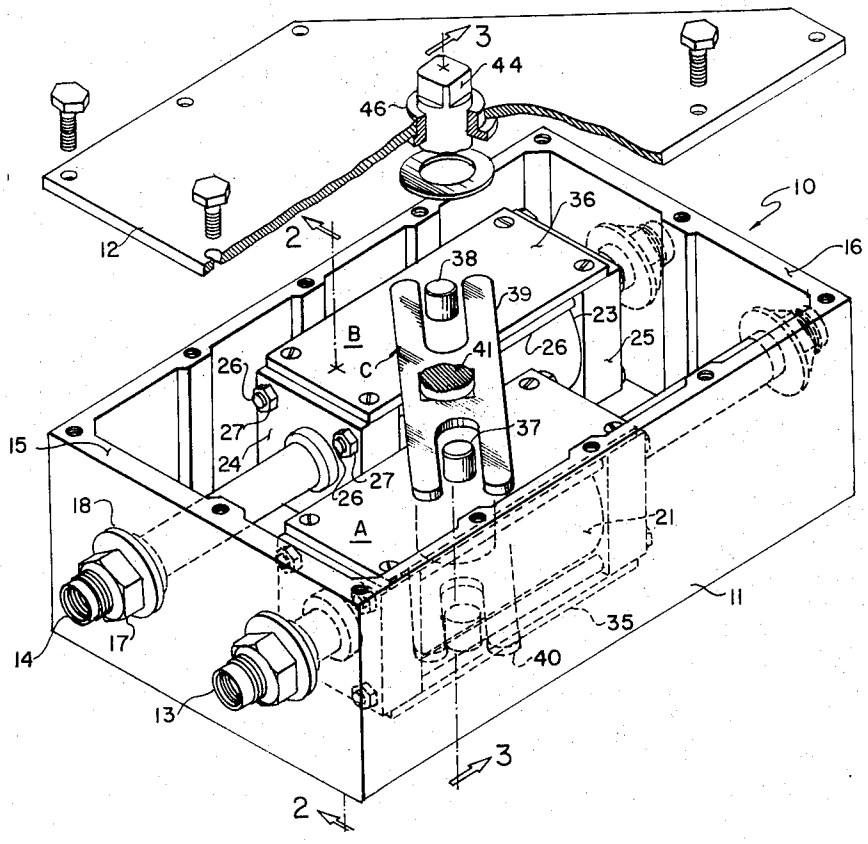
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Attorney—Augustus G. Douvas

[57] **ABSTRACT**

A fluid power operator for generating a rotary output torque. A pair of fixed, linear piston rods is located in a parallel spaced disposition to extend between and through a pair of housing end walls. Two fixed pistons are individually fixed to a midportion of a different rod. A cylinder envelopes each piston rod for guided movement along the piston rod. Mechanical coupling means, which may be a Scotch yoke, rack and pinion gear, or a slotted plate cooperating with disc or lever supported pins, interconnect both cylinders to an output drive shaft extending through the housing cover and bottom. Fluid passageways formed in each piston rod supply fluid pressure and exhaust to the cylinder chambers. Accordingly, the application of varying differential pressures to the opposite sides of both pistons reciprocate both cylinders relative their associated rods to apply a rotating force to the drive shaft through the coupling means.

