Nov. 10, 1964 K. H. MEYER ETAL 3,156,160

ACTUATOR

Filed Feb. 15, 1963 2 Sheets-Sheet 1

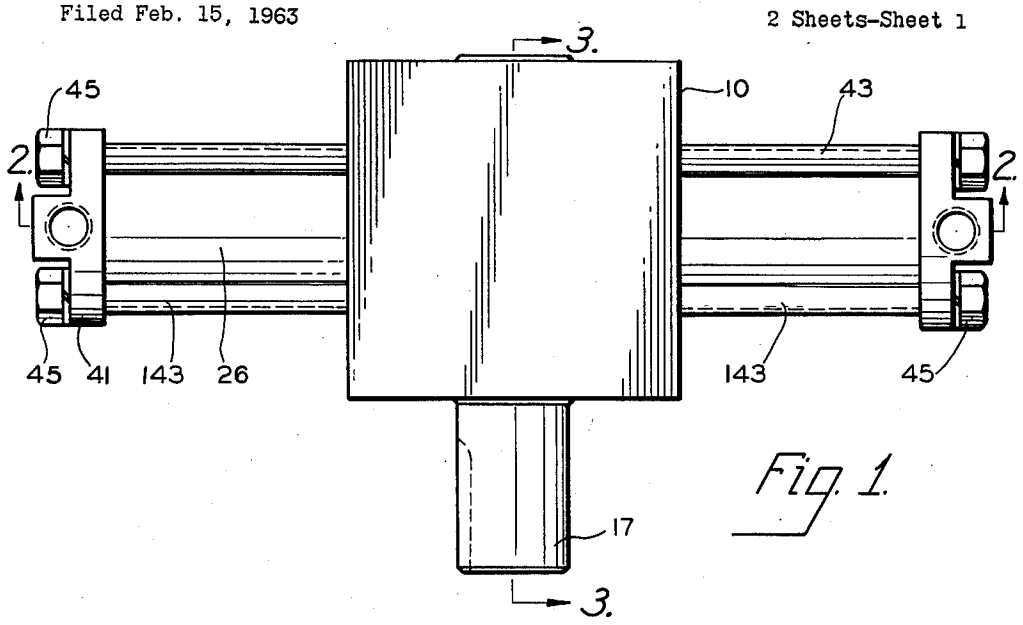


Fig. 1.

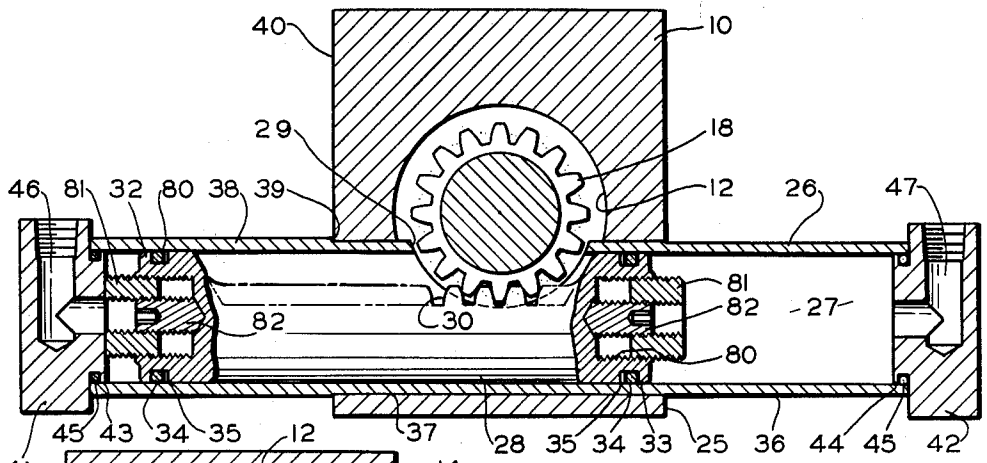


Fig. 2.

