United States Patent [19]

Ridley

[11] **3,709,105**

[45] **Jan. 9, 1973**

[54] FLUID PRESSURE OPERATED ROTARY ACTUATORS

[76] Inventor: **John Cecil Ridley**, Newcourt House, New Street, Lymington, England

[22] Filed: **July 6, 1971**

[21] Appl. No.: **159,771**

Related U.S. Application Data

[63] Continuation-in-part of Ser. No. 95,572, Dec. 7, 1970.

[52] **U.S. Cl.** **92/137**

[51] **Int. Cl.** **F01b 9/00**

[58] **Field of Search** ...92/137, 138, 151, 150; 91/186

[56] **References Cited**

UNITED STATES PATENTS

3,267,816	8/1966	Graham	92/137
3,267,817	8/1966	Adams	92/137
2,875,734	3/1959	Winters	92/137

FOREIGN PATENTS OR APPLICATIONS

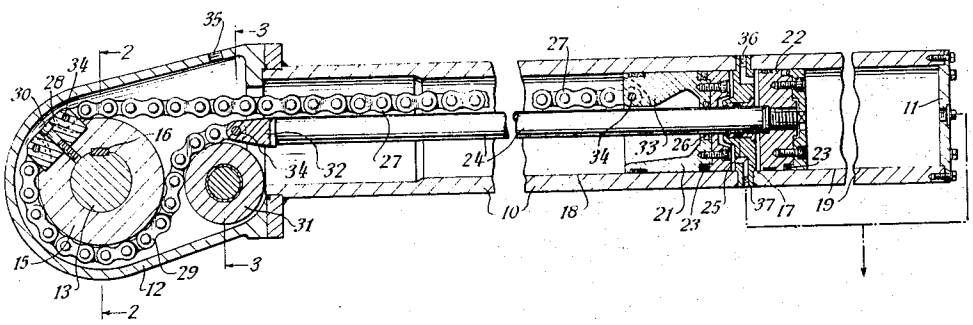
484	2/1877	Great Britain	92/137

Primary Examiner—Milton Kaufman
Assistant Examiner—Ronald H. Lazarus
Attorney—John A. Young

[57] **ABSTRACT**

A fluid pressure rotary actuator comprises a rotatable output shaft, a cylinder in which two pistons are movable simultaneously in opposite directions by fluid pressure acting on at least one of them, and a chain extending from one piston to a rod fixed to the other piston and passing through the first piston, the chain being wrapped around a cylindrical surface on the output shaft so that its longitudinal movement by the pistons rotates the output shaft.

7 Claims, 8 Drawing Figures



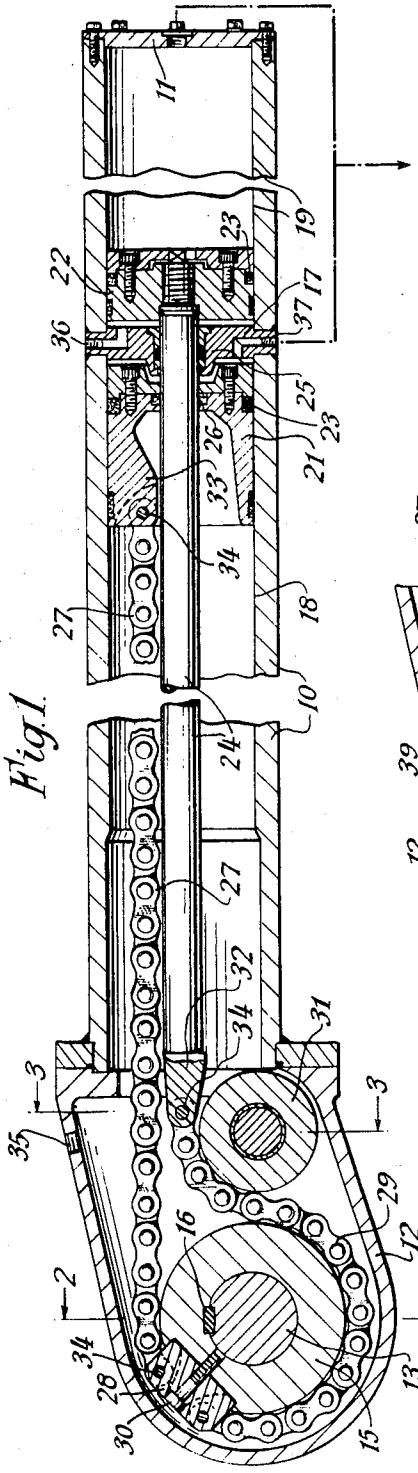


Fig 1.

