July 25, 1961 J. B. OTTESTAD 2,993,475

ADJUSTABLE ACTUATOR

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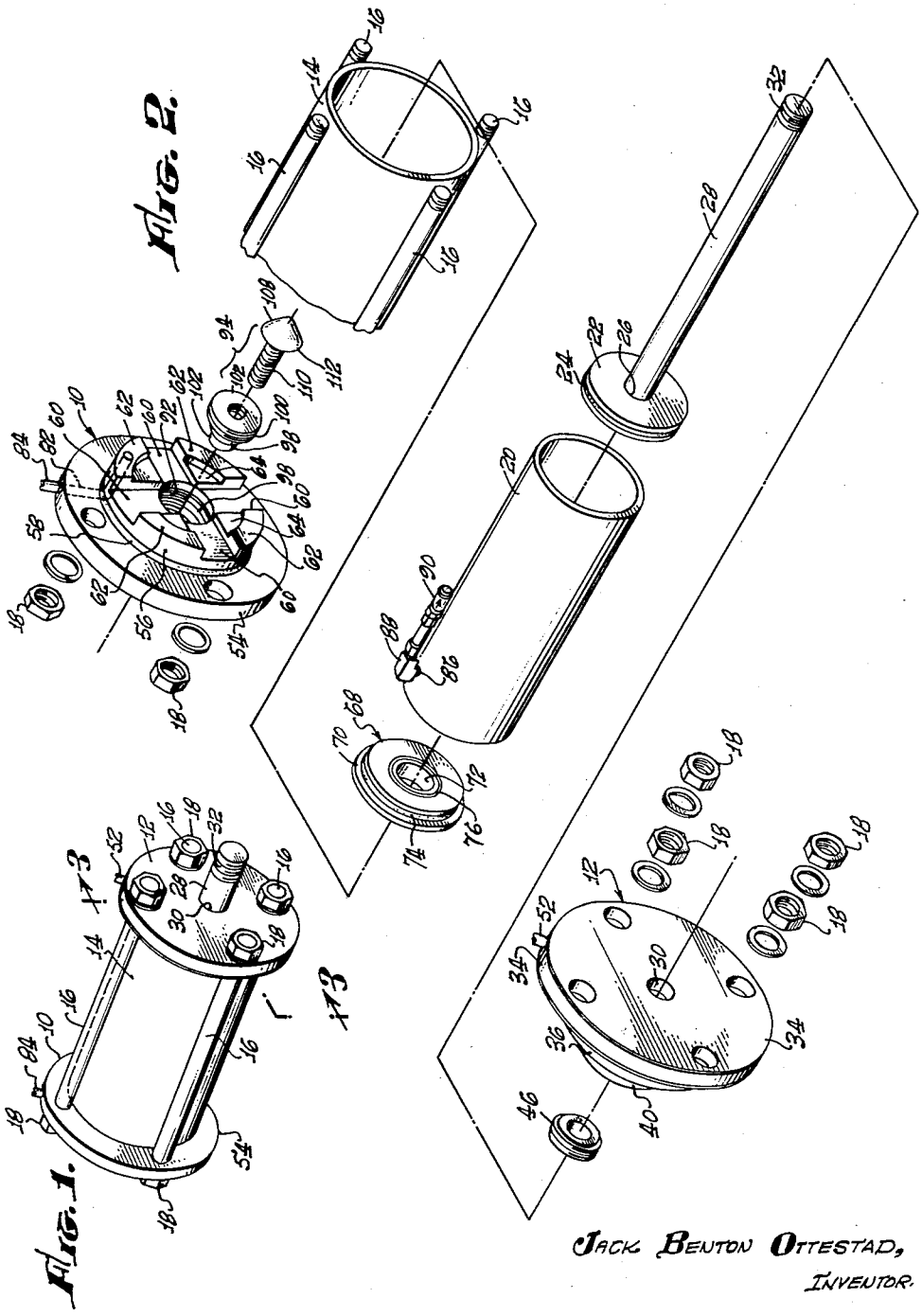


FIG. 1.

FIG. 2.

FIG. 3.

JACK BENTON OTTESTAD,
INVENTOR.