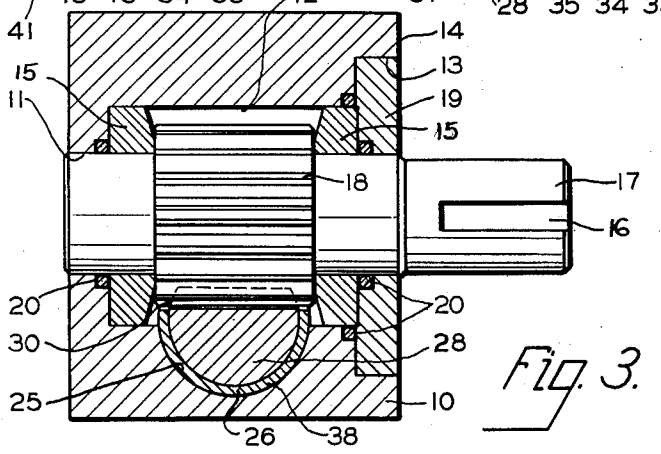


Fig. 3.

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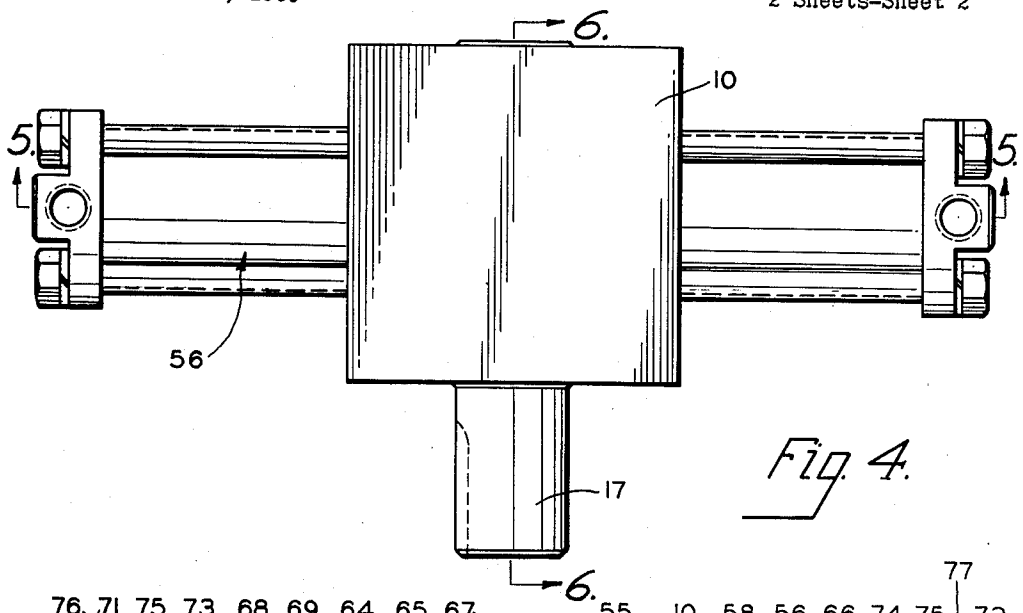


Fig. 4.

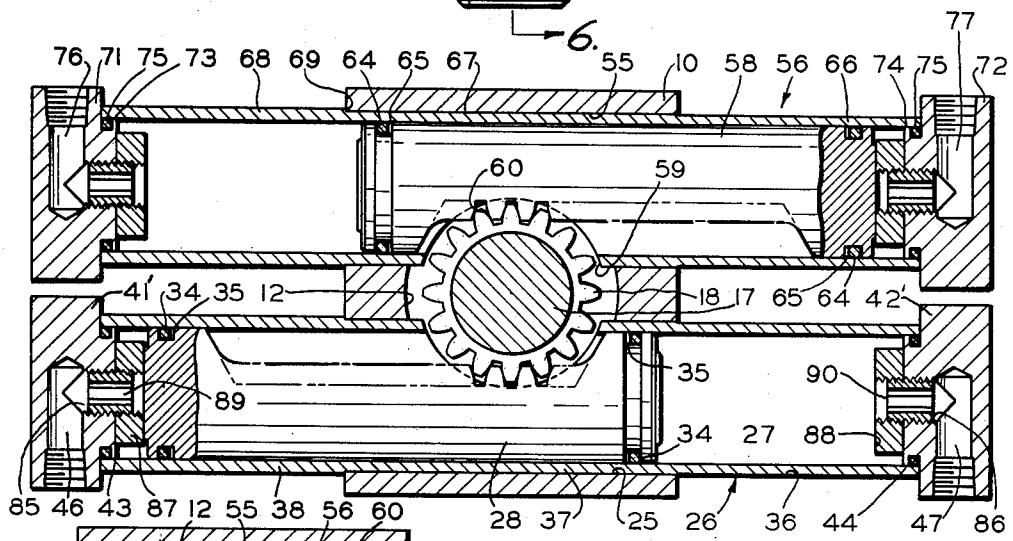


Fig. 5.

