July 21, 1964 H. M. GEYER 3,141,387

TWIN PISTON ROTARY ACTUATORS

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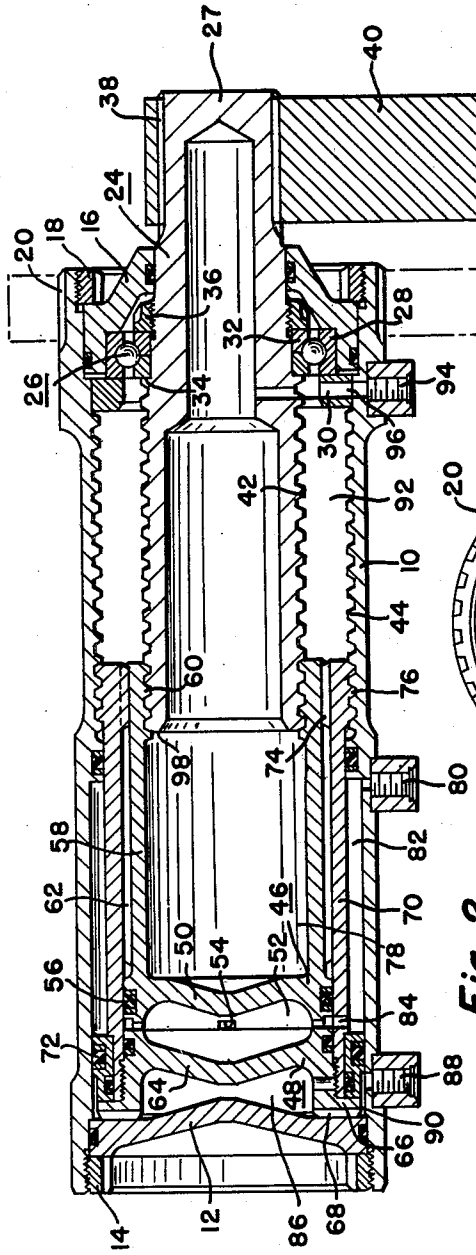



Fig. 2

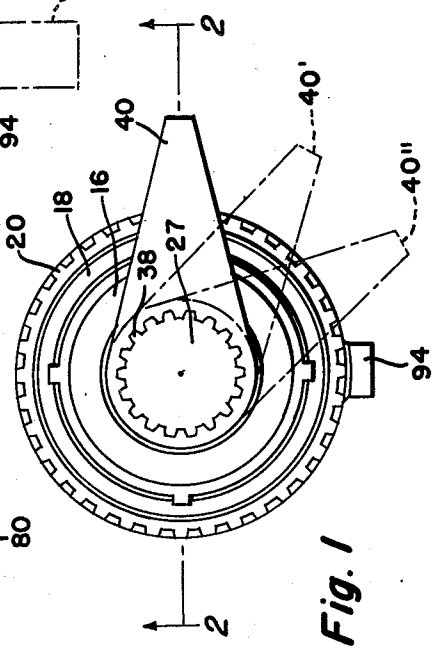



Fig. 1

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TWIN PISTON ROTARY ACTUATORS

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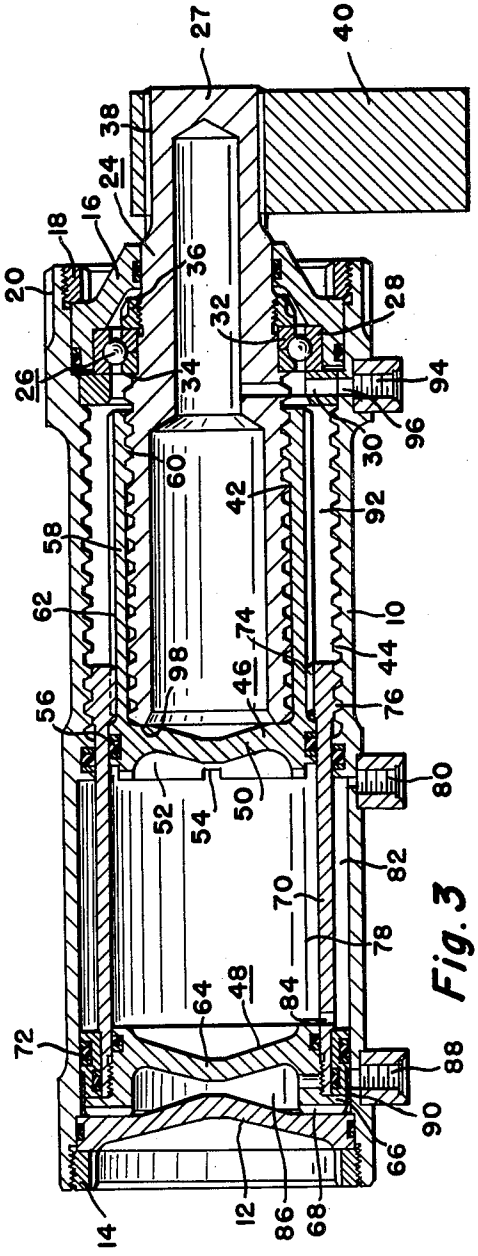


