

July 26, 1960

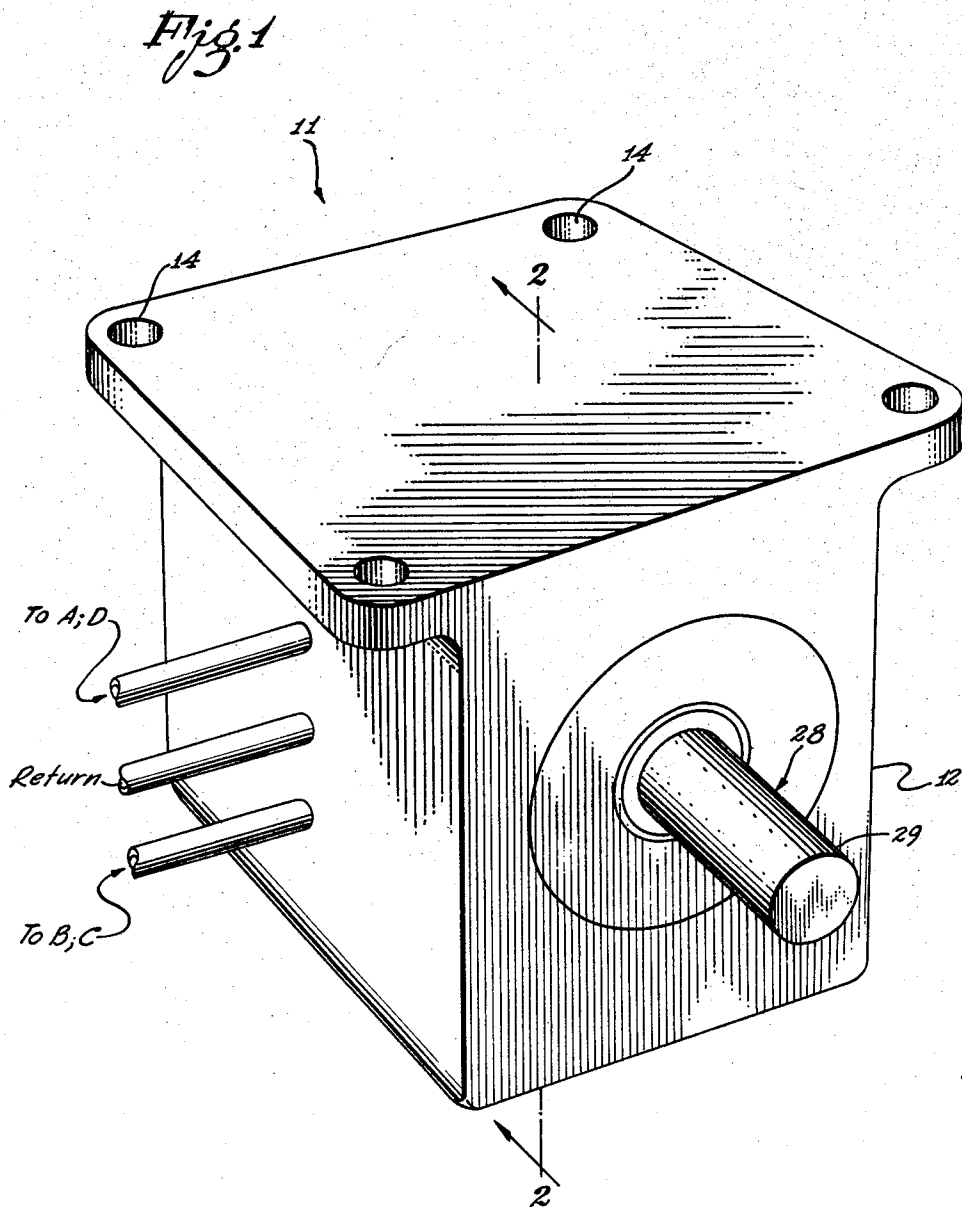
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2,946,320

