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Saida et al.

[11] **3,858,484**

[45] **Jan. 7, 1975**

[54] **HYDRAULIC, ROTARY SERVO-ACTUATOR**

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[30] **Foreign Application Priority Data**

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[52] **U.S. Cl.** ..... **91/375,** 91/376 A, 91/445

[51] **Int. Cl.** **F15b 9/10**

[58] **Field of Search** ..... 91/375, 376, 376 A, 445, 91/410

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Attorney, Agent, or Firm—Wenderoth, Lind & Ponack

[57] **ABSTRACT**

A hydraulic, rotary servo-actuator of the type having a casing, a first control valve, an input shaft provided therewithin with hydraulic fluid supply and discharge passageways, and a hydraulically actuated member further has other hydraulic fluid supply and discharge passageways formed within its casing and respectively communicating with a fluid supply source and a fluid reservoir both outside the servo-actuator and a second control valve formed within the casing and operating to communicate and shut off selectively these other passageways respectively with and from the passageways formed within the input shaft thereby to prevent excessive actuated movement of the hydraulically actuated member.

2 Claims, 9 Drawing Figures

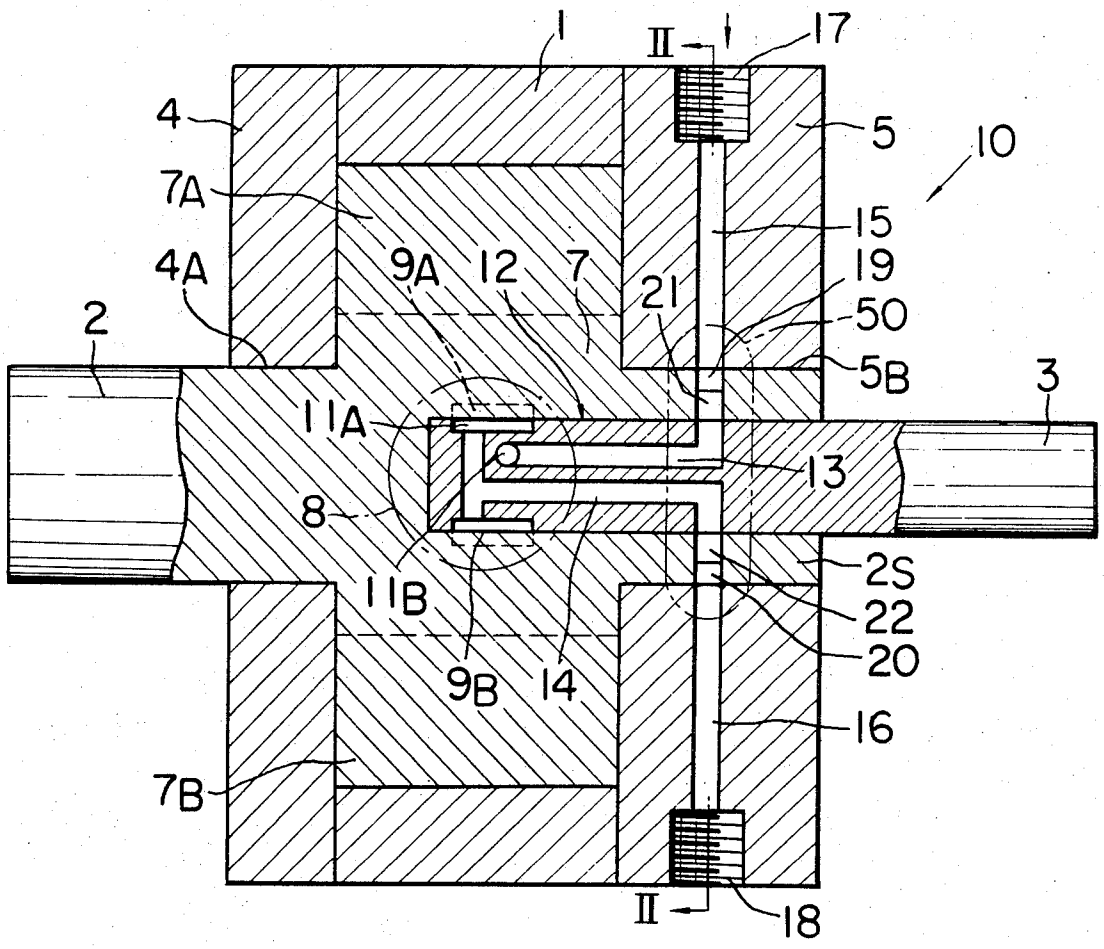
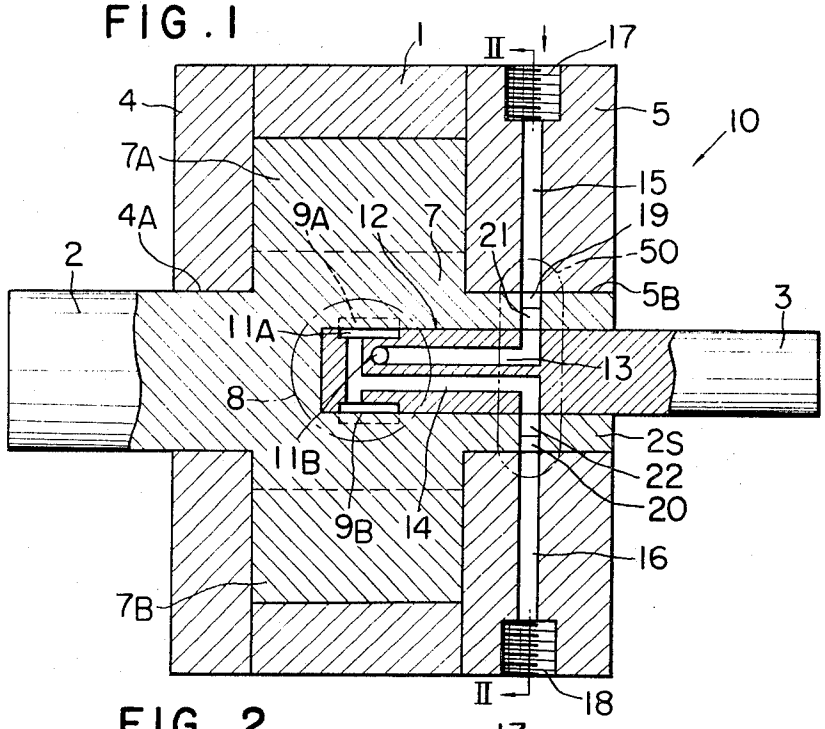