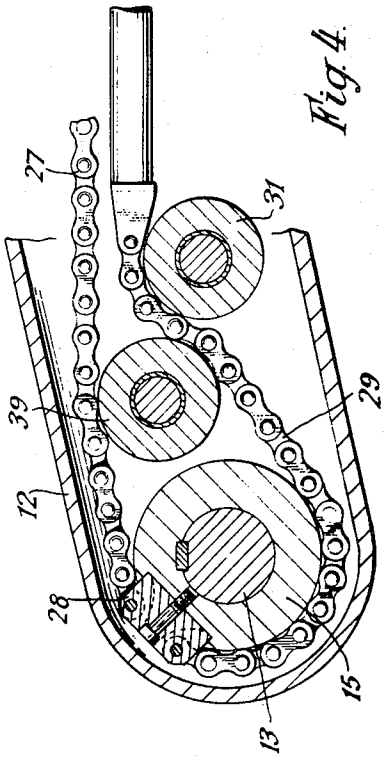


Fig 4.

INVENTOR
JOHN CECIL RIDLEY

BY John A. Young
ATTORNEY

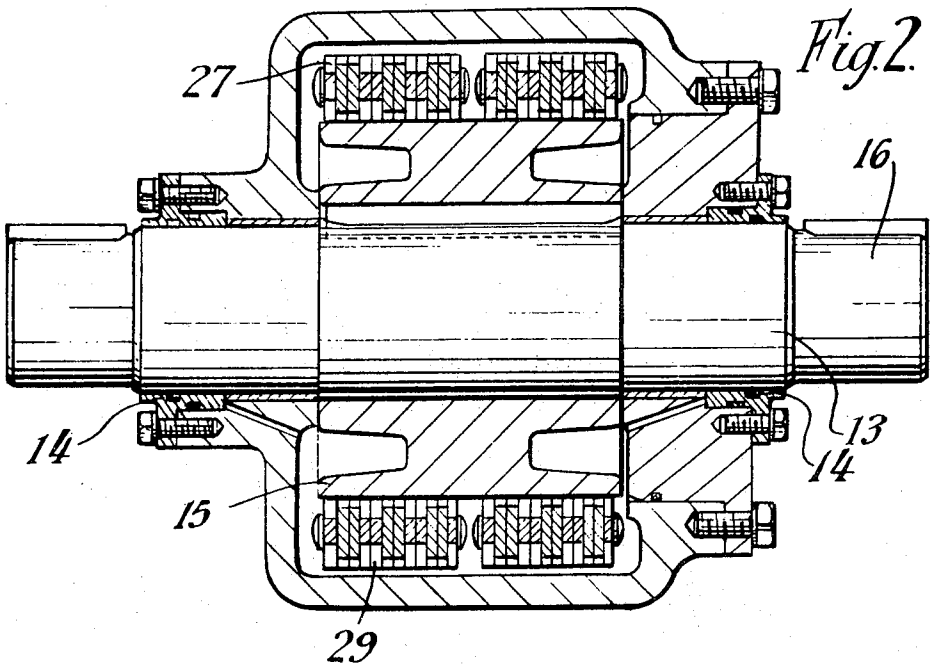


Fig. 2.

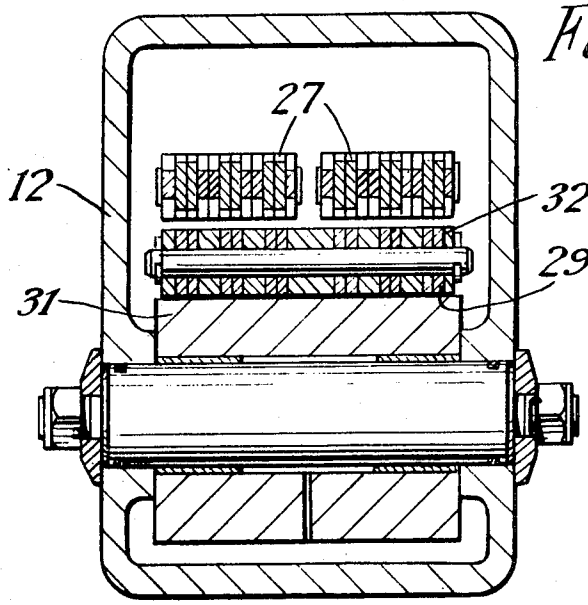


Fig. 3.