ROTARY HYDRAULIC SERVO ACTUATOR

Filed Dec. 23, 1958

2 Sheets-Sheet 1



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Fig. 2

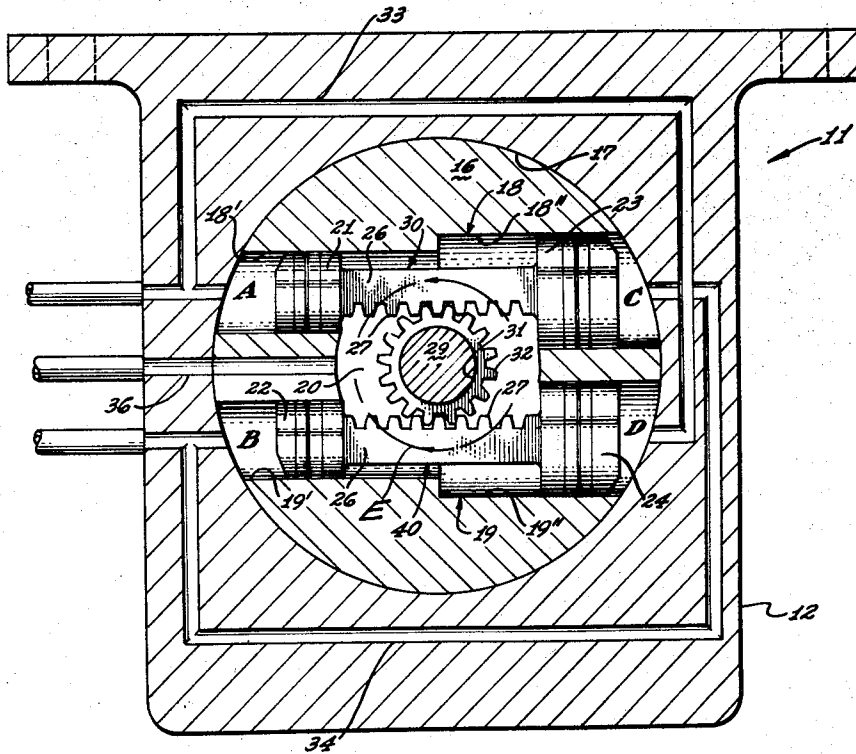
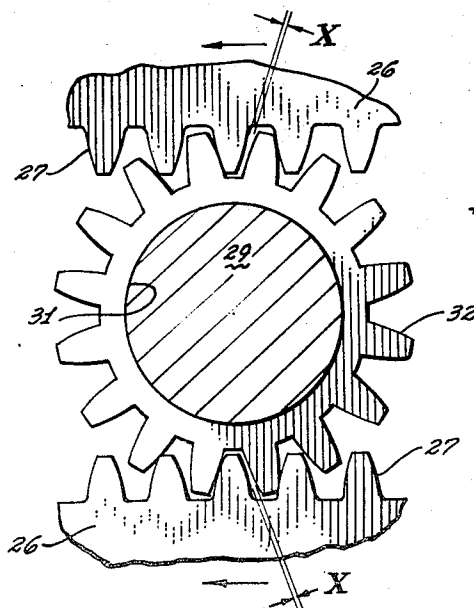


Fig. 3



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ROTARY HYDRAULIC SERVO ACTUATOR

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Filed Dec. 23, 1958, Ser. No. 782,512

4 Claims. (Cl. 121—120)

This invention relates to fluid actuators and more particularly to a rotary type fluid actuator embodying novel features rendering it especially useful as a prime mover in servo and like systems.

Fluid actuators manifest characteristics which render them generally satisfactory and in fact desirable as prime movers in servo and like systems. Notwithstanding this fact rotary and linear type actuators, the latter type at such times as their linear output is converted into rotational movement, embody undesirable features.