FIG. 1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II
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17
4
5
10
7A
15
4A
9A
12
7
21
19
50
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5B
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11A
13
8
2S
11B
22
20
9B
14
16
7B
II
18

FIG. 2

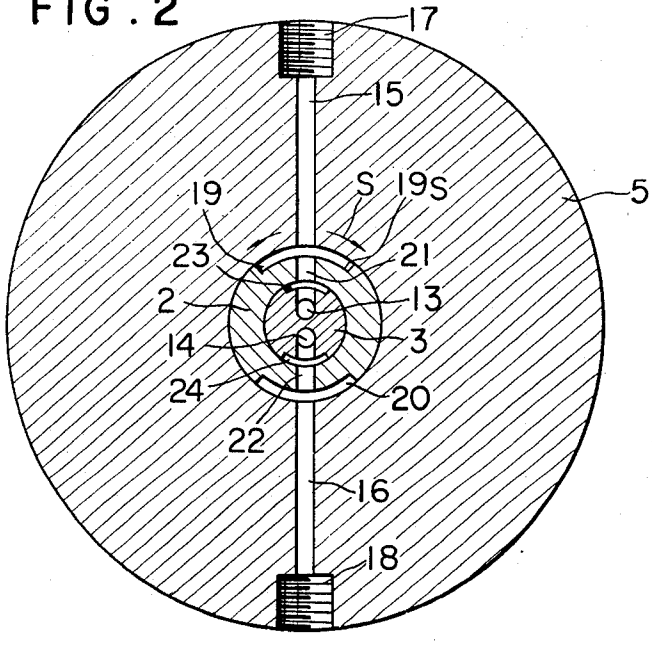
17
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FIG. 3a