INVENTOR
JOHN CECIL RIDLEY
BY John A. Young
ATTORNEY

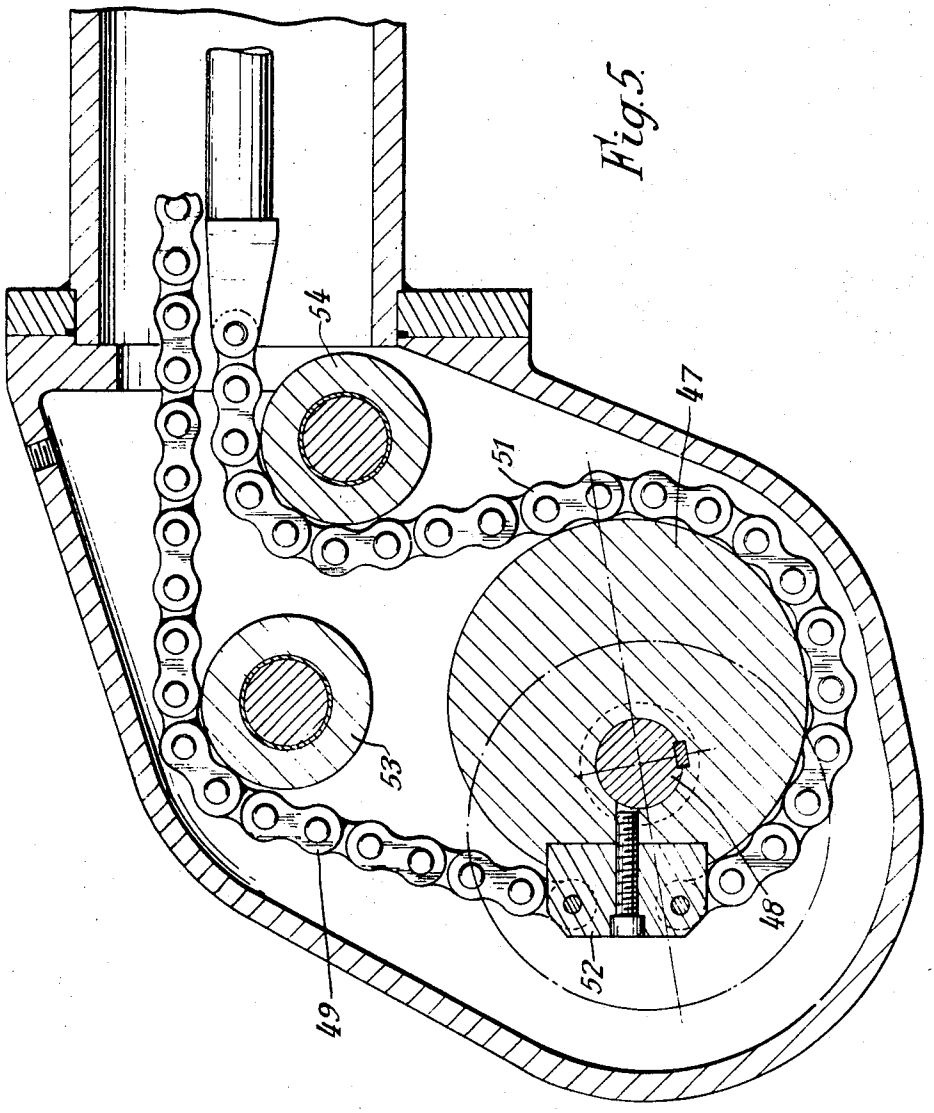
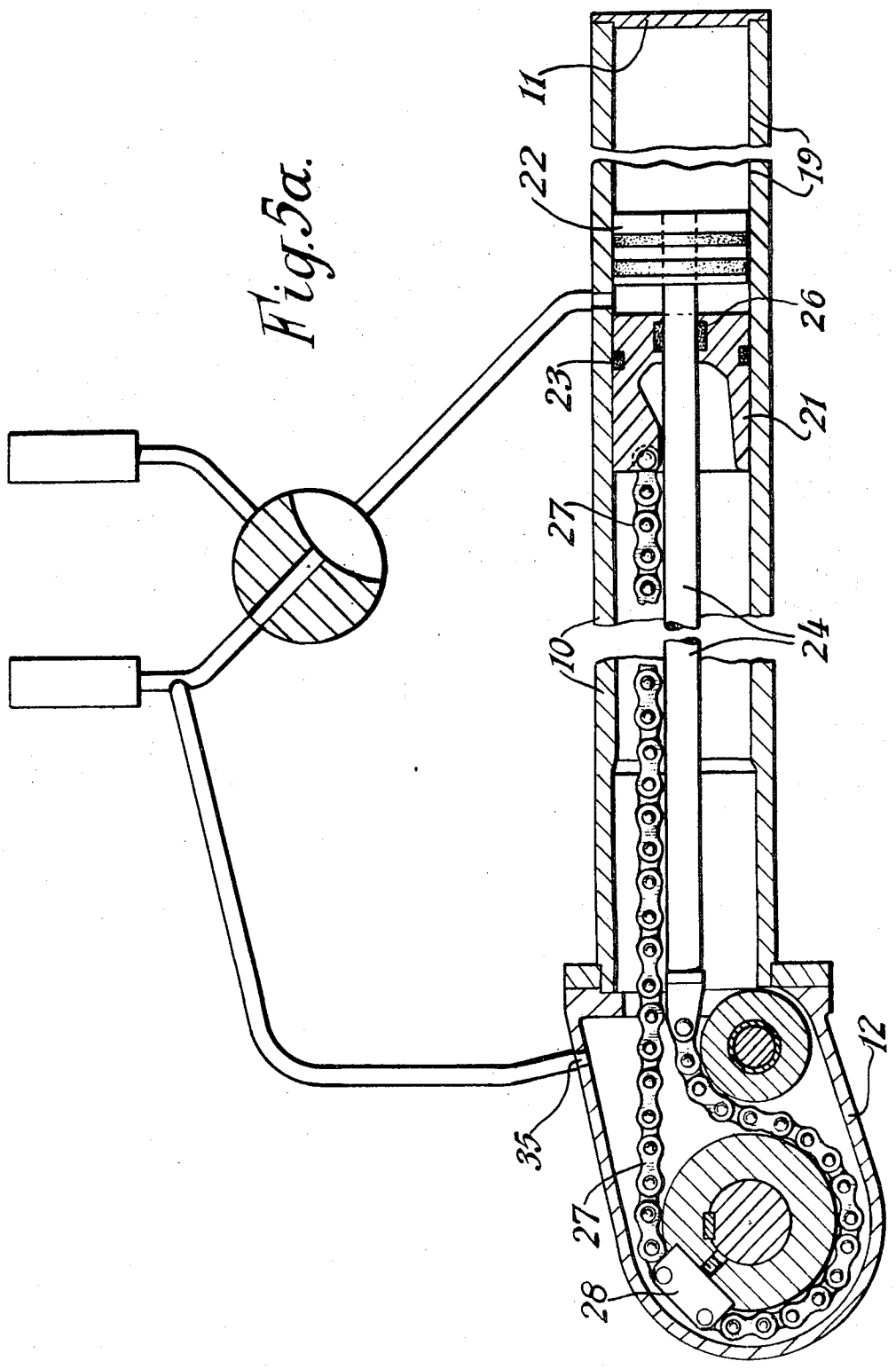