Fig. 3

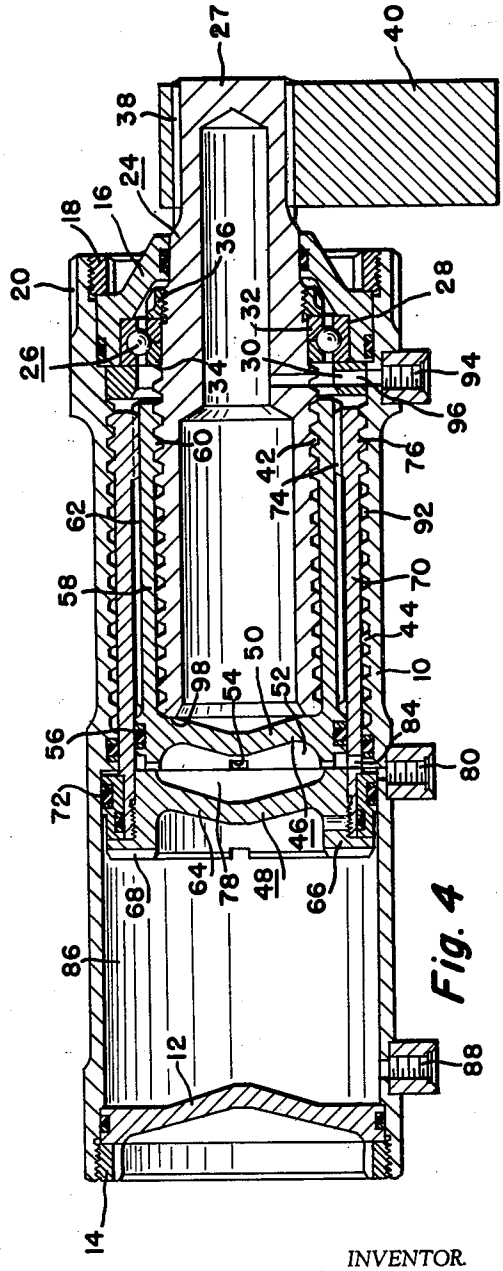


Fig. 4

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TWIN PISTON ROTARY ACTUATORS

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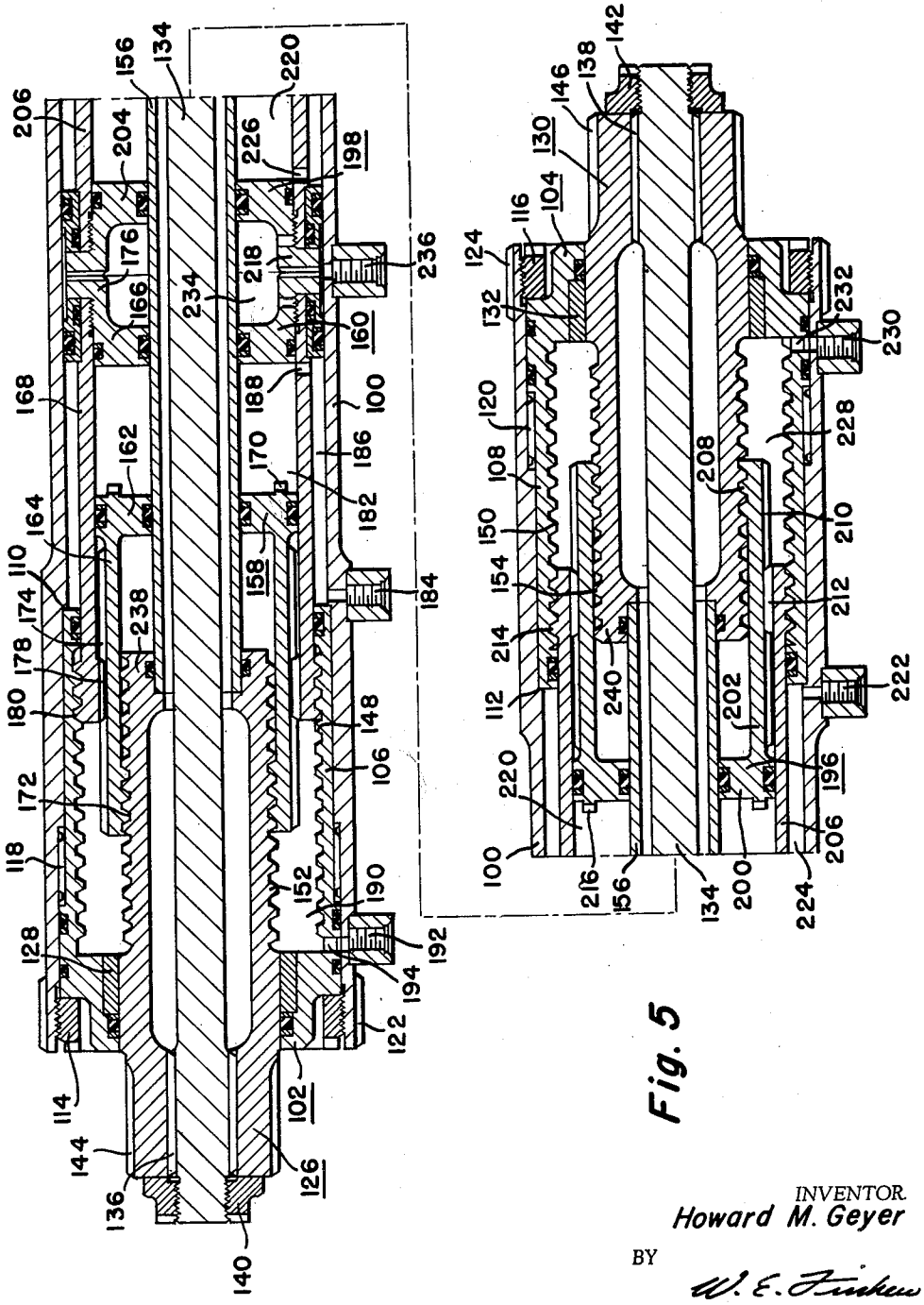