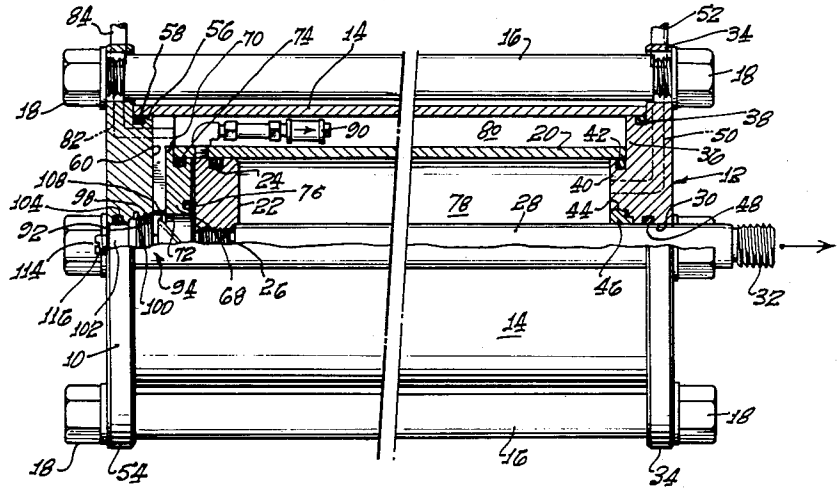
By Walter J. Jason
ATTORNEY.

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ADJUSTABLE ACTUATOR

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FIG. 3.



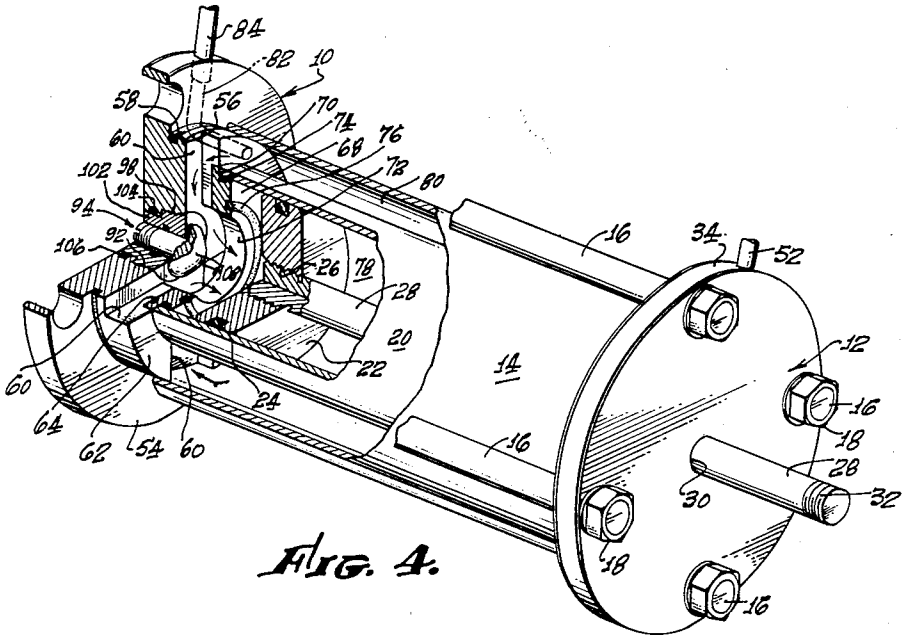


FIG. 4.

JACK BENTON OTTESTAD,
INVENTOR.

By Charles J. Jason
ATTORNEY.

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ADJUSTABLE ACTUATOR

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FIG. 5.