For example, for reasons which are well known to those skilled in the art, rotary type actuators necessarily are susceptible to a high degree of wear which in time results in excessive leakage which is highly objectionable. Initial leakage occurring in rotary actuators may be minimized by lapping the relative moving parts thereof, however, this operation is extremely expensive and necessarily increases the initial cost of the actuator. On the other hand linear actuators, of a type in which the linear output thereof is converted to rotary motion, are also objectionable in that they manifest backlash tendencies which are extremely objectionable and in fact can not be tolerated in servo and like systems. The rotary type actuator as disclosed herein effectively eliminates the above objectionable features of rotary and linear type actuators.

An important feature of the instant actuator resides in the fact that it incorporates a pair of stepped bores each comprising a major portion and a minor portion and are further characterized in that the diameter of the major portions exceeds the diameter of the minor portions. Rod means connect pistons which are mounted in the major and minor portions of each respective stepped bore, the pistons acting through the rods transmit their linear movement to the output member of the actuator to impart rotary motion thereto. The stepped bores cooperate with the pistons mounted therein to define unequal areas on which pressurized fluid acts. This novel feature places a preload on contact areas between the aforementioned rod means and output member to effectively preclude any backlash tendencies from the instant device. In view of the fact that the instant actuator initially employs linear movement to provide rotary motion, excessive wear inherently present in conventional type rotary actuators resulting from close (lapped) fits and the like, is eliminated. Also the novel construction of the instant actuator effectively eliminates backlash tendencies.

Accordingly it is an object of the present invention to provide a fluid type rotary actuator that is not subject to excessive wear of the type occurring in conventional rotary type actuators.

Another object is to provide a fluid type rotary actuator in which the output member and the operating mechanism thereof are preloaded to eliminate backlash tendencies by pressurized fluid present in the actuator.

Another object is to provide a fluid type rotary actuator in which the output member and operating mechanism thereof are preloaded in a novel manner to eliminate

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backlash tendencies therebetween throughout a predetermined pressure range of the fluid operating the actuator.

Another object is to provide a fluid type rotary actuator in which the output member and operating mechanism thereof are subject to a preload to eliminate backlash tendencies therefrom, the preload being independent of fluid pressure throughout a predetermined pressure range of the fluid operating the actuator.

Another object is to provide a fluid type rotary actuator which is simple in design yet rugged in construction, which is economical to manufacture and may be easily adapted to any purpose for which the actuator is intended.

Although the characteristic features of the present invention are particularly pointed out in the appended claims, the invention itself, also the manner in which it may be carried out, will be better understood by referring to the following description taken in connection with the accompanying drawings forming a part of this application and in which:

Figure 1 is a perspective view of a rotary type actuator of the type disclosed herein.

Figure 2 is a sectional view of the actuator shown in Figure 1 as the same appears when viewed as indicated by the arrows 2—2 of the latter figure.

Figure 3 is an enlarged view of that portion of Figure 2 enclosed within the area indicated by the letter E.

Referring to the drawings, Figures 1 and 2 show one embodiment of the instant actuator identified in its entirety by the numeral 11. Operating components of the actuator 11 are mounted in a housing 12 which is shown as being rectangular in cross-section although it may assume other configurations. The actuator may be secured to any type of supporting structure by means of bolts, cap screws or the like which extend through the bores 14 formed in the housing 11.

For ease in manufacturing the major portion of the operating components of the actuator are mounted in a cylindrical member 16 which has a force fit in a bore 17 the axis of which extends normal to two opposed side faces of the housing 12.

The fit of the member 16 in the bore 17 is such that it precludes the escape of liquid between the mating surfaces thereof, alternately the member 16 may be sealed in the housing 12 by side plates (not shown) if desired.