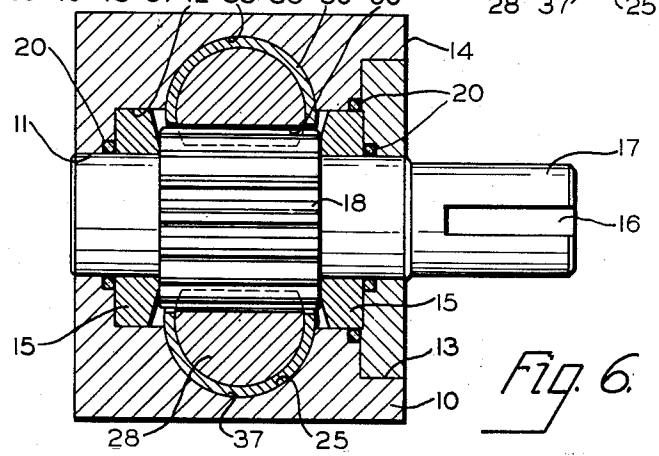


Fig. 6.

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ACTUATOR

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14 Claims. (Cl. 92—13)

This invention pertains to fluid actuators and more particularly to that class of mechanism in which fluid pressure is converted to selective and alternate rotary motion.

United States Patents Nos. 2,844,127 and 2,844,128 issued to Carl Steiner on July 22, 1958, each under the title "Fluid Pressure Torque Converter," describe and claim two types of rotary actuators of one class. This class of actuator utilizes a double ended piston with a rack formed between the ends of the piston. The rack meshes with a pinion gear carried in the actuator housing. The pinion is connected to an output shaft journaled in the housing. Reciprocation of the double ended piston causes rotary motion of the pinion and the connected shaft. Accordingly, the selective introduction of fluid under pressure to the opposite ends of the piston causes rotation of the output shaft in a selected direction.

The 2,844,128 patent discloses this class of structure with a single double ended piston while the 2,844,127 discloses a pair of pistons on opposite sides of the rack to apply pressure to the pinion with balanced torque. The concepts of the present invention are applicable to either the single or double piston construction and the application of the structure of this invention to both constructions will be disclosed.

While the Steiner structure has had good commercial success, it does have certain inherent disadvantages. Among these is that a specialized bulky housing is required for each size actuator. Thus, while it is a very sturdy and dependable actuator, it is an actuator which is relatively expensive to manufacture and produce. The present invention provides a greatly simplified structure incorporating all of the advantages of the Steiner construction.

With the present invention a block-like central body is provided. This central body has a gear chamber in which the pinion gear is disposed. The output shaft is journaled centrally in the body and connected to the pinion. A tubular member inserted in a suitable bore in the body provides the piston chamber. The tubular member has an opening in its wall which communicates with the gear chamber so that the piston and gear chambers are in communication with one another. End caps close the ends of the tube and are connected to the body by tie-rods to seal the ends of the tube and maintain the body and tube in fixed relative positions. Either one or two tubes may be employed so that either the single piston or the double piston, balanced torque, structure can be utilized.

One of the outstanding features of the invention resides in its great versatility. With a single housing body and quantities of tubing cut to selected lengths, it is possible to provide either a single or double piston actuator and an amount of rotation appropriate for a given application. The selective amount of rotation is obtained by using a tube of appropriate length and, of course, a piston of corresponding length.

With the device of this invention pistons of appropriate length can also be provided with great facility. By using a cast piston and a steel tube different metals are provided so that galling is inhibited. Use of a cast piston permits inserts to be used in a pattern so that pistons of varying but selected and appropriate lengths can be made with a single pattern.

The structure is such as to permit tubing of different diameter to be used with a given body so that in addition to the amount of travel and selection as to the number of pistons, it is also possible to utilize a single body structure with actuators of different torque output. This is true since the torque is a function of the diameter of the piston and therefore of the tube which provides a chamber for the piston.