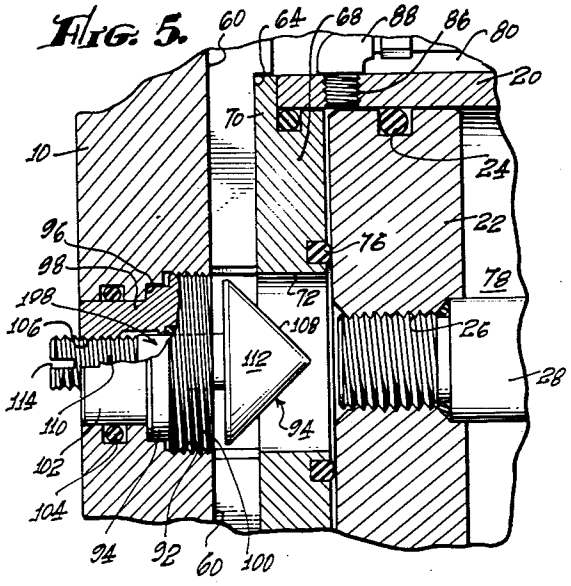


FIG. 6.

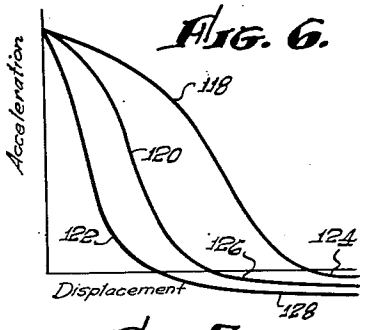


FIG. 7.

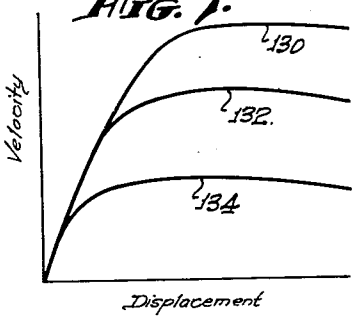
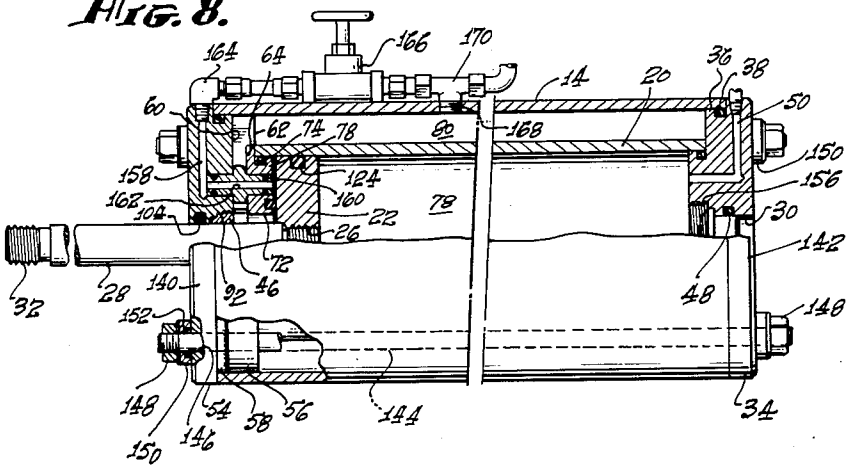


FIG. 8.



JACK BENTON OTTESTAD,
INVENTOR.

By Charles J. Jason
ATTORNEY.

United States Patent Office 2,993,475 Patented July 25, 1961

2,993,475

ADJUSTABLE ACTUATOR

Jack B. Ottestad, Claremont, Calif., assignor to General Dynamics Corporation, San Diego, Calif., a corporation of Delaware

Filed Jan. 20, 1958, Ser. No. 710,055
16 Claims. (Cl. 121—38)

This invention relates generally to actuators; more particularly, it relates to an actuator which is adjustable to provide selected output patterns.

The present invention represents improvements upon the actuators described and claimed in the copending application of Jack Benton Ottestad, Serial No. 617,014, filed October 19, 1956, now Patent No. 2,979,938 issued on April 18, 1961, and in the copending application of Jack Benton Ottestad and Samuel Arthur Skeen, Serial No. 683,855, filed September 13, 1957, now Patent No. 2,949,096 issued on August 16, 1960. In the actuators of those applications, a setting force urges a piston toward a wall or plate and causes a sealing element encircling an orifice in the plate to effect a positive pressure seal between the plate and the piston. An actuating pressure is established to act upon the portion of the piston within this pressure seal to balance the setting force. To activate the actuator, this pressure is increased to overbalance the setting force, thereby causing a slight movement of the piston and eliminating the pressure seal. The actuating pressure is thus suddenly released upon the area of the piston outside the sealing element to produce rapid acceleration of the piston. Certain embodiments of the inventions of the copending applications effect control of an output thrust-time pattern through the coaction of the orifice with a contoured metering member on the piston to regulate pressure release to the piston. A particular metering pin must be used to produce a certain output pattern. Disassembly and reassembly of the actuator are necessary in order to change metering pins to produce different output patterns with a given actuating pressure. The actuators of the copending applications are generally elongated in configuration, because pressure chambers extend from both sides of the orifice plate.