Fig. 5

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United States Patent Office 3,141,387 Patented July 21, 1964



3,141,387

# TWIN PISTON ROTARY ACTUATORS

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Filed May 8, 1962, Ser. No. 193,251
20 Claims. (Cl. 92—33)

This invention pertains to rotary actuators operated by fluid under pressure, and particularly to rotary actuators of the twin piston type having positive, mechanical intermediate stops.

It is highly desirable to embody positive, mechanical intermediate stops in actuators designed for operating the control flaps on an aircraft so that the flaps may be positively held in an intermediate position during certain aircraft maneuvers. Moreover, it is also desirable to have separate operating systems for extending the control flaps to an intermediate extended position and a fully extended position, while providing a single operating system for fully retracting the control flaps. The present invention relates to two forms of twin piston hydraulically operated actuators embodying the aforesaid features.

Accordingly, among my objects are the provision of a rotary actuator having a positive, mechanical intermediate stop; the further provision of a fluid pressure operated rotary actuator of the piston and cylinder type embodying twin pistons and separate fluid pressure systems for extending the actuator to an intermediate position and to a fully extended position; the further provision of a rotary actuator having a centrally mounted through shaft and opposed pairs of piston assemblies which are interconnected for simultaneous movement in opposite directions and embodying positive mechanical intermediate stops; and the still further provision of a through shaft rotary actuator of the helical spline type with opposed pairs of piston assemblies and wherein the cylinder and through shaft are placed in tension or compression in accordance with the direction of movement so as to eliminate the necessity for thrust bearings.

The aforementioned and other objects are accomplished in the present invention by utilizing twin tandem arranged pistons, or a split piston assembly, which coact with a pair of coaxial reaction and output members so that each piston can impart only a part of the total angular movement to the output member, and the inner piston of which is adapted to abut the output member to constitute a positive, intermediate mechanical stop. Specifically, two embodiments of the improved two piston rotary actuators are disclosed herein, both embodiments utilizing helical spline connections between the pistons and the output and reaction members to convert piston reciprocation to angular movement of the output member.

In one embodiment the actuator comprises a cylinder having an elongate, centrally mounted output member constituting a stop for limiting movement of the inner piston in the extend direction. The twin pistons are coaxially arranged and are interconnected by a set of splines. A primary extend chamber is defined between the inner and outer pistons for extending the actuator to an intermediate position. A secondary extend chamber is defined between the piston and the cylinder for fully extending the actuator. A common retract chamber is formed in the cylinder to fully retract both of the pistons.

In the second embodiment the output members are connected to a shaft which extends through the cylinder, and the cylinder encloses pairs of opposed twin piston assemblies. The inner piston of each pair coacts with its output member to form a positive intermediate mechanical stop. The inner and outer pistons of each pair are interconnected for simultaneous movement in opposite directions by reason of being operatively connected to the through shaft. By embodying opposed pairs of pistons, the cylinder and through shaft are placed in tension during extension of the actuator, and in compression during retraction of the actuator thereby eliminating the need for thrust bearings.



Further objects and advantages of the present invention will be apparent from the following description, reference being had to the accompanying drawings, wherein preferred embodiments of the present invention are clearly shown.

In the drawings:

FIGURE 1 is an end view of an actuator constructed according to the present invention.

FIGURE 2 is a longitudinal sectional view taken along line 2—2 of FIGURE 1 of an actuator constructed according to one embodiment of the present invention, shown in the fully retracted position.

FIGURE 3 is a view similar to FIGURE 2 depicting the actuator in the intermediate extend position.

FIGURE 4 is a view of the actuator of FIGURE 1 shown in the fully extended position.