From the preceding discussion it will be apparent that the actuator of this invention is a compact light-weight actuator which is simple to produce and which is inexpensive to produce. It is also an actuator which is easy to repair and which, with the mere changing of a rack and tube if required, can provide varying amounts of rotation if the conditions in a given application change.

Another of the features of the invention resides in novel and improved adjustable stops which permit, within the range of adjustment, the control of the amount of rotation to very careful and precise limits. As an example, if one of these actuators is used to control a ball valve, it is quite important that rotation be exactly ninety degrees from the close to the open position, so that when the valve is in the open position it is in a fully open position and conversely when closed is fully closed.

Accordingly, the object of this invention is to provide a novel and improved mechanism for converting fluid pressure to alternate rotary motion which is more versatile and simpler to produce than prior actuators.

Other objects and a fuller understanding of the invention may be had by referring to the following description and claims taken in conjunction with the accompanying(s) in which:

In the drawings:

FIGURE 1 is a top plan view of a single piston actuator;

FIGURES 2 and 3 are sectional views of the actuator of FIGURE 1 as seen respectively from the planes indicated by the lines 2—2 and 3—3 of FIGURE 1;

FIGURE 4 is a top plan view of a two piston actuator; and

FIGURES 5 and 6 are sectional views of the actuator of FIGURE 4 as seen respectively from the planes indicated by the lines 5—5 and 6—6 of FIGURE 4.

Referring now to the drawings, an actuator body is shown generally at **10**. The body may be a metal rectangular solid of either cast or machined configuration. The body **10** has a through shaft receiving bore **11**. An intermediate gear chamber counterbore **12** is in axial alignment and communication with the shaft bore **11**. A closure cap counterbore **13** extends from the gear chamber counterbore **12** to a face **14** of the body **10**. A pair of bearings **15** are carried in the gear chamber bore **12**.

An output shaft **17** is rotatably supported by the bearings **15**. The shaft is equipped with a key way **16** for driving connection to a driven member. A pinion **18** is provided on the shaft **17**. The pinion **18** may be integrally formed on the shaft or, in the alternative, secured to it and in either event is disposed in the gear chamber counterbore **12**.

An annular shaft retaining cap **19** is disposed in the cap counterbore **13**. The shaft retaining cap **19** maintains the bearings and the shaft in the body in an assembled condition. Suitable O-ring seals **20** surround the shaft and are interposed between the cap **19** and the body **10** to seal the gear chamber.

The structure thus far defined is common to both the single piston actuator of FIGURES 1–3 and the double piston actuator of FIGURES 4–6. For clarity in the description the single piston actuator of FIGURES 1–3 will be described next.

Referring to FIGURES 2 and 3, a through transverse piston bore **25** is provided in the lower portion of the body **10**. The piston bore **25** extends from one side of the body to the other. A piston tube **26** is disposed in

the piston bore 25. The piston tube 26 has cylindrically contoured internal walls defining a piston chamber 27. A piston 28 is reciprocally mounted in the piston tube.

The piston tube 26 has an opening 29 which is centrally disposed, axially speaking. This opening 29 communicates with the gear chamber defined by the intermediate bore 12 so that the gear chamber and the piston chamber 27 are in fluid communication with one another. The gear 18 projects through the opening 29 to mesh with a rack 30 which is integrally formed in the piston 28.

The piston has cylindrically contoured end portions 32, 33 at opposite ends of the piston. The end portions 32, 33 respectively carry O-ring seals 34 and backup rings 35 which form endless seals between the rack and the ends of the tube. These seals serve multiple purposes. The seals serve somewhat obvious purpose of preventing leakage of fluid under pressure introduced between the piston and an end of the tube to drive the piston. Similarly, and conversely, these seals 34 prevent lubricant in the gear chamber from passing past the ends of the piston. Accordingly, a sealed, self-agitating lubricating chamber is provided as is taught and described in greater detail in the referenced patents. As is further taught and described in greater detail in the referenced patents, the pistons, apart from the portion where the rack is integrally formed, are cylindrically contoured so that the tube 26 and the piston 28 coact to provide a thrust bearing to absorb lateral thrust imposed by the coaction of the rack and the pinion.