Fig. 5

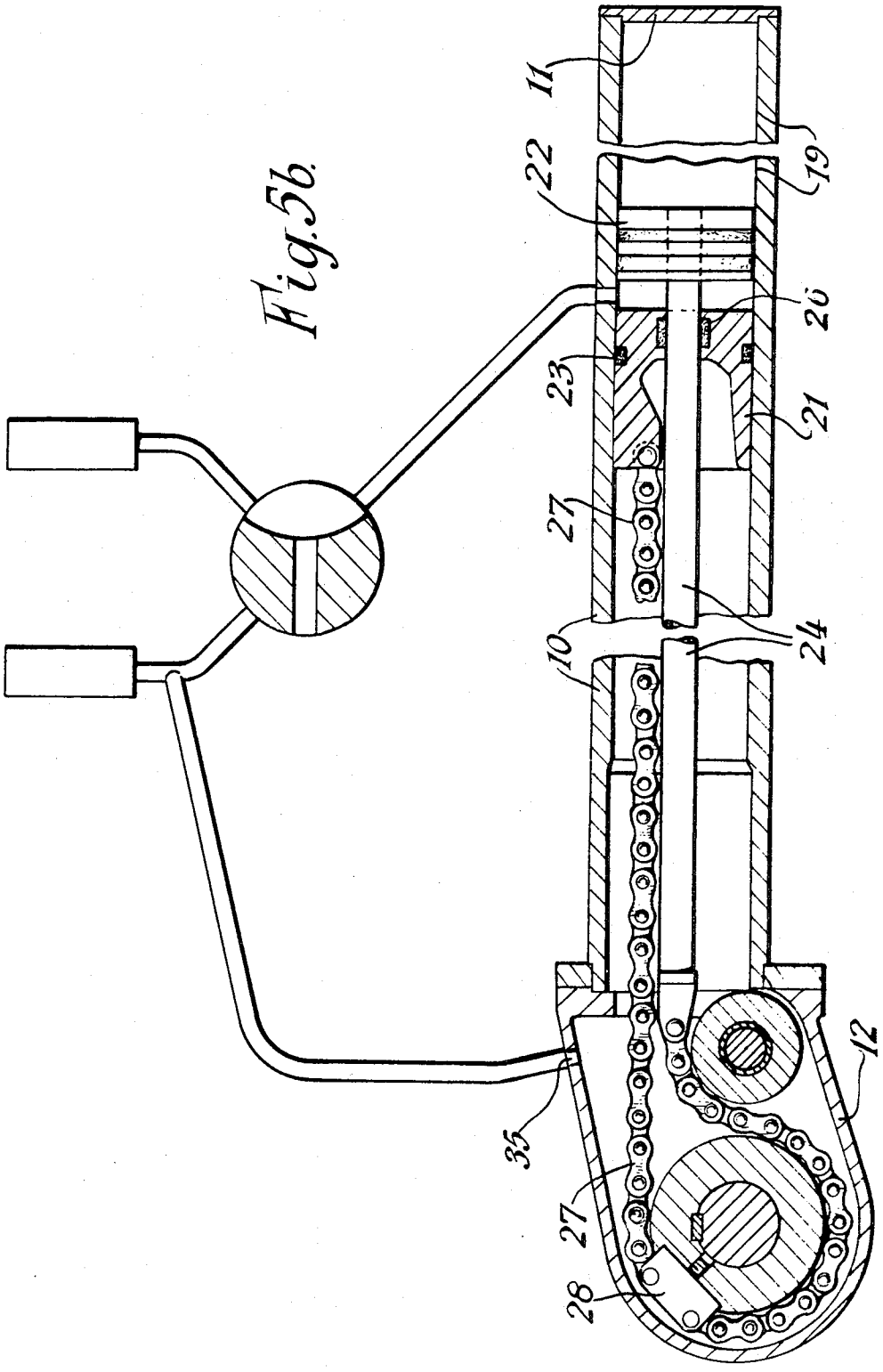
INVENTOR
JOHN CECIL RIDLEY
BY John A. Young
ATTORNEY