FIGURE 5 is a longitudinal, sectional view of an actuator constructed according to the second embodiment of the present invention shown in the partially extended position.

With reference to FIGURES 1 and 2, in one embodiment the improved actuator assembly comprises a cylinder sleeve **10**, one end of which is closed by a cylinder head **12** held in assembled relation with the cylinder sleeve by a nut **14**. The other end of the cylinder sleeve **10** is closed by a centrally apertured cap **16** held in assembled relation with the cylinder sleeve by a nut **18**. This end of the cylinder is formed with a set of external straight splines **20** for attaching the actuator assembly to a fixed mounting support **22**, shown in phantom.

An elongate sleeve-type output member **24** having a closed outer end **26** is journalled in the end cap **16** by a combined radial and thrust ball bearing assembly **26**. The bearing assembly **26** includes an outer race **28** which is confined between the end cap **16** and an annulus **30** by the nut **18**, and a split inner race **32** held against a shoulder **34** of the output member **24** by a nut **36**.

The output member **24** is formed with a set of straight splines **38** adjacent its outer end for attachment to a movable load device, in this case a crank arm **40** adapted to be connected to the control flaps of an aircraft. In addition the output member **24** is formed with an elongate set of external helical spline teeth **42**. The cylinder sleeve **10** is formed with an elongate set of internal helical spline teeth **44**.

The cylinder assembly comprising the sleeve **10**, the cylinder head **12** and the end cap **16** encloses a pair of coaxial, tandem arranged piston assemblies **46** and **48** constituting a split piston assembly. The piston assembly **46** includes a head portion **50** having an upstanding rim **52** with a plurality of radial notches **54**, and carrying a suitable seal **56**. In addition, the piston assembly **46** includes an axially extending skirt **58** having a relatively short set of internal helical spline teeth **60** mating with the external helical spline teeth **52** on the output member **42**. The skirt **58** is also formed with an elongate set of external straight spline teeth **62**.

The piston assembly **48** includes a head **64** having an upstanding rim **66** with a plurality of radial passages **68**, and an axially extending skirt **70** which is threadedly connected and pinned to the head **64**, and carries sealing means **72**. The sealing means **72** engages the inner periphery of the cylinder sleeve **10** while the sealing means **56** of the piston assembly **46** engages the inner periphery of the skirt **70**. The skirt **70** has a set of short internal straight splines **74** which engage the elongate set of

straight splines 62 on the skirt 58, and a relatively short set of external helical spline teeth 76 which engage the internal helical spline teeth 44 on the cylinder sleeve 10. The cylinder assembly constitutes the reaction member since it is designed to be attached to a fixed support which restrains it against rotation.

A primary extend chamber 78 is defined between the two piston assemblies 46 and 48. This primary extend chamber 78 is connected to an extend port 80 through the annular space 82 between the skirt 70 and the cylinder sleeve 10, and one or more radial passages in the skirt 70. A secondary extend chamber 86 is formed between the piston head 64 and the cylinder head 12, the chamber 86 communicating with an extend port 88 through an annular chamber 90 formed between the rim of the piston head 64 and the cylinder sleeve 10. A common retract chamber 92 is formed between the ends of the skirts and the piston head 50, and the end cap 16, the chamber 92 communicating with a retract port 94 through a radial passage 96 in the ring 30.

The actuator is shown in the fully retracted position in FIGURE 2. As alluded to hereinbefore, the instant rotary actuator embodies a positive, intermediate mechanical stop which, in accordance with the helix angle of the several sets of helical splines may be located at the mid position of total angular movement of the output member, or at some other position. As illustrated, the intermediate stop is located at the mid position of angular movement of the output member 26 and its crank arm 40. This intermediate stop is constituted by engagement of the piston head 46 with the end 98 of the output member 24, as shown in FIGURE 3.

To effect actuator extension to the intermediate positive, mechanical stop, fluid under pressure is supplied to the primary extend port 80 through the annular space 82 and the port 84 to the extend chamber 78, while the retract chamber 92 is connected to drain. In this manner the piston assembly 46 will move from the fully retracted position of FIGURE 2 to its fully extended position of FIGURE 3 wherein the piston head 50 abuts the end 98 of the output member 24. During movement of the piston assembly 46 from its fully retracted position to its fully extended position, as shown in FIGURE 3, angular movement will be imparted to the output member 24 by virtue of the helical spline connection between the skirt 58 and the output member 24. The intermediate stop position of the output crank arm 40 is depicted by numeral 40' in FIGURE 1.

To fully extend the actuator and move the output crank 40 to the position 40'', hydraulic fluid under pressure is supplied to the port 88, and hence to the secondary extend chamber 86 so as to move the piston assembly 48 to the position shown in FIGURE 4. During movement of the piston assembly 48 relative to the piston assembly 46, both the piston assembly 48 and the piston assembly 46 rotate by virtue of the helical spline connection between the skirt 70 and the cylinder sleeve 10, and the straight spline connection between the skirt 70 and the skirt 58. Moreover, this rotary movement imparted to the piston assembly 48 will be imparted to the output member 24 and its output crank 40.