The improved actuator of the present invention provides means for externally adjusting the actuator to provide a selected output pattern. Dismantling and reassembly are therefore not required in order to alter the output waveform. An adjustment element mounted on the housing restricts the release of actuating pressure to the piston. Coaxial construction facilitates the positioning of this adjustment element and provides a compact actuator. Modular construction permits assembly for the production of either outward or inward actuating action.

It is accordingly an object of the present invention to provide an actuator which is externally adjustable for selection of an output pattern.

An object of this invention is the provision of an improved actuator which is capable of producing a selected output velocity over a predetermined displacement.

An object of the present invention is the provision of an actuator having a coaxial construction which facilitates the mounting of an adjustment element and which effects space economy.

It is an object of the present invention to provide an actuator capable of producing rapidly applied selected linear forces.

An object of the present invention is the provision of an actuator having a modular construction which permits assembly for either compressive output or tensile output.

Other objects and features of the present invention, as well as many advantages thereof, will become apparent to those skilled in the art from a consideration of the following description, the appended claims, and the accompanying drawings, in which:

FIGURE 1 is a perspective view showing a preferred embodiment of the actuator of the present invention;

FIGURE 2 is an exploded perspective view showing details of the elements of the embodiment shown in FIGURE 1;

FIGURE 3 is an elevational view, partially in section, of the actuator of FIGURE 1;

FIGURE 4 is a perspective view, partially in section, of the actuator shown in FIGURE 1;

FIGURE 5 is a fragmentary sectional view showing a portion of the actuator shown in FIGURE 3 on an enlarged scale;

FIGURE 6 is a graphical representation of the acceleration-displacement patterns produced by an actuator of the present invention under certain conditions of adjustment;

FIGURE 7 is a graphical representation of the velocity-displacement output patterns which correspond to the acceleration-displacement patterns shown in FIGURE 6; and

FIGURE 8 is an elevational view, partially in section, showing a modified form of the improved actuator of the present invention.

Referring to the drawings, and particularly to FIGURES 1, 2, 3, 4, and 5, there is shown a preferred embodiment of the present invention. This embodiment is an actuator capable of producing rapidly applied longitudinal forces with selected velocity patterns. The actuator includes a base member **10**, an end member **12**, and an outer cylinder **14**, these parts being secured together by tie-bolts **16** to form a housing. The tie-bolts extend through appropriate openings in flange portions of the base and end members and are secured by engagement of their threaded end portions with nuts **18**.

An inner cylinder **20** is disposed in coaxial relation with the outer cylinder **14**. A piston **22** is slidably positioned within cylinder **20**. Pressure sealing between the piston and the cylinder is provided by an annular resilient sealing element **24** disposed in a peripheral groove in the piston. A threaded axial opening **26** in the piston secures a threaded end portion of a thrust column **28**, which extends throught an opening **30** in end member **12**. Exterior of the housing, the column is provided with a threaded end portion **32** for engagement with a workpiece or other member (not shown) for utilization of the thrust produced by the actuator.

A flange portion **34** of end member **12** is provided with openings equally spaced about its circumference to accommodate tie bolts **16**, which are secured by nuts **18** and appropriate washers. The outer cylinder abuts the flange portion and fits closely about cylindrical section **36** of the end member. Pressure sealing between section **36** and the outer cylinder is provided by an annular seal **38** disposed in an appropriate groove in the section and adjacent to the flange portion.

The inner cylinder **20** fits closely about a reduced cylindrical section **40** and abuts the inner face of cylindrical section **36**, pressure sealing being provided by an annular seal **42** disposed in an appropriate groove in section **40**, as shown.