7 Claims, 9 Drawing Figures



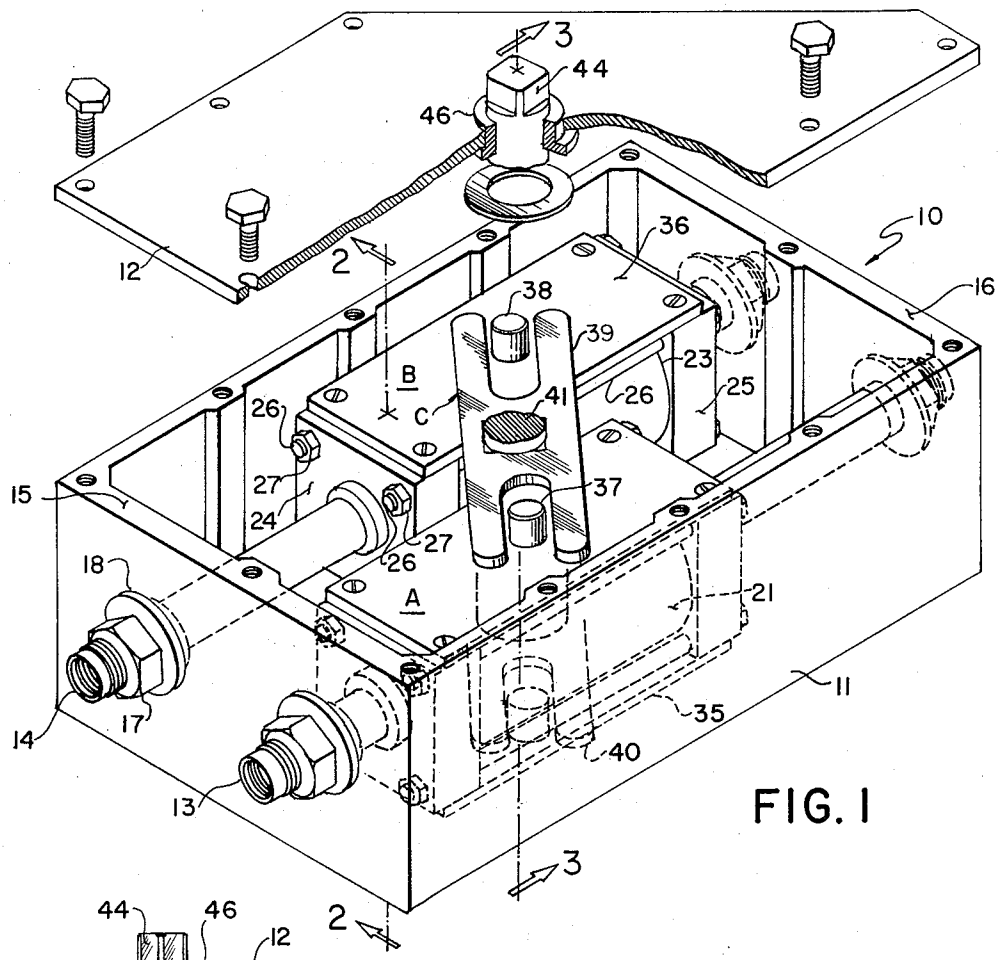


FIG. 1

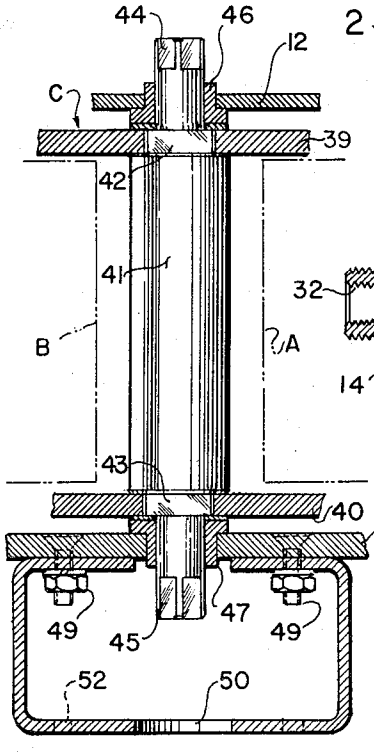


FIG. 3

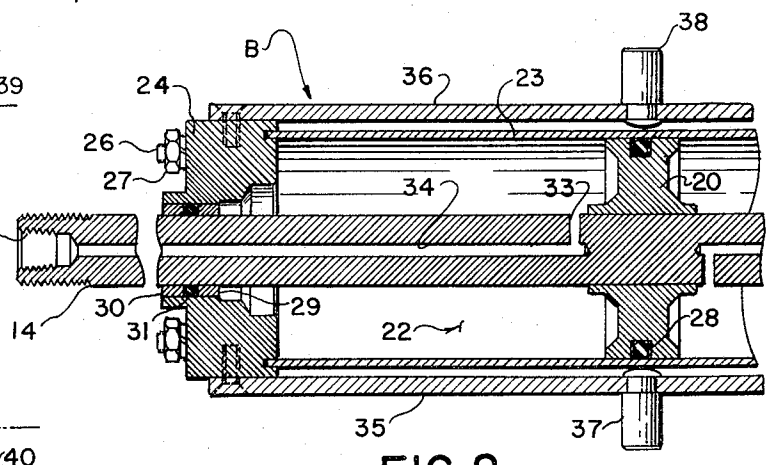


FIG. 2

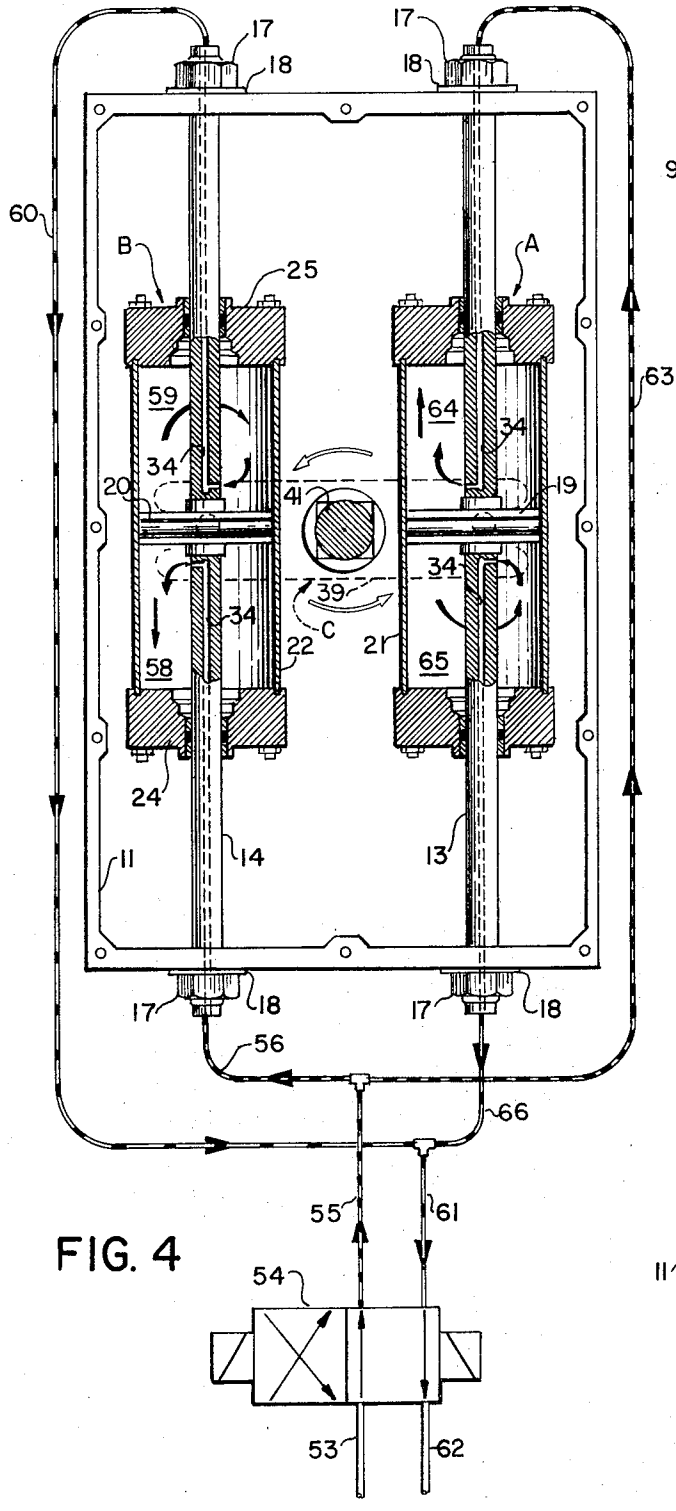


FIG. 4

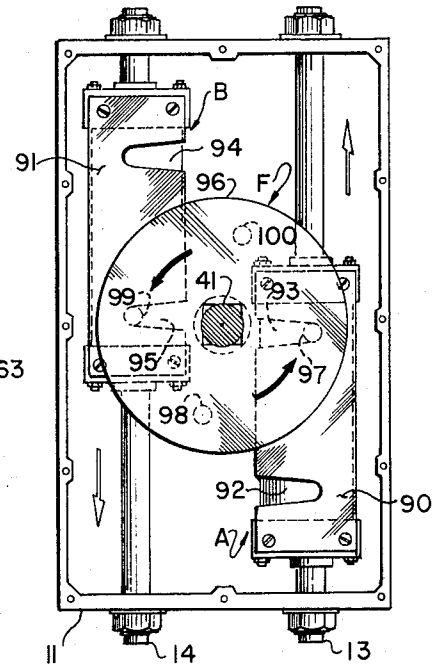


FIG. 9

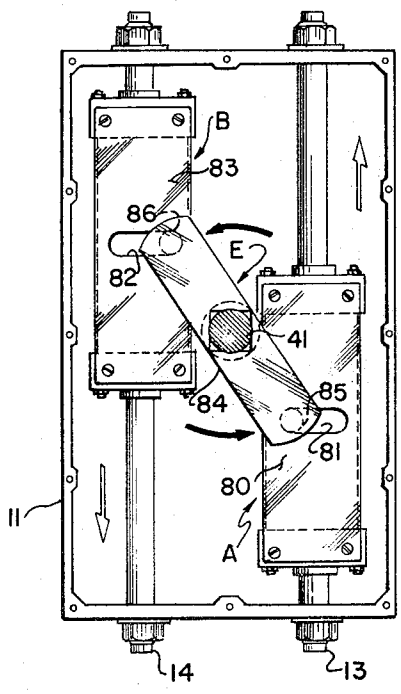


FIG. 8