The actuator can be fully retracted by connecting both extend chambers 78 and 86 to drain while connecting the retract chamber 92 to pressure through port 94 and passage 96, thereby moving the piston assemblies 46 and 48 to the position shown in FIGURE 2 and returning the output crank arm to the full line position shown in FIGURE 1. The actuator can also be fully retracted from the intermediate, positive mechanical stop position of FIGURE 3 by pressurizing the retract chamber 92 while the primary extend chamber 78 is connected to drain. Moreover, the actuator can be fully extended from its fully retracted position of FIGURE 2 by simultaneously applying pressure to both extend chambers 78 and 86, or by pressurizing only the secondary extend chamber 86.

With reference to FIGURE 5, the second embodiment



of a rotary actuator having a positive, intermediate mechanical stop constitutes an improvement over the through shaft rotary actuator of my copending application Serial No. 179,590, filed March 14, 1962, in that the actuator assembly embodies opposed pairs of pistons thus eliminating the necessity for thrust bearings. The actuator assembly comprises a cylinder sleeve 100, opposite ends of which are closed by centrally apertured end caps 102 and 104. The end caps 102 and 104 may, as shown, have integral axially extending skirt portions 106 and 108, respectively, which seat against internal shoulders 110 and 112, respectively, of the cylinder sleeve 100. The end caps 102 and 104 are held in assembled relation with the cylinder sleeve 100 by nuts 114 and 116, respectively. The end caps 102 and 104 are restrained against rotation relative to the cylinder sleeve 100 by straight spline connections 118 and 120, respectively.

The cylinder sleeve is formed with sets of straight splines 122 and 124 at opposite ends for attaching the same to a fixed mounting support, not shown. A tubular, rotatable output member 126 is journalled in the end cap 102 by a sleeve bearing 128 and a second tubular, rotatable output member 130 is journalled in the end cap 104 by a sleeve bearing 132. A centrally mounted through shaft 134 has straight spline connections 136 and 138 adjacent opposite ends with the two output members 126 and 130 thus interconnecting the output members for synchronous rotation. The through shaft 134 is held in assembled relation with the output members 126 and 130 by a pair of nuts 140 and 142 which engage the threaded ends of the through shaft. The output members 126 and 130 are formed with an external set of straight splines 144 and 146, respectively, for connecting the same to a movable load device, not shown.

The skirts 106 and 108 are formed with elongate sets of internal helical spline teeth 148 and 150, respectively, and the output members 126 and 130 are formed with elongate sets of external helical spline teeth 152 and 154, respectively. Since the cylinder assembly, comprising the sleeve 100 and end caps 102 and 104, is adapted to be attached to a fixed support, the skirts 106 and 108 constitute reaction members which are restrained against rotation. In addition, the two output members 126 and 130 sealingly engage the ends of a tube 156, coaxial with the through shaft and radially spaced therefrom, the tube 156 constituting the inner peripheral wall of the cylinder assembly which receives the pistons.

The left hand end of the actuator assembly includes coaxial, tandem piston assemblies 158 and 160. The piston assembly 158 includes an annular head 162 having an integral axially extending skirt 164. The piston assembly 160 includes an annular head 166 and an axially extending skirt 168 threadedly connected and pinned thereto. The piston head 162 sealingly engages the inner periphery of the skirt 168 and the outer periphery of the tube 156, while the piston head 166 sealingly engages the inner periphery of the cylinder sleeve 100 and the outer periphery of the tube 156.

The piston head 162 has an axially extending, radially slotted rim 170, a relatively short set of internal helical spline teeth 172 on the skirt 164 mating with the helical spline teeth 152, and an elongate set of external straight spline teeth 174 on the skirt 164. The piston assembly 160 likewise has a radially slotted piston head rim 176, and a relatively short set of internal straight spline teeth 178 on its skirt 168 mating with the straight splines 174, and a relatively short set of external helical spline teeth 180 on its skirt mating with the helical splines 148.

A primary extend chamber 182 is formed between the piston heads 162 and 166, this chamber being connected to a primary extend port 184 through the annular space 186 between the cylinder sleeve 100 and the skirt 168, and one or more radial ports 188 through the skirt 168. A retract chamber 190 is formed between the end cap 102 and the ends of the skirts 164 and 168 and the piston head 162, the retract chamber 190 being connected at a

retract port **192** through a radial port **194** in the skirt **106**.

The right hand end of the actuator assembly is a substantial duplicate of the left hand end, and thus includes coaxial, tandem piston assemblies **196** and **198**. The piston assembly **196** includes an annular head **200** having an integral axially extending skirt **202**, and the piston assembly **198** includes an annular head **204** to which an axially extending skirt **206** is attached by a threaded and pinned connection. Similarly, the annular piston head **200** sealingly engages the skirt **206** and the tube **156**, while the piston head **204** sealingly engages the cylinder sleeve **100** and the tube **156**.