The piston tube 26 has a stepped exterior configuration. The tube has a reduced diameter pilot portion 36 at the end which is the right-hand end as viewed in FIGURE 2. This pilot portion 36 is of a diameter slightly less than the diameter of the piston bore 25 to permit ready insertion of the tube into the bore. The tube has a cylindrically contoured central portion 37 which is sized to telescope tightly into the bore 25 so that a shrink or expansion fit may be provided to effect a fluid seal between the tube and the body, and to secure the tube tightly in the body. The remaining portion of the tube is identified by the numeral 38 and is of a larger diameter than the bore 25. This provides a body abutting shoulder 39 between the remaining portion 38 and the central portion 37 to abut the left-hand face 40 of the body 10 and appropriately, relatively locate the piston tube 26 and the body 10.

The ends of the piston chamber 27 are closed by left- and right-hand end caps 41, 42 which are identical to one another and oppositely oriented. The caps 41, 42 have annular sealing portions 43, 44 which telescope into the ends of the piston tube 26 and carry O-ring seals 45. Tie rods in the form of studs 143 are threaded into the sides of the body 10 and project through apertures in the end caps 41, 42. Nuts 45 are threaded onto the ends of the tie rods to clamp the end caps against the ends of the piston tube 26. These tie rods serve both to lock the end caps on the piston tube 26 and also to anchor the tube and body together.

The end caps 41, 42 are provided with fluid ports 46, 47. When fluid under pressure is introduced through the port 46, the piston 28 will be driven to the right as seen in the drawings causing counterclockwise rotation of the pinion gear 18 and the shaft 17. At this time the port 47 in the right-hand end cap 42 serves as an exhaust port. When fluid under pressure is introduced through the right-hand port 47, the left-hand port 46 serves as an exhaust port, and the piston 28 travels to the left causing clockwise rotation of the pinion.

Referring now to the FIGURES 4–6, that portion of the structure which is identical to the previously described single piston actuator is identified by identical numerals. The end caps are designated respectively as 41', and 42' because of a modification in the piston stop structure yet to be described. In other respects the end caps are identical with the exception that for convenience of attachment of fluid supply lines, they are inverted with respect to the structure of FIGURES 1–3.

In the structure of FIGURES 4–6, an upper piston tube 56 is positioned within an upper piston bore 55 formed in the body 10. The bore 55 parallels the bore 25 and is spaced an equal distance from the axis of the shaft 17 on the opposite side of the shaft. The tube 56 is identical to the tube 26 with the exception that an opening 59 is inverted with respect to the opening 29. A piston 58 is mounted in the tube 56 and has a rack portion 60 in engagement with the pinion 18. Since the structure of the tube 56 and the piston 58 is identical to the tube 26 and the piston 28, like components of the tube and piston are identified by the same numerals plus 30. Thus the tube 56 is the counterpart of the tube 26, while the portions 66 and 67 are the counterparts of the portions 36, 37.

As is suggested in the introductory portion of the specification, it is desirable to have adjustable stops so that the exact and desired amount of rotation of the shaft can be obtained between precise limits. These adjustable stops contribute materially to the present invention because of the use of pistons and tubes of appropriate and selected length. With adjustable stops, the determination of the proper lengths for the piston and tubes for a given application need not be as precise as might otherwise be required. Additionally, as suggested above, the adjustment of the amount of travel is often desirable in a given application, especially if conditions in that application change and to coordinate an actuator and its driven member. It is also desirable that this adjustment be internal so that it cannot be altered either accidentally or intentionally by persons other than those who are skilled in the adjustment of the actuator.

In the embodiment of FIGURES 1–3, an adjustable stop is provided on the piston 28. Referring to FIGURE 2, the end portions 32, 33 of the piston 28 have axially disposed threaded bores 80. A pair of annular, adjustable stops 81 are provided and each is threaded into one of the bores 80. A lock screw 82 is threaded into the interior of each of the adjustable stops 81 and in abutment with the base of its threaded bore 80. In adjusting the piston travel, the adjustable stops 81 are first threaded into a selected position and then the adjustable lock nut 82 is tightened down to fix the adjustable stop 81 in its selected position.

In the structure of FIGURE 5, outlet portions of the ports 46, 47 are threaded at 85, 86 respectively. Internally threaded, annular stops 87, 88 are held in position by tubular lock members 89, 90 which are threaded respectively into the threaded port portion 85 and the stop member 87 and the threaded port portion 86 and the stop member 88.