A pair of stepped cylindrical bores 18 and 19, spaced with respect to each other, are provided in the member 16. The bores 18 and 19 extend in a direction normal to and at equal distances on each side of the axis of the member 16. The portion of the member 16 adjacent the axis, that is that portion of the member 16 separating the bores 18 and 19, is removed to provide a chamber 20 in which operating fluid may collect and also to provide a space in which a spur gear 31 is mounted. Each of the bores 18 and 19 is further characterized in that they include respective major and minor end portions, the major and minor end portions comprising the bores 18 and 19 are identified by the numerals 18"—18' and 19"—19', respectively. The diameters of the major end portions 18" and 19" are equal as are the diameters of the minor portions 18' and 19', however, it will be seen that the diameters of the major portions 18" and 19" exceed the diameters of the minor portions 18' and 19' by equal amounts.

Mounted in each of the major and minor portions 18", 19", 18' and 19' are respective pistons 21—24, inclusive. The pistons 21 and 23 and the pistons 22 and 24 are connected by identical rods 26 constructed as gear racks having teeth 27 provided thereon. The position of the rods 26—26 is further characterized in that the teeth 27 are located in opposed spaced relation substantially

as shown in Figure 2. The pistons together with outer ends of the bores 18', 19', 18'' and 19'' define minor and major expandable chambers A, B, C and D.

Rotatably mounted in the housing 12 is an output member 28 including a stub shaft 29 and the aforementioned spur gear 31, having teeth 32 fixed securely on the shaft 29. The position of the shaft 29 is further characterized in that its axis extends in a direction normal to the axes of the bores 18 and 19 and at a location midway therebetween, in other words the axes of the member 16 and shaft 29 coincide. So positioned the gear 31 is located in the cavity 20 and its teeth 32 are in mesh with the teeth 27 of the rods 26—26, the latter imparting rotary motion to the output member 28 as the racks 26 reciprocate.

The construction of the actuator 11 is completed by passages 33, 34 and 36. The passages 33 and 34 provide means whereby pressurized fluid may be directed to or exhausted from the chambers A, B, C and D under control of a transfer valve (not shown). It will be noted that the expandable chambers are cross-ported, that is fluid entering through the passage 33 is directed to the chambers A and D while fluid entering through the passage 34 is directed to the chambers B and C. Fluid which may escape past the pistons 21—24 accumulates in the chamber 20 and subsequently flows from the chamber through the passage 36.

The construction of the actuator 11 having been described a better understanding of its novel features and advantages will be forthcoming from the following description of its operation.

The pistons 21, 23 and respective connecting rod 26, also the pistons 22, 24 and respective connecting rod 26, hereinafter referred to as piston combinations 30 and 40, respectively, have a neutral position, substantially as shown in Figure 2. The piston combinations may be moved equal distances, either to the right or to the left from their neutral positions, in their respective end portions 18', 18'', 19' and 19''. At this time fluid at 150 p.s.i. is directed to the chambers A, B, C and D through the passages 33 and 34 by the aforementioned transfer valve. For purposes of illustration it is further assumed that the working area of each of the pistons 21 and 22 is two (2) sq. in. and the working area of each of the pistons 23 and 24 is three (3) sq. in.

Under the above conditions it will be apparent that forces, due to fluid pressure acting on the pistons 21—24, inclusive, will be balanced and no movement thereof or of the output member 28 will result. Under these conditions the piston combinations 30 and 40 will be urged to the left and the teeth 27 and 32 will assume relative positions as shown in detail in Figure 3. By referring to Figure 3 it will be seen that corresponding sides of the teeth 27, located on both the upper and lower rods 26—26, are in contact with the corresponding or driving sides of the teeth 32 of the gear 31. Thus any clearance, for example the clearance "X" present between the teeth 27—27 and the teeth 32, will be located on the non-driving side of the teeth 32.

From the foregoing discussion it will be seen that, throughout a predetermined fluid pressure range, both sets of teeth 27 are continuously urged into contact with the driving side of the teeth 32 on the gear 31. Accordingly, at such time as there is a fluid pressure change in the chambers A and D with respect to the pressure in chambers B and C or vice versa, immediate rotary movement of the output member 28 will follow, in other words movement of the pistons and output member will be instantaneous and there will be no lost motion therebetween.