The skirt **202** has a short set of internal helical spline teeth **208** engaging the helical spline teeth **154** of the output member **130**, and a set of straight spline teeth **210** which engage a relatively short set of internal straight spline teeth **212** on the skirt **202**. The skirt **206** includes a relatively short set of external helical spline teeth **214** which engage the elongate set of internal helical spline teeth **150** on the reaction skirt **108**. The piston head **200** has an upstanding rim **216** with radial slots therein, and the piston head **204** has a radially slotted rim **218**.

A second primary extend chamber **220** is formed between the piston heads **200** and **204**, this chamber being connected to a primary extend port **222** through the space **224** between the cylinder sleeve **10** and the skirt **206**, and one or more radial ports **226** through the skirt **206**. Similarly, a retract chamber **228** is formed between the end cap **104** and the ends of the piston skirts and the piston head **200**, the retract chamber being connected to a retract port **230** through a radial port **232** in the skirt **108**. A secondary extend chamber **234** is formed between the piston heads **166** and **204**, the secondary extend chamber being connected to a secondary extend port **236**.

It will be appreciated that since the two output members **126** and **130** are interconnected for simultaneous rotation by the through shaft **134**, the left and right hand twin piston assemblies are likewise connected for simultaneous movement in opposite directions. The actuator is shown in the partially extended position in FIGURE 5, wherein the inner piston assemblies **158** and **196** are neither in engagement with their outer piston assemblies **160** and **198**, respectively, or with their positive, intermediate mechanical stop **238** and **240**, respectively, constituted by the ends of the output members **126** and **130**, respectively. Upon continued application of fluid under pressure to the primary extend chambers **182** and **220**, while the retract chambers **190** and **228** are connected to drain, the piston assemblies **158** and **196** will move simultaneously in opposite directions until they engage their respective stops **238** and **240**. During extending movement of the piston assemblies **158** and **196** in opposite directions, the output members **126** and **130** will be rotated to an intermediate stop position due to the helical spline connections between the skirts **164** and **202** with their respective output members. During extending movement of the piston assemblies **158** and **196** to the intermediate stop position, the through shaft **134** will be placed in tension through the output members **126** and **130** and the nuts **140** and **142**, respectively, thus supporting the thrust loads.

To fully extend the actuator, the secondary extend chamber **234** is pressurized to effect simultaneous movement of the piston assemblies **160** and **198** in opposite directions. Since the skirts **168** and **206** of the piston assemblies **160** and **198** have helical spline connections with the reaction skirts **106** and **108**, respectively, angular movement will be imparted to the skirts **168** and **202**, which angular movement will be transmitted through the straight spline connections between the skirts **168** and **206** with the skirts **164** and **202** to the output members **126** and **130**, respectively. During extending movement of the piston assemblies **160** and **198**, the cylinder sleeve **100** will be placed in tension through the end caps **102** and **104** to support the thrust loads.



During retraction of the actuator from its fully extended position, the output members **126** and **130** will be rotated in the opposite direction, retracting being effected by pressurizing the retract chambers **190** and **228** while the extend chambers are connected to drain. The piston assemblies **158**, **160** and **196**, **198** will move simultaneously in opposite directions towards each other thereby rotating the output members **126** and **130**. During retraction the through shaft **134** and the cylinder sleeve **100** are placed in compression to support the thrust loads.

In both embodiments of the actuator as disclosed herein, the control systems for moving the actuators to their intermediate, mechanical stop positions can be entirely separated from the control systems for moving the actuators to their fully extended positions. This arrangement constitutes an important feature of the present invention, particularly when the actuators are used to operate the control surfaces on aircraft since the control surfaces can be automatically moved to an intermediate extended position by actuating the primary extend control system thereby obviating the possibility of pilot error in positioning the control surfaces.

While the embodiments of the invention as herein disclosed constitutes preferred forms, it is to be understood that other forms might be adopted.

What is claimed is as follows:

1. A rotary actuator comprising, a cylinder, a rotary output member journalled in said cylinder, a pair of reciprocable pistons disposed in said cylinder having operative helical connections with said output member for imparting rotation thereto upon reciprocation of either piston, independent means operable to effect movement of each piston in one direction, common means for effecting movement of said pistons in the opposite direction, and a positive mechanical stop engageable with one of said pistons to limit reciprocable movement thereof in said one direction to determine an intermediate angular position of said output member.

2. A rotary actuator including, a cylinder, a rotary output member journalled in said cylinder, a pair of coaxial reciprocable pistons disposed in said cylinder having operative helical connection with said output member for imparting rotation thereto upon reciprocation of either piston, means interconnecting said piston so as to preclude relative rotation therebetween while permitting relative reciprocation therebetween, independent means operable to effect movement of each piston in one direction, common means for effecting movement of said pistons in the opposite direction, and a positive mechanical stop engageable with one of said pistons to limit reciprocable movement thereof in said one direction to determine an intermediate angular position of said output member.