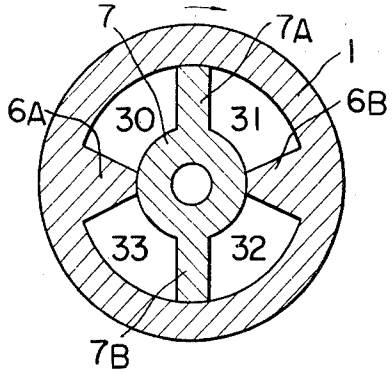


FIG. 4a

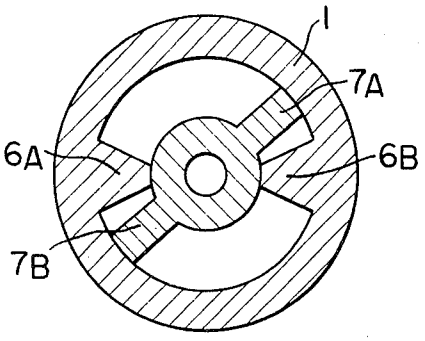


FIG. 3b

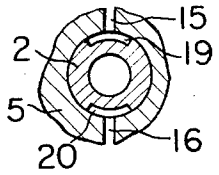


FIG. 4b

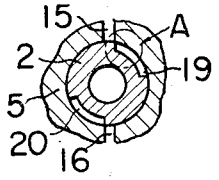


FIG. 5a

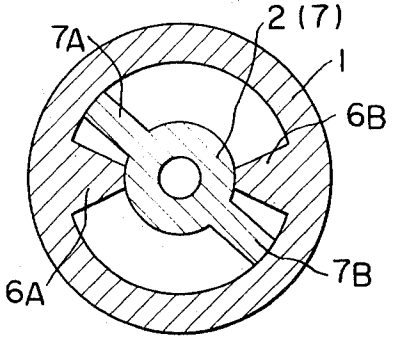


FIG. 6

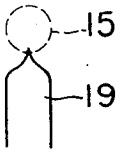
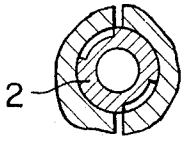


FIG. 5b



HYDRAULIC, ROTARY SERVO-ACTUATOR

BACKGROUND OF THE INVENTION

This invention relates to hydraulic-type, rotary-action servo-actuators and more particularly to a servo-actuator of this type provided with an input shaft and an output shaft coaxially disposed relative to the input shaft and rotatably fitted on the inner part thereof and having a servo-valve at the fitted surfaces of the input and output shafts.

We have previously developed a hydraulic, rotary servo-actuator comprising a cylindrical enclosure having a plurality of divided hydraulic fluid acting chambers, an output shaft rotatably supported within the cylindrical enclosure, and an input shaft rotatably fitted in a central bore formed along the rotational axis of the output shaft (as disclosed in the specification of U.S. Pat. application Ser. No. 265,178, filed June 22, 1972, now abandoned and entitled "ROTARY SERVO-MECHANISM").

A servo-actuator of this type is provided with a servo-valve which, structurally, is built-in at the mutually fitted surfaces of the input shaft and the output shaft and is adapted to return automatically to the neutral position when the output shaft rotates in response to a rotation of the input shaft. For this reason, there is no risk of the output shaft rotating excessively beyond a predetermined maximum rotational angle under normal operational conditions.

However, there is the possibility of the output shaft being caused by impact force due to the hydraulic fluid entering the fluid acting chambers provided within the cylindrical enclosure to rotate beyond this predetermined maximum angle thereby to cause pressure-actuated members fixed to the outer periphery of the output shaft to collide with partition walls within the cylindrical enclosure and thereby to give rise to unforeseen damage to the rotating mechanism.

SUMMARY OF THE INVENTION

It is an object of this invention to solve the above described problem in a hydraulic, rotary servo-actuator.

More specifically, an object of the invention is to provide a hydraulic, rotary servo-actuator of the type referred to above in which, without externally installing a special rotation control mechanism, excessive rotation of the output shaft is prevented by safety means comprising a control valve provided in built-in state at the fitted surfaces of the input shaft and the cylindrical enclosure and operating when the output shaft in rotation reaches an angular position just short of the above mentioned limiting maximum angle to shut off either one or both of the hydraulic fluid supply to a fluid supply path and the fluid discharge from a fluid discharge.