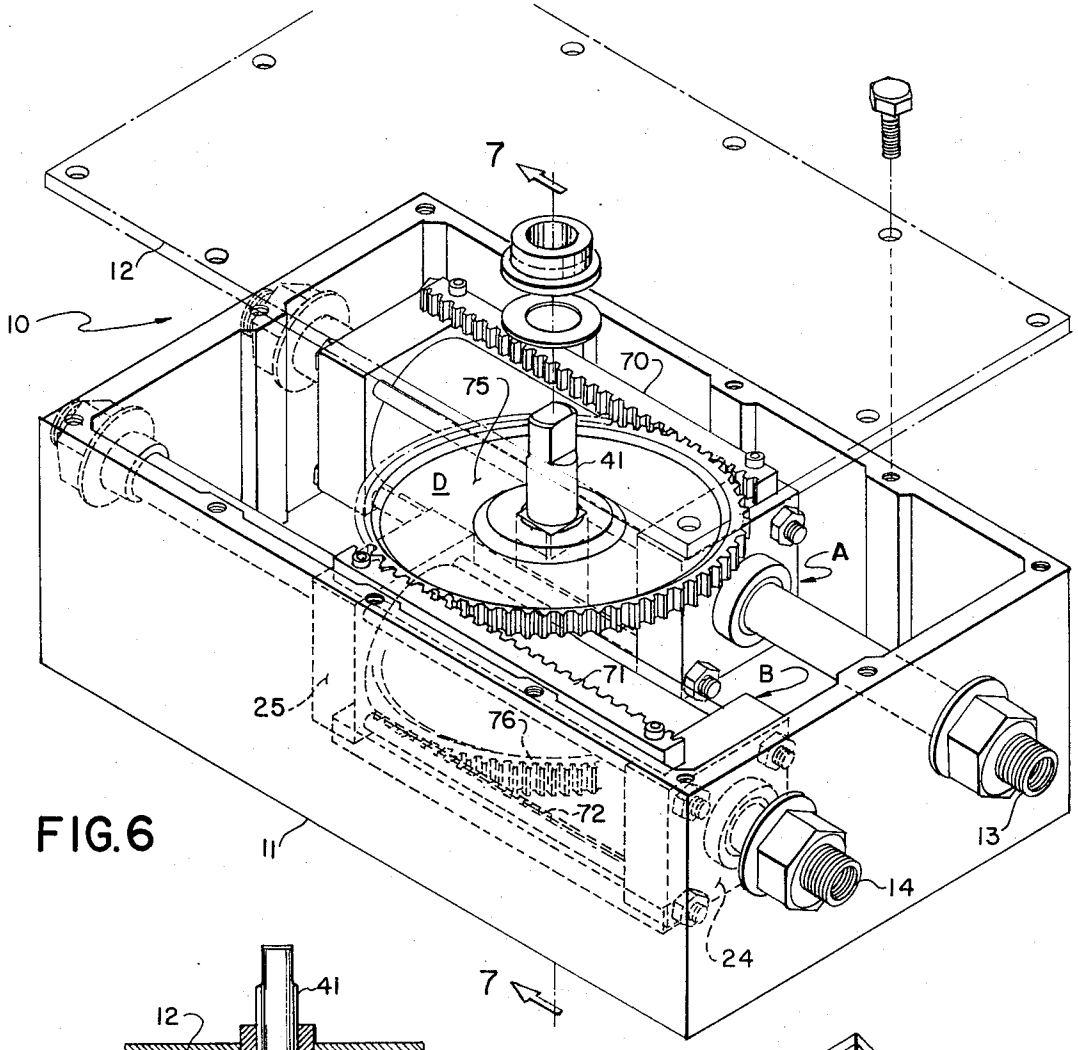


FIG.6

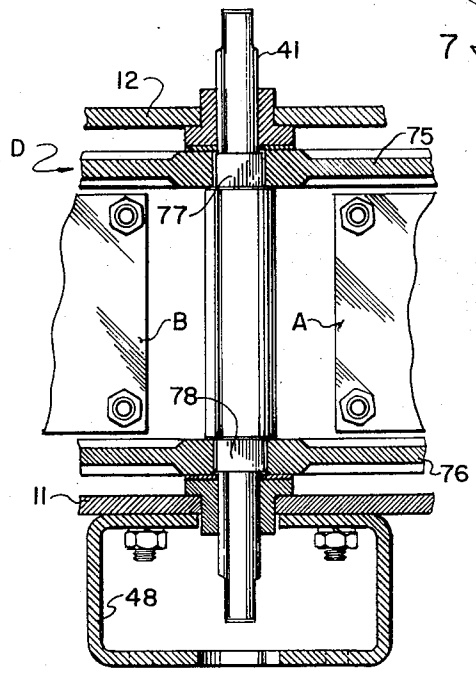


FIG.7

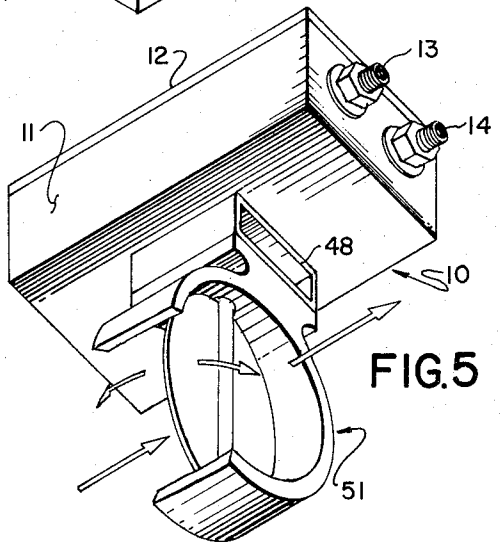


FIG.5

FLUID TORQUE OPERATOR

CROSS-REFERENCE TO RELATED APPLICATION

This is a continuation-in-part of application Ser. No. 168,674, filed Aug. 3, 1971, and now abandoned, for Fluid Torque Operator.

BACKGROUND OF THE INVENTION

1. Field of the Invention

This invention relates to a fluid actuated operator for generating a rotary torque to drive various devices through a desired angular range.

2. Description of the Prior Art

Most fluid power operators which provide rotary output employ one of two basic structures to generate a rotary torque.