Fig. 5a.



INVENTOR
JOHN CECIL RIDLEY
BY John a. Young
ATTORNEY

Fig. 5b.



INVENTOR
JOHN CECIL RIDLEY
BY John A. Young
ATTORNEY

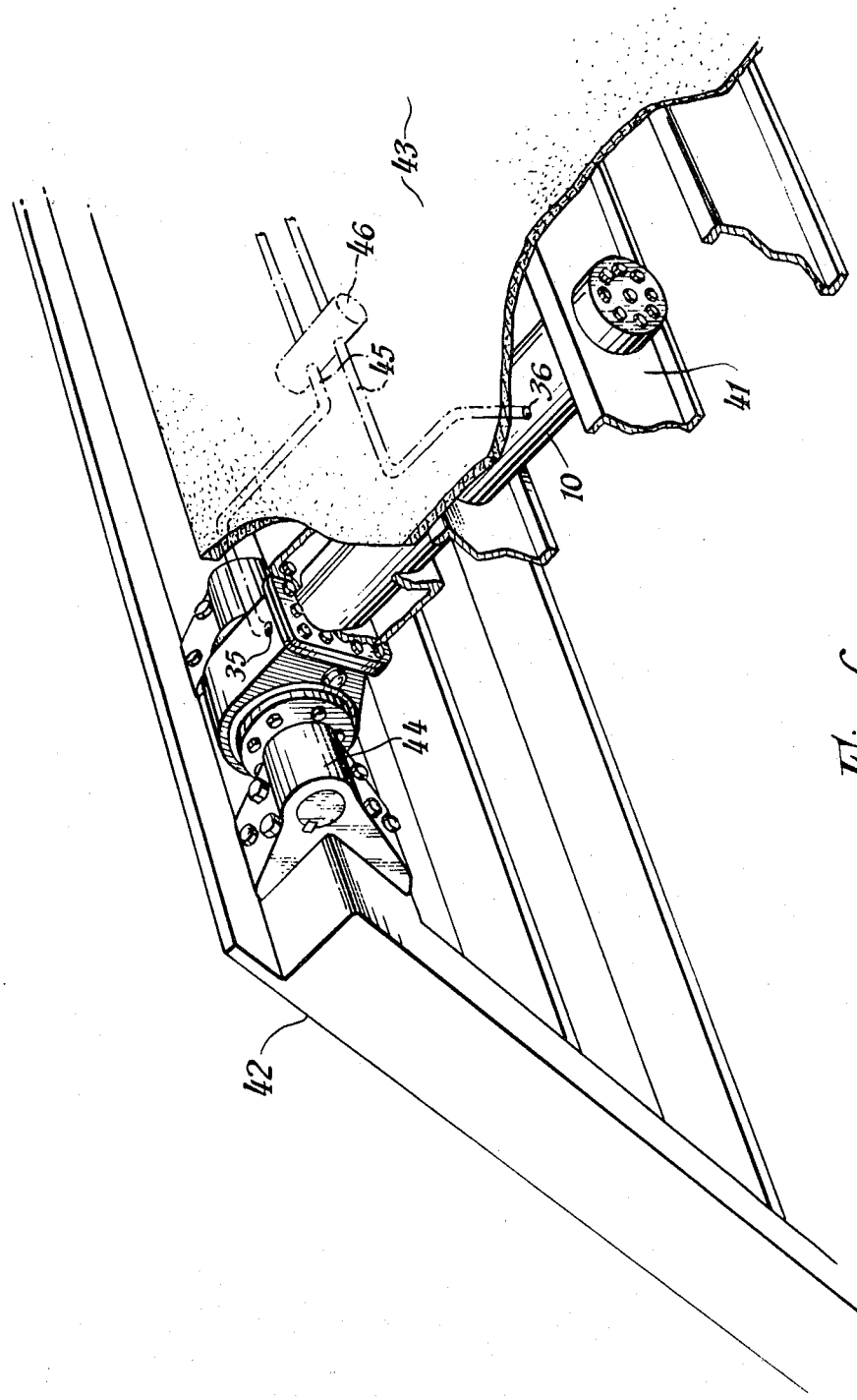


Fig. 6.

INVENTOR
JOHN CECIL RIDLEY
BY John a. Young
ATTORNEY

FLUID PRESSURE OPERATED ROTARY ACTUATORS

This application is a continuation-in-part application of United States application Ser. No. 95,572 filed on or about Dec. 7, 1970, and entitled "IMPROVEMENTS IN OR RELATING TO FLUID PRESSURE OPERATED ROTARY ACTUATORS."

This invention relates to fluid pressure operated rotary actuators and, more specifically, to fluid pressure rotary actuators in which the rectilinear movement of a piston in a cylinder by the action of fluid pressure is converted into rotary movement of an output shaft.

It is the object of the invention to provide an improved rotary actuator.

According to the present invention there is provided a fluid pressure rotary actuator comprising a housing, an output shaft rotatably mounted in said housing, a cylinder fixed to said housing with its axis tangential to a circle about the axis of said output shaft, two pistons in said cylinder movable simultaneously in opposite directions by fluid pressure acting in said cylinder, and transmission means for converting rectilinear movement of said pistons into rotary movement of said output shaft said transmission means comprising pivotally connected link members forming a tension connection between said pistons and adapted to make peripheral embracing contact with the output shaft.

The assembly of pivotally connected link members may comprise pivoted link chain, preferably leaf chain as herein defined.

One of the pistons may be fixed to a piston rod extending through the other piston, the ends of the tension connection being connected one to said rod and the other to said other piston.

A fixed partition may be provided in the cylinder between the two pistons. At least one guide pulley is provided over which the tension connection passes between the output shaft and one of its end connections and the pivoted link chain may be connected to an anchorage member on the output shaft.