According to this invention, briefly summarized, there is provided a hydraulic, rotary servo-actuator comprising: a closed cylindrical enclosure having therewithin a plurality of hydraulic action chambers; an input shaft rotatably supported along the central axis of the cylindrical enclosure by a wall part thereof and having a part extending in the interior of the enclosure; an actuated member having a part passing through a wall of the enclosure and having a central axial bore, into which the input shaft is rotatably fitted, and further having a rotor part provided with hydraulically actuated parts movably disposed within the hydraulic action chambers; and a first control valve provided in the central axial bore and operating to communicate the hydraulic action chambers selectively with hydraulic fluid supply and discharge passageways formed within the input shaft, the servo-actuator being characterized in that other hydraulic fluid supply and discharge passageways respectively communicating with a hydraulic fluid supply source and a hydraulic fluid reservoir both outside of the servo-actuator are formed within a wall of the enclosure, and in that a second control valve for operating interrelatedly with the first control valve to selectively communicate and shut off these other hydraulic fluid supply and discharge passageways respectively with and from the aforesaid passageways formed within the input shaft thereby to prevent excessive actuated movement of the hydraulically actuated parts is provided in a wall of the enclosure.

The nature and further features of the invention will be apparent from the following detailed description with respect to a preferred embodiment of the invention when read in conjunction with the accompanying drawings, in which like parts are designated by like reference numerals.

BRIEF DESCRIPTION OF THE DRAWINGS

In the drawings:

FIG. **1** is a side view, for the most part in longitudinal section, showing the essential parts of one example of the hydraulic, rotary servo-actuator according to the invention;

FIG. **2** is a cross section taken along the plane indicated by line II — II in FIG. **1** as viewed in the arrow direction;

FIG. **3***a* is a diagrammatic end view showing the rotor of the servo-actuator in neutral position;

FIG. **3***b* is a diagrammatic end view indicating a second control valve in neutral position;

FIG. **4***a* is a diagrammatic end view showing the rotor in a clockwise rotated position;

FIG. **4***b* is a diagrammatic end view indicating the state of the second control valve corresponding to the state of rotor indicated in FIG. **4***a;*

FIG. **5***a* is a diagrammatic end view showing the rotor in a counterclockwisely rotated position;

FIG. **5***b* is a diagrammatic end view indicating the state of the second control valve corresponding to the state of the rotor indicated in FIG. **5***a;* and

FIG. **6** is a diagrammatic projection of a hydraulic fluid groove as viewed in the direction of the arrow A in FIG. **4***b*.

DETAILED DESCRIPTION

Referring first to FIG. **1**, there is illustrated an example of a hydraulic, rotary servo-actuator **10** according to this invention the principal structural parts of which are a cylindrical enclosure **1** having two ends respectively closed by end walls **4** and **5** of disc shape, an output shaft **2** formed integrally and coaxially with a rotor part **7** accommodated rotatably within the enclosure **1**, the ends of the output shaft **2** extending out through central journal holes **4A** and **5B** in the end walls **4** and **5**, respectively, and an input shaft **3** rotatably and coaxially fitted within an axial bore formed in the output shaft from its end extending out through the central hole **5B** to the middle part of the rotor **7**.

As indicated in FIG. **3***a*, the cylindrical enclosure **1** is provided in its interior with two longitudinal partition

walls 6A and 6B extending radially inward to the rotor part 7 and disposed in substantially diametrically opposite positions. The outer surface of the rotor part 7 is engaged in a liquidtight yet slidable manner with the innermost edges of the partition walls 6A and 6B. The rotor part 7 is provided with pressure-actuated members 7A and 7B of vane-like shape secured unitarily at their base parts to the rotor part 7 on substantially diametrically opposite sides thereof and extending radially outward therefrom to the inner cylindrical surface of the cylindrical enclosure 1, where the outermost tips of the vanes 7A and 7B are engaged in a liquid-tight yet slidable manner with the inner surface of the enclosure 1.