In the structure of FIGURES 4–6, adjustment of the stops is obtained by using stop members 87, 88 of appropriate and selected thickness and, if desired, placing shims between the stops 87, 88 and the end caps 41', 42', respectively.

Although the invention has been described in its preferred form with a certain degree of particularity, it is understood that the present disclosure of the preferred form has been made only by way of example and that numerous changes in the details of construction and the combination and arrangement of parts may be resorted to without departing from the spirit and the scope of the invention as hereinafter claimed.

What is claimed is:

1. A fluid actuator comprising,

(*a*) a body member having a gear chamber,

(*b*) an output shaft journaled in the body,

(*c*) said shaft including a pinion gear disposed in the gear chamber,

(*d*) said body having a piston bore extending laterally therethrough and communicating with the gear chamber bore,

(e) a tubular member in the piston bore and projecting from the body,

(f) said tubular member having internal walls defining a cylindrical piston chamber and an opening in said walls connecting the gear and the piston chambers,

(g) piston means disposed in the piston chamber and including a rack engaged with the pinion,

(h) closure means closing the ends of said tubes and providing fluid inlets to the piston chamber for the selective introduction of fluid under pressure to the opposite ends of the tube,

(i) said tube including a pilot portion projecting from one side of the body and of a diameter smaller than the piston bore, a central portion tightly disposed in the piston bore, and an enlarged portion projecting from the side of the body opposite the pilot portion; and

(j) said tubular member including a shoulder extending between the adjacent ends of the enlarged and central portions, the shoulder being abuttable against the body.

2. A rotary actuator comprising,

(a) a body having parallel piston bores and a shaft bore, said shaft bore being positioned between the piston bores with its axis substantially normal to the axes of the piston bores,

(b) said body including a central gear chamber,

(c) a shaft journaled in the shaft bore and including a pinion gear disposed in the gear chamber,

(d) first and second piston tubes disposed in the piston bores in aligned relationship, each of said tubes having spaced end portions projecting past the body,

(e) each of said tubes having an internal wall defining a piston chamber,

(f) each of said tubes having an opening connecting its piston chamber to the gear chamber,

(g) first and second pistons respectively disposed in the first and second piston tubes, each of said pistons including a rack formed intermediate its ends, the racks each being in meshing engagement with the pinion,

(h) seal means near each end of each piston between each piston and its chamber wall,

(i) caps closing the ends of each of said tube end portions and including ports for the selective supply of fluid under pressure to the ends of the piston chambers, said caps being maintained in spaced relationship with the body by said tube end portions; and

(j) tie means connecting each cap to the body to clamp the caps against the ends of the tubes.

3. A fluid actuator comprising,

(a) a body member having a gear chamber,

(b) an output shaft journaled in the body,

(c) said shaft including a pinion gear disposed in the gear chamber,

(d) said body having a piston bore extending laterally therethrough and communicating with the gear chamber bore,

(e) a tubular member in the piston bore and having portions projecting in both directions from the body,

(f) said tubular member having internal walls defining a piston chamber and an opening in said walls connecting the gear and the piston chambers,

(g) a double-ended piston disposed in the piston chamber and including a rack intermediate its ends engaged with the pinion,

(h) a pair of caps each closing one end of said tube and providing fluid inlets to the piston chamber for the selective introduction of fluid under pressure to the opposite ends of the tube,

(i) each of said caps being spaced from the body and maintained in spaced relationship with the body by the projecting tube portions; and

(j) tie rod means connecting each cap to the body and clamping each cap against an end of the tube.

4. A rotary actuator comprising,

(a) a central body having a shaft bore and an aligned intermediate counterbore defining a gear chamber, said body also having an aligned cap receiving counterbore communicating with the intermediate bore,

(b) a shaft including a pinion gear disposed in the intermediate bore and journaled in the body,

(c) a closure member around the shaft and disposed in the aligned enlarged counterbore for closing the gear chamber,

(d) seal means interposed between the shaft and the body and between the shaft and the closure member to seal the gear chamber,

(e) a lateral piston bore formed in said body with its axis spaced from and normal to the axis of the shaft,

(f) a tube in said piston bore and including a cylindrically contoured inner wall defining a piston chamber, said tube also including a wall opening connecting the chambers and spaced portions extending from opposite sides of the body,

(g) a cylindrically contoured pison disposed in the tube and having a rack formed intermediate its ends, said rack being in meshing engagement with said pinion,

(h) end caps having portions projecting into said tube spaced portions and other cap portions each overlying the adjacent ends of the tube, said caps being maintained in spaced relationship with the body by said tube spaced portions; and

(i) tie rods connecting each of the end caps to the body and maintaining the caps in compressing engagement with the ends of the tube and fixing the tube and the body in fixed relative position.