One form of fluid pressure rotary actuator according to the invention will now be described, by way of example, with reference to the accompanying drawings, in which:

FIG. 1 is a longitudinal sectional elevation of the form of actuator described;

FIG. 2 is a section on the line 2—2 of FIG. 1;

FIG. 3 is a section on the line 3—3 of FIG. 1;

FIG. 4 is a partial longitudinal section, corresponding to part of FIG. 1, showing a modification;

FIG. 5 is a partial longitudinal section similar to FIG. 4, showing another modification;

FIGS. 5*a* and 5*b* are further modifications shown in longitudinal section and illustrating in the respective views, pressure connections for moving the actuator in opposite directions; and,

FIG. 6 is an isometric view showing an exemplary installation of the actuator.

Referring to FIGS. 1 to 3 of the drawings, the actuator comprises a cylinder 10 closed at one end by an end plate 11 and open at its other end, a closed casing 12 being secured to the open end of the cylinder. The closed casing 12, as shown in FIG. 2, provides bearings for an output shaft 13 having its axis normal to the cylinder axis and so positioned that the said cylinder axis is tangential to a circle about the output shaft axis.

Sealing devices 14 prevent leakage of fluid along the shaft 13. A drum 15 is keyed to the output shaft 13 inside the casing 12 so as to constitute, in effect, a part of said output shaft, and projecting ends of the shaft 13 are provided with keys 16, as shown in FIG. 2, or are splined or otherwise formed to provide for the fixing thereto of operating arms or other components for transmitting rotation of the shaft to an operated device or devices.

The cylinder 10 is divided by a transverse partition 17 into two cylinder chambers 18 and 19, the chamber 18 opening into the casing 12 and the chamber 19 being closed by the end plate 11. A first piston 21 is slidable in the chamber 18 and a second piston 22 is slidable in the chamber 19, both pistons being provided with fluidtight packing rings 23 engaging the cylinder walls. The piston 22 is mounted on a rod 24 which passes through a central opening in the partition 17 and through a central opening in the piston 21, packing means 25 and 26 being provided respectively in the said openings.