Opening **30** in end member **12** has an enlarged inner threaded portion **44** within which is secured a bearing **46**. A resilient annular sealing element **48** is disposed in an appropriate groove within this opening to provide pressure sealing between the end member and the thrust column. A passage **50** in the end member and an ex-

ternal fluid connection **52** interconnect the interior of the inner cylinder with a source of pressure (not shown).

Base member **10** has a flange portion **54**, which is similar to the flange portion of the end member and is provided with spaced openings to accommodate the tie-bolts **16**. A body portion **56** of the base member fits closely within outer cylinder **14**. Pressure sealing is provided between this cylinder and the base member by an annular seal **58** disposed in a peripheral groove of the body portion adjacent to the flange portion.

Four mutually perpendicular radial grooves **60** define four wedge-shaped sections **62** of the body portion. A circular recess of less depth than grooves **60** is machined in the body portion to produce a wedge-shaped recess **64** on each of the four sections **62**, as shown. An orifice plate or wall **68** is secured in the recesses by engagement of its flange portion **70** with the end of inner cylinder **20**, as shown, and is provided with an orifice **72** for a purpose explained hereinbelow. Pressure sealing between the plate and the cylinder is provided by an annular resilient seal **74** disposed in an appropriate groove in the orifice plate.

A circular resilient seal **76** is secured as by bonding in a circular groove of orifice plate **68**, and serves a purpose which is explained hereinbelow.

From the foregoing description, it will be understood that inner cylinder **20**, end member **12** and the orifice plate cooperate to define a first pressure chamber **78**, and that outer cylinder **14**, end member **12** and base member **10** cooperate to define a second pressure chamber **80**. It will be further understood that the orifice plate and the base member cooperate to provide passages by means of the radial grooves **60** between chamber **80** and the orifice **72**. A passage **82** in the base member and a fluid coupling **84** interconnect pressure chamber **80** with a source of pressure (not shown).

A threaded opening **86** in inner cylinder **20** adjacent to the orifice plate secures an elbow coupling **88**, which is joined through appropriate connections with a unidirectional valve **90**. The valve communicates directly with the interior of chamber **80**. It will be observed that means are thereby provided for unidirectional pressure release between chambers **78** and **80** under certain conditions. The purpose of this arrangement will become clear from further discussion herein.

A threaded axial opening **92** in the base member accommodates an adjustment assembly **94**. A shoulder **96** is provided for seating the assembly. Adjustment assembly **94** includes a retainer **98**, an enlarged threaded portion **100** of which secures the assembly in threaded opening **92**. Pressure sealing is provided between the base member and a reduced portion **102** of the retainer by a resilient seal **104** which is disposed in an annular groove within the opening, as shown. A threaded bore **106** in the retainer is adapted to accommodate an adjustment element or needle **108** by engaging a threaded shank portion **110** thereof. An annular seal insures pressure sealing between retainer **98** and the adjustment needle. The needle is coaxial with orifice **72** and has a conical head or plug portion **112** which is adapted for extension and retraction upon rotation of the needle in the retainer. A screw slot **114** is provided in the end of shank portion **110** and is accessible from outside the actuator, thereby providing means for selectively adjusting the position of head **112** of element **108** relative to the orifice plate.

In operation, the actuator described hereinabove is capable of producing rapidly applied high level linear forces at selected velocities. Very rapid activation is effected by the coaction of the orifice plate, circular resilient seal **76** and the piston. Although the manner of effecting this sudden action is more fully described in the copending application of Jack Benton Ottestad, Serial No. 617,014, hereinbefore mentioned, it is briefly described herein for convenience in relating it to the discussion of the present invention.