3. A rotary actuator including, a cylinder assembly, a pair of tandem arranged, relatively movable reciprocable pistons disposed in said cylinder assembly, a rotary output member journalled in said cylinder assembly, means interconnecting said pistons so as to preclude relative rotation therebetween although permitting relative reciprocation therebetween, a helical connection between one of said pistons and said rotary output member, a helical connection between the other of said pistons and said cylinder assembly whereby reciprocation of either of said pistons will impart rotation to said rotary output member, and a positive mechanical stop limiting reciprocable movement of one of said pistons in one direction to determine an intermediate angular position of said output member.

4. A rotary actuator including, a cylinder assembly, a pair of tandem arranged, coaxial pistons disposed in said cylinder assembly, means interconnecting said pistons so as to preclude relative rotation therebetween while

permitting relative reciprocation therebetween, a rotary output member journalled in said cylinder assembly and coaxial with said pistons, and helical means interconnecting said one piston with said output member and the other piston with said cylinder assembly whereby reciprocation of either or both pistons will impart rotation to said output member, said rotary output member being engageable by one of said pistons to constitute a positive mechanical stop limiting reciprocation of one of said pistons in one direction and thus determine an intermediate angular position of said output member.

5. A rotary actuator including, a cylinder assembly, a pair of tandem arranged pistons disposed in said cylinder assembly, means interconnecting said pistons so as to preclude relative rotation therebetween while permitting relative reciprocation therebetween, a rotary output member journalled in said cylinder assembly, one of said pistons having a helical connection with said output member and the other of said pistons having a helical connection with said cylinder assembly, each piston having a stroke during which it imparts a portion of the total angular movement to said output member, and a positive mechanical stop in said cylinder engageable with one of said pistons limiting reciprocable movement of said one piston in one direction to determine an intermediate angular position of said output member.

6. A rotary actuator including, a cylinder assembly, a pair of tandem arranged, coaxial pistons disposed within said cylinder assembly, means interconnecting said piston so as to preclude relative rotation therebetween while permitting relative reciprocation therebetween, reaction means restrained against rotation relative to said cylinder, a rotary output member journalled in said cylinder, helical means interconnecting the inner piston with said output member, and helical means interconnecting the outer piston with said reaction member whereby reciprocation of the inner piston throughout its stroke relative to the outer piston will rotate said output member throughout a portion of its total angular movement and reciprocation of said outer piston relative to its inner piston will rotate the output member through the remaining portion of its total angular movement.

7. A rotary actuator including, a cylinder assembly, an output member rotatably journalled in said cylinder assembly, reaction means restrained against rotation relative to said cylinder assembly, and a reciprocable, split piston assembly disposed within said cylinder having helical connections with said reaction means and said output member whereby movement of one part of said split piston assembly imparts only a fraction of the total rotary movement to said output member, reciprocation of the other part of said split piston assembly imparting the other fraction of the total rotary movement to said output member, or simultaneous reciprocation of both parts of the split piston assembly imparts rotation to the output member throughout its total angular movement.

8. A fluid pressure operated rotary actuator including, a cylinder assembly, a pair of tandem arranged, coaxial pistons disposed in said cylinder and defining a primary extend chamber, a secondary extend chamber and a common retract chamber, means interconnecting said pistons so as to preclude relative rotation therebetween while permitting relative reciprocation therebetween, reaction means restrained against rotation relative to said cylinder assembly, an output member journalled in said cylinder assembly, a helical connection between the inner piston and said output member, and a helical connection between the outer piston and said reaction means whereby extending movement of said inner piston throughout its stroke will impart only a fraction of the total angular movement to the output member when the primary extend chamber is pressurized and thus constitutes a positive, mechanical intermediate stop for the output member, and extending movement of the outer piston throughout its stroke upon pressurization of the secondary extend chamber will rotate the output member through the other fraction of its total angular movement.

9. A helical spline assembly for rotating an output member through a fraction of its total angular movement or throughout its total angular movement and embodying a positive, mechanical intermediate stop including, a pair of reciprocable members interconnected so as to preclude relative rotation while permitting relative reciprocation therebetween, stationary reaction means having a helical connection with one of said members, a rotary output member journalled in said stationary reaction means, and a helical connection between the other reciprocable member and said output member whereby reciprocation of said other member relative to said one member throughout its stroke will impart a fraction of the total angular movment to said output member, and reciprocation of said one member relative to the other member will rotate the output member through the other fraction of its total angular movement.

10. A helical spline assembly for rotating an output member through a fraction of its total angular movement or throughout its total angular movement and embodying a positive, mechanical intermediate stop including, a pair of reciprocable members interconnected so as to preclude relative rotation therebetween while permitting relative reciprocation therebetween, a stationary reaction member having a set of internal helical spline teeth, one of said reciprocable members having external helical spline teeth mating with the internal helical spline teeth of said reaction member, the other of said reciprocable members having a set of internal helical spline teeth, and a rotary output member journalled in said stationary reaction member and having a set of external helical spline teeth mating with the internal helical spline teeth of the other reciprocable member whereby movement of said other reciprocable member throughout its stroke relative to said one reciprocable member will impart a fraction of the total angular movement to the output member, and reciprocation of the one reciprocable member relative to the other reciprocable member will rotate the output member through the other fraction of its total angular movement.