A first prior art operator utilizes a conventional fluid cylinder which has a cylindrical body that is closed at both ends. The cylinder is fixed to prevent linear movement, although in some designs the cylinder is pivoted for non-linear movement. An internally housed piston is disposed between cylinder and caps, and the piston is connected to a piston rod. The piston rod protrudes through one of the end caps and is sealed in the cap to prevent external leakage of fluid pressure from the cylinder body. Seals are also provided on the piston to prevent escape of fluid pressure from one side of the piston to the other. Consequently, when fluid pressure is introduced through a port in one of the end caps, this pressure will drive the piston to the opposite end of the cylindrical body. The resulting movement of the piston rod converts fluid pressure into a linear mechanical force. The linear movement of the rod transmits this thrust mechanically to an arm usually through a pivot pin or fork. This arm, which is often referred to as a rotor arm or pivot arm, is mechanically connected perpendicularly to an output drive shaft. This shaft provides a rotary torque.

The second prior art operator also has a fixed fluid cylinder so that the cylinder body cannot move in a linear motion. In this class of operator, the cylinder cannot be pivoted. This operator has a geared shaft or rack attached to the piston instead of having a round piston rod or shaft. When the piston is driven by fluid pressure, it carries the attached geared rack to drive an engaged gear wheel. The gear wheel is connected to an output shaft that provides the rotary movement.

In both prior art structures, the operators have fixed cylinder bodies so that the freely moving piston is the primary generator of the output driving force.

Prior art United States Pats. include the following: Nos. 2,194,374 ; 2,290,527 ; 2,316,052 ; 2,324,224 ; 2,386,589 ; 2,390,882 ; 2,911,953 ; 2,954,754 ; and Re. 26,664.

SUMMARY OF THE INVENTION

A principal object of the operator of this invention is to generate a rotary torque which is transferred through a shaft to a load, such as a butterfly, ball, or plug valve, or any device requiring rotation. Usually the required rotation is of the order of 90°. Although 90° turn valves (commonly referred to as quarter turn valves) represent a principal application for the operator, the present invention is not limited to this field entirely. Also, substantially greater angular output ranges can be attained in certain of the designs hereafter described.

Basically, a closed cylinder body is driven freely in a linear reciprocating motion. A fixed piston rod is mounted to a stationary frame or structure. Thus, the cylinder body itself becomes the driving element that provides movement to a rotatable output drive shaft.

With the cylinder body being the movable member and also the external member, an almost unlimited number of mechanical linkages may be adapted to attachment to the cylinder body, such as trunnions or pivot pins, plates, gear racks, cable, chain, etc. The adaptability of the design to many different types of linkages offers output variations in torque and degrees of rotation which are optimum for particular applications. Furthermore, the operator may use only one cylinder for less power, or may use dual cylinders as shown in the preferred embodiments. This cylinder option provides a maximum amount of power output for the operator space used.

DETAILED DESCRIPTION OF THE DRAWINGS

In order that all of the structural features for attaining the objects of this invention may be readily understood, detailed reference is herein made to the accompanying drawings wherein:

FIG. **1** is an isometric view of a first preferred embodiment of the fluid operator of this invention employing two movable cylinders linked to an output drive shaft by a Scotch yoke assembly;

FIG. **2** is a section view taken along line **2—2** of FIG. **1** and showing internal details of part of one piston-cylinder assembly;

FIG. **3** is a section view taken along line **3—3** of FIG. **1** showing details of the output drive shaft assembly;

FIG. **4** is a plan view of the operator of FIGS. **1–3** showing the fluid interconnection of the two piston-cylinder assemblies;

FIG. **5** is an external isometric view of the operator coupled to a butterfly valve;

FIG. **6** is an isometric view of a second preferred embodiment of the operator in which the two movable cylinders are linked to the output drive shaft by a rack and pinion gear assembly;

FIG. **7** is a section view taken along line **7—7** of FIG. **6** showing details of the output drive shaft assembly of the embodiment of FIG. **6**;

FIG. **8** is a plan view of a third preferred embodiment of the operator in which the two movable cylinders carry slotted plates which cooperate with lever supported pins to rotate the output drive shaft upon which the lever is pivoted; and

FIG. **9** is a plan view of a fourth preferred embodiment of the operator in which the two movable cylinders carry multiply slotted plates which cooperate with disc supported pins to rotate the output drive shaft upon which the disc is pivoted.

DETAILED DESCRIPTION OF THE INVENTION

Referring now to the drawings, FIGS. **1** through **4** show a first preferred embodiment comprising a piston-cylinder assembly A coupled to a piston-cylinder assembly B by a Scotch-yoke coupling assembly C. These principal elements are contained within a housing **10** which includes a base **11** and a cover **12**. As is hereafter set forth, each assembly A, B has a stationary piston disposed on a piston rod upon which a movable cylinder reciprocates. Assembly C interconnects both mov-

able cylinders to rotate an output drive shaft. It is this shaft which produces the rotary driving torque.

Piston rods **13, 14** project through and extend between end walls **15** and **16.** The projecting ends of each rod are externally threaded to receive a lock nut **17** and a washer **18.** Accordingly, the rods are fixed relative housing base **11.** As shown in FIG. **4,** piston rods **13, 14** have a parallel spaced disposition relative one another. A stationary circular piston **19** is centrally fixed on piston rod **13;** and a like piston **20** is centrally fixed on rod **14.**

Piston **19** is housed within cylinder **21** and piston **20** is housed within cylinder **22.** Each of the cylinders is identical in construction and accordingly only cylinder **22** will be described in detail.