Thus, four hydraulic action chambers 30, 31, 32, and 33 are formed between the inner surface of the cylindrical enclosure 1 and the outer cylindrical surface of the rotor part 7 by these surfaces, the partition walls 6A and 6B, and the vanes 7A and 7B.

As shown in FIG. 1, a control valve or a servo-valve 8 is provided at the fitting surfaces of the output shaft 2 and the input shaft 3 slidably fitting thereinto. This control valve 8 is formed by hydraulic fluid recesses or grooves 9A and 9B formed in the inner wall surface of the aforementioned central bore 12 of the output shaft 2 and hydraulic fluid recesses or grooves 11A and 11B formed in the outer surface of the input shaft 3. While not shown in the drawings, the fluid grooves 9A and 9B are communicatively connected via suitable passageways to the aforedescribed hydraulic action chambers 30 and 32 and hydraulic action chambers 31 and 33, respectively.

The input shaft 3 is provided therewithin with longitudinal hydraulic fluid passageways 13 and 14. The passageway 13 for fluid supply opens at one end thereof into the above mentioned fluid groove 11B formed on the outer surface of the input shaft 3 and is communicatively connected at its other end by way of a mechanism to be described hereinafter to a hydraulic fluid supply source (not shown) outside of the actuator. The passageway 14 for fluid discharge opens at one end thereof into the above mentioned fluid groove 11A of the input shaft 3 and is communicatively connected at its other end to a hydraulic fluid reservoir (not shown) outside of the actuator.

When, at the time of operation, the rotation of the input shaft 3 operates the control valve 8 in a manner such that the fluid groove 11B communicating with the hydraulic fluid supply passageway 13 of the input shaft coincides with the fluid groove 9A communicating with the aforementioned hydraulic action chambers 30 and 32, while the fluid groove 11A communicating with the fluid discharge passageway 14 of the input shaft registers with the fluid groove 9B communicating with the hydraulic action chambers 31 and 33, hydraulic fluid is supplied into the hydraulic action chambers 30 and 32, while hydraulic fluid is discharged from the hydraulic action chambers 31 and 33. As a result, the rotor 7 is rotated in the clockwise direction as viewed in FIG. 3*a* until it reaches the state indicated in FIG. 4*a*.

Inversely, when the rotation of the input shaft 3 operates the control valve 8 in a manner to communicate the fluid discharge passageway 14 with the hydraulic action chambers 30 and 32 and the fluid supply passageway 13 with the hydraulic action chambers 31 and 32, hydraulic fluid is discharged from the chambers 30 and 32, while hydraulic fluid is supplied into the chambers 31 and 33, whereby the rotor 7 is rotated counterclockwise until it reaches the state indicated in FIG. 5*a*.

A vitally important feature of this invention lies in the provision of a separate control valve 50 for limiting the quantity of the hydraulic fluid entering the fluid chambers thereby to prevent the pressure-actuated vane members 7A and 7B of the rotor 7 from colliding with the longitudinal partition walls 6A and 6B of the cylindrical enclosure 1 at the time of rotation, this control valve 50 being provided at the slidably fitted surfaces of the input shaft 3, the output shaft 2, and the end wall 5 of the enclosure 1.

In the construction indicated in FIGS. 1 and 2, the right end (as viewed in FIG. 1) of the output shaft 2, being provided with a central bore 12, for rotatably accommodate the input shaft 3, has the shape of a sleeve 2S rotatably fitted in the journal hole 5B of the end wall 5 as mentioned hereinbefore. The end wall 5 is provided with a hydraulic fluid supply inlet 17 and discharge outlet 18, which are respectively connected by suitable piping (not shown) to the aforementioned hydraulic fluid supply source and reservoir. The inlet 17 and the outlet 18 on their inner sides are communicatively connected by a hydraulic fluid supply passageway 15 and a hydraulic fluid discharge passageway 16, respectively to the journal bore 5B.

The sleeve-shaped part 2S of the output shaft 2 is provided in its outer peripheral surface with arcuate fluid grooves 19 and 20 adapted to communicate with the fluid supply passageway 15 and discharge passageway 16 at their ends opening into the bore 5B in accordance with the angular position of the output shaft 2. The fluid grooves 19 and 20 are communicatively connected respectively by radially extending passageways 21 and 22 in the output shaft 2 to the central bore 12 of the output shaft 2.