11. The helical spline assembly set forth in claim 10 wherein the interconnection between said reciprocable members comprises mating straight splines.

12. A three position rotary actuator including, a cylinder assembly, a pair of tandem arranged pistons disposed in said cylinder assembly, means interconnecting said pistons to preclude relative rotation therebetween while permitting relative reciprocation therebetween, reaction means restrained against rotation relative to said cylinder assembly, a rotary output member journalled in said cylinder assembly, a helical connection between one of said pistons and said reaction means, and a helical connection between the other of said pistons and said output member whereby when both pistons are fully retracted said output member is in one extreme angular position, when both pistons are fully extended the said output member is in a second extreme angular position, and when one piston is fully retracted and the other piston is fully extended said output member is in a third angular position intermediate the first and second angular positions.

13. A rotary actuator including, a cylinder assembly having a set of internal helical spline teeth, a rotatable output member journalled in said cylinder and extending thereinto and having a set of external helical spline teeth, a pair of tandem arranged, coaxial, reciprocable pistons disposed within said cylinder, and means interconnecting said pistons to preclude relative rotation therebetween while permitting relative reciprocation therebetween, the inner piston having a set of internal helical spline teeth mating with the external helical spline teeth on the output member, and the outer piston having a set of external helical spline teeth mating with the internal helical spline teeth on said cylinder, the inner piston being engageable

with said output member and constituting a positive, mechanical intermediate stop for said output member.

14. The actuator assembly set forth in claim 13 wherein each piston includes an axially extending skirt having said helical spline teeth thereon, and wherein the means precluding relative rotation between said pistons while permitting relative reciprocation therebetween comprise mating sets of straight spline teeth on said skirts.

15. The actuator assembly set forth in claim 13 wherein a primary extend chamber is defined between said two pistons, a secondary extend chamber is defined between the outer piston and the cylinder assembly, and a common retract chamber is defined between said pistons and said cylinder assembly whereby pressurization of the primary extend chamber will move the inner piston against its stop so as to move the output member to an intermediate position throughout a fraction of its total angular movement.

16. A fluid pressure operated actuator assembly including, a cylinder assembly, a pair of spaced reaction members restrained against rotation relative to said cylinder assembly, a pair of spaced output members journalled in said cylinder assembly, a through shaft interconnecting said output members for rotation in unison, and opposed pairs of tandem arranged piston assemblies, each pair of piston assemblies comprising a pair of pistons interconnected so as to preclude relative rotation therebetween while permitting relative reciprocation therebetween, one piston of each pair having a helical connection with its respective output member and the other piston of each pair having a helical connection with its respective reaction member whereby simultaneous movement of said one piston of each pair in opposite directions imparts a fraction of the total angular movement to said output members, and simultaneous movement of both pairs of pistons in opposite directions will rotate said output members throughout their total angular movement.

17. The actuator assembly set forth in claim 16 wherein each pair of pistons are coaxially arranged, wherein the thrust loads of the inner pistons are supported by placing the through shaft in tension or compression, and wherein the thrust loads of the outer pistons are supported by placing the cylinder assembly in tension or compression, dependent upon the direction of movement.

18. A fluid operated rotary actuator assembly including, a cylinder assembly, a pair of spaced reaction members restrained against rotation relative to said cylinder assembly and having sets of internal helical spline teeth, a pair of output members journalled in said cylinder and extending thereinto having sets of external helical spline teeth, a through shaft drivingly interconnecting said output members for rotation in unison, and opposed pairs of piston assemblies disposed within said cylinder, each pair of piston assemblies comprising coaxial, tandem arranged, pistons interconnected so as to preclude relative rotation while permitting relative reciprocation therebetween, the inner piston of each pair having a set of internal helical spline teeth mating with the external helical spline teeth of its respective output member, and the outer piston of each pair having a set of external helical spline teeth mating with the internal spline teeth of its respective reaction member, the inner piston of each pair being engageable with its respective reaction member to determine a positive, mechanical intermediate stop determining an intermediate angular position of said rotary output member.

19. The actuator assembly set forth in claim 18 wherein each piston has an axially extending skirt, and wherein the interconnection between each pair of pistons for precluding relative rotation therebetween while permitting relative reciprocation therebetween comprises mating straight splines on said piston skirts.

20. The actuator assembly set forth in claim 18 wherein a primary extend chamber is defined between the inner and outer pistons of each pair, a common secondary extend chamber is defined between the inner ends of the opposed outer pistons, and a pair of retract chambers are defined between said cylinder assembly and the outer ends of said piston assemblies.

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