Cylinder **22** comprises a movable cylindrical body **23** (FIG.2) containing stationary piston **20.** The otherwise open ends of cylindrical body **23** are closed by end caps **24** and **25** through which piston rod **14** extends (FIG. **4**).

Four tie rods **26** (only one of which is partially shown in FIG. **1**) project through and extend between end caps **24, 25** to tightly fix cylindrical body **23** between the caps. The projecting end of each rod is externally threaded to receive a nut **27** to maintain the end caps tightly against the adjacent surfaces of body **23.**

As is shown in FIGS. **2** and **4,** piston **20** is immovably fixed to the central portion of rod **14.** The peripheral surface of piston **20** adjacent cylinder **23** is formed with a groove which houses O-ring **28** which forms a seal between the piston and the cylinder body.

A pair of metallic bushings **29** and **30** sandwich O-ring **31** in each end cap **24, 25** (FIG. **2**). As cylinder assembly B reciprocates on piston rod **14,** as hereafter outlined, each O-ring **31** provides a seal between the cylinder end caps and the outer surfaces of the piston rod.

Each of piston rods **13, 14** is fabricated with identical fluid ports and passageways so that fluid pressure and exhaust may be applied to the opposite sides of stationary pistons **19, 20** as required. Referring to FIGS. **2** and **4,** piston rod **14** is formed with an external port **32** and an internal port **33** which communicate with one another by a passageway **34** which is formed along the longitudinal axis of approximately one-half of the piston rod. Identical ports and passageways are formed in each of the piston rods to provide operating fluid flow and exhaust to the opposite sides of the pistons **19, 20.**

Pin support plates **35** and **36** extend between end caps **24** and **25** of cylinder **22** (FIG. **2**). Cylinder **21** has an identical set of support plates. Lower support plate **35** carries a centrally disposed projecting pin **37,** and upper support plate **36** carries an upper projecting pin **38.** A like set of projecting pins also projects from the support plates of cylinder **21.**

Cylinders **21, 22** are mechanically coupled to the other by Scotch-yoke assembly C. In particular, each of the pins carried by the support plates, such as pins **37** and **38,** reciprocate with their associated cylinders. The upper pins of both cylinders are captured between a Scotch-yoke **39** and the lower pins of both cylinders are captured between a Scotch-yoke **40.**

Scotch yokes **39, 40** are fixed to drive shaft **41** and pivot thereon. In particular, yoke **39** is removably locked to a square shank portion **42** of shaft **41** and Scotch-yoke **40** is removably locked to a square shank portion **43** of shaft **41** (FIG.3).

The upper end of drive shaft **41** projects through cover **12** (FIGS. **1** and **3**), and the lower end of drive shaft **41** projects through the bottom of base **11.**

Bushings **46** and **47** (FIGS. **1** and **3**) provide a bearing for the upper and lower ends of drive shaft **41,** respectively.

As is shown in FIGS. **3** and **5,** coupling adapter **48** is fixed to the bottom of base **11** by a plurality of screws **49.** The lower end **45** of drive shaft **41** projects into and is received by the interior of coupling adapter **48.** A hole **50** is formed in the bottom segment of coupling adapter **48** in axial alignment with drive shaft **41** so that a device such as butterfly valve **51** (FIG. **5**) may be rotatably driven by the output torque delivered at the lower end **45** of drive shaft **41.** Butterfly valve **51** is fixed to the lower segment of coupling adapter **48** by a plurality of screws (not shown) inserted within holes **52** (FIG.3) and connected to the adjacent supporting base flange of butterfly valve **51.** Coupling adapter **48** is merely representative of one of several different types of mounting to which an output device may be attached.

FIG. **4** shows the interconnection of piston rods **13, 14** to appropriate fluid pressure lines and a four-way solenoid valve. Fluid pressure provided by a source thus can appropriately reciprocate piston-cylinder assemblies A and B to responsively move Scotch-yoke assembly C. This movement of assembly C provides a rotary output torque at shaft **41.**

In the particular disposition of cylinders **21** and **22** (FIG.4; assumed for the purposes of illustration only) fluid pressure and exhaust are effected through the ports and passageways of rods **13** and **14** so that cylinder **21** is moving upwardly and cylinder **22** is moving downwardly. Accordingly, Schotch-yoke assembly C is also responsively moved so that upper drive shaft **41** is rotated in a counterclockwise direction.