A flexible tension connection is provided between the two pistons 21 and 22 by leaf chain consisting of two lengths of chain one length 27 extending between the piston 21 and an anchorage member 28 on the drum 15 and the other length 29 extending between the said anchorage member 28 and the end of the rod 24 remote from the piston 22, the length 29 passing over an idler drum 31 rotatably mounted in the casing 12.

The term 'leaf chain' is to be understood as meaning a chain comprising groups of flat side-by-side link members, each two adjacent groups being connected by a pivot pin and the link members of one group extending between adjacent link members of the next group so that the connecting pivot pin passes through holes in links of both groups. Each length of chain may, as shown in FIGS. 2 and 3, consist of two separate chains arranged side-by-side.

The anchorage member 28 comprises a block set into a recess formed in the periphery of the drum 15 and secured to the drum 15 by a bolt 30. Each of the said block 28, a head 32 carried by the rod 24, and an internal lug 33 on the piston 21 is provided with slots to receive end link members of the chain which are pivotally secured thereto by pins 34. The section, FIG. 3, is taken through the axis of the pivot pin 34 connecting the chain length 29 to the head 32 on the rod 24, and shows the portions of the said head between the slots therein and between which the ends of the chain links lie. The axes of the output shaft 13 and idler drum 31, are so positioned with respect to the cylinder axis, and the radii of the drum 15 and the idler drum 31 are so selected, that the portion of chain between the idler drum 31 and the rod 24 is aligned with the said rod, and the portion of chain between the drum 15 and the chain anchorage on the piston 21 is parallel to the cylinder axis.

A port 35 is provided in the casing 12, and a port 36 in the partition 17 is connected to the cylinder chamber 19 between the said partition 17 and the piston 22, the said ports 35 and 36, when the actuator is incorporated in a fluid pressure system, being connected by suitable conduits to a selector valve (not shown) arranged to connect either one of said ports to a source of fluid pressure and the other to a drain. Thus by connecting

the port 35 to the pressure source the piston 21 can be urged towards the partition 17, pulling the piston 22 in the opposite direction towards the partition, and by connecting the port 36 to the pressure source the piston 22 can be urged away from the partition 17, pulling the piston 21 in the opposite direction away from the partition 17, the output shaft being rotated in one direction or the other by the chain, the direction depending on which port is connected to the pressure source.

In a modified arrangement (FIGS. 5*a*, 5*b*) according to the invention the partition in the cylinder may be omitted (see FIGS. 5*a* and 5*b*). When this modified form of actuator is incorporated in a fluid pressure system, the port 35 is connected by a suitable main conduit to a source of fluid pressure, and the space between the two pistons is connected by a suitable conduit to a selector valve, the selector valve being arranged to connect the space between the two pistons 22, 23 either to the source of fluid pressure (FIG. 5*b*) through a branch conduit connected to said main conduit, or to drain (FIG. 5*a*). Thus, to operate the actuator in one direction, the selector valve 48 is operated to connect the space between the two pistons 22, 23 to the source of fluid pressure, whereas to operate the actuator in the other direction the selector valve 48 is operated to connect the space between the two pistons to drain. During operation of the actuator in said one direction, the liquid loading on the piston 21 is balanced whereas there is a difference between the liquid pressure acting on the two sides of the piston 22. The liquid loading on the piston 22 urges the piston 22 towards the end plate 11. Consequent movement of the piston 22 towards the end plate 11 drags the piston 21 away from the end plate 11. Such movement of the piston 21 away from the end plate 11 forces liquid from within the casing 12 through the port 35, the said main conduit and the said branch conduit to augment liquid supplied directly to the said space by the source of fluid pressure through the said main conduit and the said branch conduit.

A further port 37 in the partition 17, opening into the cylinder chamber 18 between the piston 21 and the partition, and a port 38 in the end plate 11, may be connected either to the atmosphere or to a reservoir containing oil at substantially atmospheric pressure, so that air or oil can move freely into and out of the spaces to which said ports are connected. The connection of the said spaces to an oil reservoir provides lubrication and reduces the danger of corrosion of the cylinder walls.

If it is not convenient to arrange the drum on the output shaft so that the chain length extending to the piston in the adjacent end of the cylinder is led off that drum in a line parallel to the cylinder axis, a further idler drum 39, similar to the drum 31, may be provided as shown in FIG. 4 to deflect the chain into the desired alignment, the other chain length also engaging the idler drum 39 between the drum and the idler drum 31.