The input shaft 3 is provided in its outer peripheral surface with arcuate fluid grooves 23 and 24 communicatively connected on their inner sides to the aforedescribed fluid supply passageway 13 and fluid discharge passageway 14, respectively. Furthermore, these fluid grooves 23 and 24 are adapted to communicate on their outer sides with the inner open ends of the above mentioned radial passageways 21 and 22 provided in the sleeve part 2S of the output shaft 2.

With the essential parts of the actuator in their relative positions indicated in FIGS. 1 and 2, the fluid supply passageway 13 in the input shaft 3 is in communication by way of the arcuate fluid groove 23, the radial passageway 21, the arcuate groove 19, and the radial supply passageway 15 with the fluid inlet 17, while the fluid discharge passageway 14 is in communication by way of the arcuate groove 24, the radial passageway 22, the arcuate groove 20, and the radial discharge passageway 16 with the fluid outlet 18.

In the case where the input shaft 3 is rotated in the counterclockwise direction, for example, from the state indicated in FIGS. 1 and 2, the output shaft 2 follows up this rotation and rotates counterclockwise as a result of the functioning of this hydraulic servo-actuator. During this operation, since the servo-valve 8 returns automatically to the neutral position, the output shaft 2 stops at a specific angular position.

However, by appropriately selecting the length S of the arc of the arcuate fluid groove 19 provided in the sleeve part 2S of the output shaft 2 as shown in FIG. 2, the ledge or shoulder 19S of the fluid groove 19 can be

caused to close the fluid supply passageway **15** in the end wall **5** thereby to shut off the supply of hydraulic fluid to the supply passageway **13** within the input shaft **3.** Consequently, at a stage prior to the action of the control valve **8,** which is an essential characteristic of this actuator, the fluid supply is shut off. Therefore, the control valve **50** comprising the arcuate grooves **19** and **20** of the output shaft **2** and the hydraulic fluid supply and discharge passageways **15** and **16** of the end wall **5** constitutes a safety device for preventing excessive rotation of the rotor **7.**

The neutral position of the control valve **50** is diagrammatically indicated in FIG. **3***b*, while its operational position at the time when the output shaft **2** has rotated counterclockwise is indicated in FIG. **4***b*. The width of the arcuate fluid groove **19** is reduced at its end as indicated in FIG. **6.**

What we claim is:

1. A hydraulic, rotary servo-actuator comprising:

a closed cylindrical enclosure having therewithin a plurality of hydraulic action chambers;

an input shaft entering said enclosure one end thereof and rotatably and coaxially supported therewithin;

an actuated member comprising a part having a central axial bore, into which said input shaft is rotatably fitted, a rotor part provided with hydraulically actuated parts movably disposed within said chambers, and an output shaft connected unitarily to said rotor part;

a first control valve provided in said input shaft and central axial bore and operating to communicate the chambers selectively with hydraulic fluid supply and discharge passageways formed within the input shaft;

other hydraulic fluid supply and discharge passageways formed within a wall of the enclosure and respectively communicating with a hydraulic fluid supply source and a hydraulic fluid reservoir both outside of the servo-actuator; and

a second control valve provided within the input shaft and central axial bore and operating interrelatedly with said first control valve to communicate and shut off selectively said other supply and discharge passageways respectively with and from the aforesaid passageways formed within the input shaft thereby to prevent excessive actuated movement of said hydraulically actuated parts.

2. A hydraulic, rotary servo-actuator as set forth in claim **1** in which said second control valve is constituted by pertinent parts of the input shaft, the actuated member, and said wall of the enclose which define said other hydraulic fluid supply and discharge passageways, grooves formed in an outer surface of the actuated member to perform valve action cooperatively with said passageways and communicating with third passageways leading to the peripheral surface of the input shaft, grooves formed in said peripheral surface of the input shaft to perform valve action cooperatively with said third passageways and communicating with the first mentioned passageways formed in the input shaft.

* * * * *