5. A rotary actuator comprising,

(a) a central body having a shaft bore and a communicating central gear chamber and a closure receiving opening communicating with the gear chamber,

(b) a shaft journaled in the body and including a pinion gear disposed in the gear chamber,

(c) a chamber closure member around the shaft and disposed in the closure opening for closing the gear chamber,

(d) seal means interposed between the shaft and the body and between the shaft and the closure member to seal the gear chamber,

(e) a pair of parallel, lateral piston bores formed in said body each with its axis spaced from and normal to the axis of the shaft, said piston bores being symmetrically disposed on opposite sides of the shaft axis,

(f) a pair of tubes each in a different one of said piston bores and including a cylindrically contoured inner wall defining a piston chamber, each of said tubes having spaced end portions projecting past the body,

(g) a pair of cylindrically contoured pistons each disposed in a different one of the tubes and having a rack formed intermediate its ends, each of said racks being in meshing engagement with said pinion,

(h) end caps having portions projecting respectively into each of said end portions and other cap portions each overlying the adjacent end of one of the tubes, each of said caps being maintained in spaced relation with the body by the adjacent one of said tube end portions; and

(i) tie rods connecting each of the end caps to the body and maintaining the caps in compressing engagement with the ends of the tubes and fixing the tubes and the body in fixed relative position.

6. A fluid actuator comprising,

(a) a body having a gear chamber,
(b) an output shaft journaled in the body,
(c) said shaft including a pinion gear disposed in the gear chamber,
(d) said body having a piston bore extending laterally therethrough and communicating with the gear chamber bore,
(e) a tube in the piston bore and projecting from the body,
(f) said tube having internal walls defining a piston chamber and an opening in said walls connecting the gear and the piston chambers,
(g) a double-ended piston member disposed in the piston chamber and including a rack intermediate its ends engaged with the pinion,
(h) a closure member closing one end of said tube and a closure means closing the other end of the tube, said closure means and said closure member providing fluid inlets to the piston chamber for the selective introduction of fluid under pressure to the opposite ends of the tube; and
(i) stop and lock elements in threaded engagement with one another and in threaded engagement with one of said members, said stop element being disposed in said piston chamber and positionable to abut the other of the members and thereby limit reciprocable travel of the piston in the chamber to a selected and adjusted predetermined amount.

7. In a rotary actuator having a housing with an output shaft journaled in the housing and driven by a pinion the combination of:
(a) housing means defining a piston chamber,
(b) piston means reciprocally mounted in the chamber and including a rack in engagement with the pinion,
(c) said housing means including ports communicating with the piston chamber on opposite sides of the piston means for selectively introducing fluid under pressure; and
(d) stop and lock elements in threaded engagement with one another and in threaded engagement with one of said means, said stop element being disposed in said piston chamber and positionable to abut the other of the means and thereby limit reciprocal travel of the piston in the chamber to a selected and adjusted predetermined amount.

8. The device of claim 7 wherein,

(a) the piston means has a threaded bore at one end,
(b) the stop element is annular, threaded into the bore, and projecting past the one end of the piston means; and
(c) the lock element is a screw threaded into the stop element and abutting the base of the bore.

9. The device of claim 7 wherein,
(a) the stop member is annular and internally threaded,
(b) one of the ports includes a threaded portion; and,
(c) the lock element is a threaded tube in threaded engagement with the lock element and the port threaded portion to lock the stop element against the housing.

10. The device of claim 3 wherein said tubular member includes external shoulders means abutting the body.

11. The device of claim 7 wherein one of said elements is tubular and threaded into one of said ports whereby fluid under pressure passes through said one element when introduced into the chamber.

12. The device of claim 7 wherein one of the stop and lock elements is threaded into the piston means.

13. The device of claim 7 wherein one of the stop and lock elements is threaded into the housing means.

14. The device of claim 1 wherein there are two tubular members and a pison in each tubular member and wherein the pistons are on opposite sides of the gear.

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