In the embodiments of the invention so far described, the drum 15 mounted on the output shaft 13 is concentric with the said output shaft, so that a constant torque is exerted throughout the range of operation of the actuator.

In some applications of the actuator, for example, to hinged hatch covers on ships, the maximum torque required is very high, and a concentric drum capable of providing such torque may be inconveniently large. The maximum torque is, however, required only during the initial stages of movement in one direction, a lesser torque being sufficient during the later stages of movement in that direction and during movement in the opposite direction. The required high torque at the required stage of operation can be obtained by using an eccentric drum on the output shaft 13 so arranged that, when the actuator is in the extreme position from which it moves to effect movement of the operated device in the said one direction, the chain is led off the said drum at the point of its periphery which is furthest from the output shaft axis.

FIG. 5 of the drawings shows an embodiment of the invention in which such an eccentric drum is used, the drum being shown at 47 and the output shaft on which it is eccentrically mounted at 48. The chain lengths providing the flexible tension connection to the pistons, which pistons are not shown in the drawing, are shown at 49 and 51 and are anchored to the drum 47 by means of an anchorage member 52 similar to that shown in FIG. 1, the said anchorage member being positioned at a point on the drum periphery adjacent its position of minimum distance from the shaft axis. Two idler drums 53 and 54 are provided over which the chain lengths 49 and 51 pass respectively to bring the portions of the said chain lengths adjacent their ends which are attached to the pistons into parallelism with the direction of piston movement.

Assuming that the maximum torque is required during initial stages of clockwise movement of the output shaft 48, FIG. 5 shows the drum 47 in full lines in the position which it occupies at the commencement of that movement, and in chain dotted lines in its other extreme position.

Sprocket chain may be used instead of leaf chain, and need not be anchored to the drum 15 on the output shaft 16, the said drum being provided with teeth engaged by the sprocket chain. When a leaf chain is used the angle of rotation of the output shaft is limited to about 180° no such limitation being necessary when sprocket chain is used but, since a leaf chain of given dimensions has a breaking load considerably greater than that of a sprocket chain of the same dimensions, an actuator for producing a given effort, using leaf chain, can be considerably smaller than an actuator for producing the same effort using sprocket chain. The drum may be replaced by an integral enlargement of the output shaft.

Fluid locking means of known type may be provided to trap fluid in at least one of the chambers in the cylinder so as to hold the output shaft of the actuator against rotation except when a drive is being applied thereto.

FIG. 6 shows, by way of example, an application of an actuator according to the invention. The actuator cylinder 10 is mounted in a fixed framework 41, a panel 42, required to be moved pivotally between a piston in the same plane as a fixed surface 43 carried by the framework and a position at an angle thereto, carrying hinge brackets 44 which are mounted on the actuator output shaft 16. Conduits 45 connect the port 35 and 36 of the actuator to a selector valve 46 which is in turn connected to a source of fluid pressure and a drain.

I claim:

1. A fluid pressure rotary actuator comprising a housing, an output shaft rotatably mounted in said housing, a cylinder secured to said housing and disposed with its axis tangential to a circle about the axis of said output shaft, first and second pistons mounted for slidable movement within said cylinder for simultaneous actuation in opposite directions by fluid pressure within said cylinder, a piston rod secured at one end to said first piston and passing through an aperture in said second piston so that its other end projects on the opposite side of said second piston to said first piston, and transmission means for converting rectilinear movement of said pistons into rotary movement of said output shaft, said transmission means comprising pivotally connected link members forming a tension communication between said projected end of the piston rod and said second piston, a peripheral surface on said output shaft with which said transmission means make peripheral embracing contact, and at least one guide pulley over which the said transmission means passes between the output shaft and one of the transmission means end connections.

2. A fluid pressure rotary actuator according to claim 1, wherein the assembly of pivotally connected link

members comprises pivoted link chain.

3. A fluid pressure rotary actuator according to claim 2, wherein the pivoted link chain is leaf chain.

4. A fluid pressure actuator according to claim 1, wherein a fixed partition is provided in the cylinder between the two pistons.

5. A fluid pressure actuator according to claim 3, wherein the pivoted link chain is connected to an anchorage member on the output shaft.

6. A fluid pressure actuator according to claim 5, wherein the pivoted link chain comprises two separate portions each connected at one end to the anchorage member and at the other end to one of the pistons.

7. The fluid pressure actuator according to claim 1, including a selector valve for connecting the space between the two pistons to a source of fluid pressure or to drain and means for reversing the power actuation by communicating fluid pressure to an opposite side of the piston which is actuated in a direction effecting forcible tensioning of said link members and simultaneously connecting the space between said pistons to drain.

* * * * *