This particular condition of the cylinders is attained by fluid pressure applied to conduit **53** through solenoid valve **54,** conduits **55, 56** through the ports and passageways of the lower half of piston rod **14** into the lower cylinder chamber **58.** The resulting fluid pressure within cylinder chamber **58** exerted against stationary piston **20** and end cap **24** tends to drive the cylinder downwardly. At the same time the fluid pressure contained within upper cylidner chamber **59** is exhausted through the ports and passageways of the upper half of piston rod **14** through conduits **60, 61,** and solenoid valve **54** to exhaust **62.**

The pressurized fluid appearing at the upper end of the conduit **55** also flows through the alternative path provided by conduit **63** into the ports and passageways of the upper half of piston rod **13** to fill the upper cylinder chamber **64** of cylinder **21.**

The resulting pressure exerted against the upper end cap of cylinder **21** and also piston **19** tends to drive cylinder **21** upwardly. The fluid contained within lower cylinder cavity **65** of cylinder **21** is exhausted through the ports and passageways contained within the lower half of piston rod **13,** conduits **66, 61** to exhaust **62.**

As cylinder **21** attains the limit of its upward stroke and cylinder **22** attains the limit of its downward stroke, four-way solenoid valve **54** can be electrically operated to reverse the fluid air source and exhaust to conduits **55** and **61.** Accordingly, cylinders **21** and **22** reverse directions producing responsive reversal in the direction of drive shaft **41.** The cylinder stroke limits define

the maximum angular output range provided by the operator. Intermediate angular output positions are provided by regulating the fluid volume so that the cylinders are positioned intermediate their upward and downward limits.

In the Scotch yoke design described, the angle of "attack" or coupling between the yoke and pin elements varies as the cylinders reciprocate upon their respective piston rods. The angle of attack diminishes as a cylinder approaches the center of travel, and it begins to increase again as the Scotch yoke and cylinder pass through the midpoint of travel. At the greater angle of attack provided by this design, greater output torque is delivered at the output drive shaft. This greater output torque represents a highly desirable optimum delivery of power for particular applications.

A second preferred embodiment of the operator of this invention is shown in FIGS. **6** and **7.** This embodiment is identical in all respects with that previously described with the single major exception that Scotch-yoke assembly C has been replaced by a rack and pinion gear assembly D. Piston-cylinder assemblies A and B remain unchanged.

In lieu of plates **35** and **36,** and pins **37** and **38** employed in Scotch-yoke assembly C, racks such as **70, 71, 72** extend between the upper and lower surfaces of the cylinder end caps. The upper racks of each cylinder mesh with a pinion gear **75** and the lower racks also mesh with a pinion gear **76.**

As is shown in FIG. **7,** pinion gears **75** and **76** are removably locked to a square shank portion **77, 78,** respectively, of operator drive shaft **41** so that rotation of these pinion gears generates a responsive rotation in the output drive shaft. The output drive shaft is identical in construction with that previously described with reference to FIG. **3.** The use of rack and pinion gear assembly D to couple the piston-cylinder assemblies A and B provides a constant output torque and angular shaft speed from a full open to a full closed position. Additionally, in the event relatively small pinion gears **75, 76** are employed, a much greater range of angular rotation can be attained than that provided by the other embodiments of this invention.

A third embodiment of the operator of this invention is shown in FIG. **8.** The principal difference in this embodiemnt is in the manner of coupling the cylinder assemblies A and B one to the other. In particular, a slotted plate, pin-lever assembly E is substituted for assemblies C and D of the prior embodiments.

Assembly E includes a slotted plate fixed to both the upper and lower end cap surfaces of the cylinder for both assemblies A and B. For example, plate **80** extends between the end caps of the cylinder for piston-cylinder assembly A. This plate is formed with the centrally located elongated slot **81** disposed transversely to the longitudinal axis of rod **13.** A corresponding slot **82** is located in plate **83** extending between the end caps of the cylinder for piston-cylinder assembly B. A lever **84** having integral pins **85** and **86** extending into slots **81** and **82** pivots on output drive shaft **41.** Corresponding elements also couple the bottom end cap surfaces of the cylinders for piston-cylinder assemblies A and B. Accordingly, reciprocation of the cylinders produces a transverse movement of the pins within their mating slots. This particular design is employed where friction and side loading must be kept to a minimum value. Therefore, a relatively greater operating pressure may be used to drive the cylinders. This, of course, results in a greater available output torque at the drive shaft.

A fourth embodiment of the operator of this invention is shown in FIG. **9.** Again the principal difference in this embodiment is in the manner of coupling the cylinder assemblies A and B one to the other. In particular, a multiply slotted plate, pin-disc assembly F is substituted for assemblies C, D and E of the prior embodiments.

A double slotted plate extends between the upper and lower surfaces of the end caps for each cylinder. In particular, plate **90** extends between the end caps for piston-cylinder assembly A and plate **91** extends between the end caps for piston-cylinder assembly B. Plate **90** is formed with a pair of tapered and spaced slots **92** and **93;** and plate **91** is formed with a pair of tapered spaced slots **94** and **95.** A circular disc **96** is fixed to rotate with output drive shaft **41.** This disc **96** supports four space pins **97, 98, 99** and **100.** Pins **97** amd **98** engage slots **93** and **92,** respectively, as the cylinder for piston-cylinder assembly A moves upwardly; and pins **99** and **100** engage slots **95** and **94,** respectively, as the cylinder for piston-cylinder assembly B moves downwardly.

Coupling assembly F offers a substantially economic advantage over the rack and pinion gear assembly D previously described. A large pinion gear is an expensive element. However, a disc, such as disc **96** formed with integral pins **97, 98, 99** and **100,** is a relatively inexpensive element. The disc in many applications performs in a manner as satisfactory as the pinion gear. Also, the disc may be made of varying diameters to provide varying degrees of rotation as with the pinion gear.