The above described instantaneous movement of the pistons 21—24 and output member will be forthcoming until such time as the differential pressure in the chambers equals or exceeds 600 p.s.i. Assuming that fluid at 1800 p.s.i. is directed to the chambers A and D while

fluid at 1200 p.s.i. is directed to the chambers B and C. Under these conditions the piston combination 30 will no longer be preloaded in the manner described above and lost motion will occur.

In view of the above discussion of operation it will now be seen that a rotary type fluid actuator is provided that eliminates backlash tendencies normally present in linear type actuators when linear motion is converted into rotary motion. On the most part the instant actuator utilizes linear motion and, therefore, excessive wear inherently present in rotary type actuators is eliminated. Accordingly it is seen a rotary type actuator making possible the objects of the invention is disclosed.

While in order to comply with the statute, the invention has been described in language more or less specific as to structural features, it is to be understood that the invention is not limited to the specific features shown, but that the means and construction herein disclosed comprise a preferred form of putting the invention into effect, and the invention is therefore claimed in any of its forms or modifications within the legitimate and valid scope of the appended claims.

I claim:

1. A rotary type fluid actuator comprising: a housing having first and second stepped bores formed therein in spaced relation; each of said stepped bores including identical major end portions and identical minor end portions being further characterized in that the cross-sectional areas of the major end portions exceed the cross-sectional areas of the minor end portions; a piston mounted in each of said end portions and cooperating with the respective walls of said end portions to define major and minor expandable chambers; gear rack means connecting the pistons mounted in the end portions comprising said first stepped bore; gear rack means connecting the pistons mounted in the end portions comprising said second stepped bore; an elongated output member having a spur gear mounted thereon; said output member being rotatably mounted in said housing with the teeth on said spur gear meshing with the teeth on said gear rack means and at least one end of said output member extending from said housing; portions of said housing defining first and second passages; said first passage providing fluid communication with one of said major expandable chambers and the minor expandable chamber not being aligned with said one major expandable chamber and said second passage providing fluid communication with the other of said major expandable chambers and the minor expandable chamber not being aligned with the last named major expandable chamber.

2. A rotary type fluid actuator comprising: a housing having a cavity formed therein; portions of said housing defining a first pair of axially aligned major and minor bores and a second pair of axially aligned major and minor bores; the inner ends of said first and second pairs of major and minor bores opening into said cavity and being closed at their outer ends; the relative positions and sizes of said pairs of major and minor bores being characterized in that the axes of said first pair of major and minor bores are aligned, the axes of said second pair of major and minor bores are axially aligned and the cross-sectional area of each of said major bores exceeds the cross-sectional area of each of said minor bores; a piston being mounted in each of said bores and cooperating with portions of said housing to define major and minor expandable chambers; means including gear racks respectively connecting the pistons mounted in said first pair of major and minor bores and the pistons mounted in said second pair of major and minor bores; a shaft having a spur gear mounted thereon; said shaft being rotatably mounted in said housing at a position between the axes of said first and second pair of major and minor bores with the teeth of said spur gear meshing with the teeth of said gear racks and at least one end of said shaft extending from said housing; and portions of said hous-

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ing defining first and second passages through which fluid may be simultaneously directed to and exhausted from nonaligned major and minor expandable chambers to maintain a continuous pressure on the teeth of said spur gear.

3. A fluid type rotary actuator as set forth in claim 2: further characterized in that said first passage communicates with one of said major expandable chambers and the minor expandable chamber not aligned with said one major chamber and said second passage communicates with the other of said major expandable chambers and the minor expandable chamber not aligned with the last named major expandable chamber.

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4. A fluid type rotary actuator as set forth in claim 3: further characterized in that portions of said housing define a return passage one end of which opens into said cavity and its other end opens on an outside surface of said housing.

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