In the four embodimetns of this invention previously described, the piston rods of both cylinders (when the cylinders are under a power load) are always under tension rather than compression. This reduces the possibility of the piston rod buckling.

Other prior art operators are alternatively under rod tension and compression depending upon direction. If the piston rod is not large enough in diameter, it will buckle when subjected to an excessive pressure. Accordingly, the designs of this invention can be fabricated with smaller piston rods to attain equivalent output torques.

As an added advantage, the fixed pistons of this invention are relatively closer to the output drive shaft. Accordingly, the cylinder bodies are also much closer. Thus, the operator space requirements are substantially minimized.

The novel designs of this invention are also conducive to cymmetrical and evenly balanced operators enabling all the weight of the operator to be evenly balanced with respect to the rotating shaft.

It should be understood that the embodiments previously described are merely illustrative in nature and that changes can be made without departing from the scope of the invention. For example, it is not necessary to employ a pair of piston-cylinder assemblies A and B. In certain applications, a single reciprocating cylinder enveloping a fixed piston can be appropriately linked to provide adequate output torque at a drive shaft.

The cylinder stroke may be limited by a stop, such as an abutment pin, rather than by stop contact with a fixed piston. The use of an abutment stop located at adjustable positions relative each cylinder would produce

a corresponding limit control over the angle of shaft output.

The pin elements which couple the various linkages can also support friction reducing bearings (not shown) in order to minimize friction losses.

What is claimed is:

1. A fluid power operator for generating a rotary output torque and contained within a housing having a plurality of spaced walls comprising a piston, a linear piston rod fixed to a pair of said spaced walls and extending through the piston and having individual fluid passageways having openings outside of the housing and communicating with the opposite sides of the piston, the piston being fixed to an intermediate portion of the rod, a cylinder including end caps enveloping the piston for guided movement along and only by the piston and piston rod, a pair of output drive elements secured to a drive shaft means, said drive shaft means being rotatably mounted to a second pair of spaced walls and rotating on an axis fixed relative to the housing and perpendicular to the longitudinal axis of the piston rod at a point generally intermediate thereof, a pair of parallel spaced cylinder connector elements means fixing the ends of each of said connector elements to said end caps of the cylinder with the cylinder located therebetween and with the connector elements being located in planes perpendicular to the axis of rotation of the output drive shaft means, and a pair of spaced coupling elements coupled to each of the connector elements, respectively, each coupling element individually coupling a different connector element to the drive elements whereby a varying differential fluid pressure applied to opposite sides of the piston moves or reciprocates the cylinder relative the piston to apply spaced rotating forces to the drive elements through the spaced connector and coupling elements.

2. The combination of claim **1** in which all of the following operator components are also contained within the housing comprising a second piston, and a second linear piston rod fixed to said first pair of spaced walls and extending through the second piston and also having individual fluid passageways having openings outside of the housing and communicating with opposite sides of the second piston, the second piston being fixed to an intermediate portion of the second rod, a second cylinder including end caps enveloping the second piston for guided movement along and only by the second piston and second piston rod, and a second pair of spaced cylinder connector elements means fixing the ends of said connector elements to said end caps of the second cylinder with the second cylinder located therebetween and with the connector elements being located in planes perpendicular to the axis of rotation of the output drive shaft means and a second pair of spaced coupling elements each individually coupling a different connector element of said second pair to the drive shaft means with the drive elements being located between both cylinders whereby the application of varying differential fluid pressures to the opposite sides of both pistons moves or reciprocates both cylinders relative their associated rods to apply balanced spaced rotating forces to the drive elements through both pair of spaced connector and coupling elements.

3. The combination of claim **2** in which the housing includes a box and a removable cover wall and a bottom wall coupled to the box of which the end walls are a part and in which the drive shaft means is a shaft extending between and projecting through the bottom and cover.

4. The combination of claim **2** in which the drive elements are Scotch yokes and in which the coupling elements are pin elements connected to each connector element, and in which the drive shaft means is a shaft to which a midportion of each Scotch yoke is pivoted.

5. The combination of claim **2** in which the coupling elements are rack teeth and in which the drive elements are mating pinion gears, and in which two racks are connected to each cylinder, and their mating pinion gears are rotatably supported on the drive shaft means which is a shaft.

6. The combination of claim **2** in which the connector elements are plates, the coupling elements are slots in said plates, and the drive elements are pivoted pin linkages wherein two slotted plates are connected to each cylinder and the pin linkages are rotatably supported on the drive shaft means which is a shaft so that a linkage pin is engaged in each slot.

7. The combination of claim **2** in which the connector elements are plates, the coupling elements are multiple slots in said plates, and the drive elements are pivoted discs carrying multiple slot engaging pin elements wherein two slotted plates are connected to each cylinder, and the pivoted discs are rotatably supported on the drive shaft means which is a shaft so that a plurality of pin elements sequentially engage each of the plurality of slots formed in each plate connected to each cylinder during a cylinder stroke.

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