A setting pressure is first introduced into chamber **78** through passage **50** and fluid coupling **52** from a source of pressure (not shown in the drawings). The setting pressure acts upon the thrust column side of the piston and urges it against the orifice plate **68**. This effects compression of circular resilient seal **76** against the orifice plate to effect a positive pressure seal which isolates chamber **78** from chamber **80**. A relatively high actuating pressure is introduced into chamber **80** through fluid coupling **84** and passage **82** in base member **10**. This pressure acts upon the area of the piston within seal **76** and is predetermined to balance the force of the setting pressure acting upon the larger area on the opposite side of the piston. Piston **22** is thus held in a state of equilibrium. The pressure in chamber **80** is next increased by a pressure differential sufficient to unbalance the forces upon the piston and cause movement of the piston from the orifice plate to disengage seal **76**. The high actuating pressure is thereby released substantially instantaneously to act upon the area of the piston outside circular seal **76**. A great net force is thus suddenly applied to the piston to impel it from the orifice plate with high acceleration. It will be understood that the circular seal is an essential element in making possible this extremely rapid output of high force. The seal is adapted for sudden disengagement from the orifice plate for the purpose of releasing the actuating pressure substantially instantaneously.

After seal **76** has been disengaged and the piston is in motion, the pressurized fluid must be released through the passages between the base member and the orifice and through the orifice, in order to exert accelerating force on the piston.

With a given actuating pressure established in chamber **80**, a particular acceleration-displacement energy envelope is available. Such an envelope is indicated by curve **118** of FIGURE 6. A corresponding velocity-displacement envelope is produced, as indicated by curve **130** of FIGURE 7. The configurations of these envelopes are governed by the values of the initial actuating and setting pressures, the variations in pressures on the piston caused by volumetric changes during piston movement, and by design factors such as relative areas and dimensions of parts. A principal factor governing the configuration of these envelopes is the degree of restriction of the release of pressure between chamber **80** and the piston during piston movement. The degree of restriction is a matter of the design of a particular actuator.

An important feature of the present invention is the provision of means for selective adjustment of the degree of this restriction, within the inherent designed restriction, to produce selected relatively constant velocities over desired displacements and to control total stroke time. This adjustment permits selection of the degree to which flow is choked to regulate the effective force upon the piston as a function of piston displacement. The velocity-displacement output pattern for a given actuating pressure is controlled by controlling the effective duration of acceleration, as represented by the area under a particular acceleration-displacement curve in FIGURE 6.

Immediately upon disengagement of resilient seal **76** from the piston, the actuating pressure established in chamber **80** and in the passages defined between the orifice plate and base member **10** acts upon the cross-sectional area of piston **22**. Therefore, during the first increment of piston movement, the actuating pressure exerts its full accelerating force, as is shown by the left portion of curve **118** in FIGURE 6. A rapid velocity increase results, as shown by the left portion of curve **130** in FIGURE 7. As the piston moves from the orifice plate, the pressurized fluid must move through the passages and through orifice **72** to maintain the pressure against the moving piston. The velocity of the fluid through the

orifice obviously varies in accordance with the velocity of the piston. The pressure drop across the orifice increases with increasing velocity of the fluid therethrough, resulting in correspondingly decreasing accelerating force on the piston. Therefore, the acceleration decreases with increasing displacement, as shown by curve **118** in FIGURE 6.

The orifice pressure drop increases with increasing piston velocity until this drop is such that the pressure on the orifice side of the piston is decreased to a point where it is substantially balanced by the increasing pressure on the opposite side of the piston. Equilibrium of the forces on the piston results in no net accelerating force and a relatively constant velocity is produced. The drop in acceleration from a maximum to a substantially zero value to initiate this desired relatively constant output velocity is illustrated in FIGURE 6 by portion **124** of curve **118**. A corresponding relatively constant velocity, following the rapid velocity increase, is shown by curve **130** in FIGURE 7. As shown by curve **118**, zero acceleration is followed by a relatively low deceleration rate which permits the velocity to remain substantially constant at the desired level.

The total displacement or distance over which the velocity is maintained relatively constant is governed by the pressure buildup ahead of the piston. This is produced by the variations in pressure on the two sides of the piston during piston movement and by design factors which are not essential features of this invention. In the actuator hereinabove described, rapid deceleration occurs after the relatively constant velocity phase because of rapid compression at the end of the cylinder.

As indicated above, the adjustment needle is an important feature of the present invention. It permits selection of a relatively constant output velocity, or the selection of a stroke-time duration, by the selective throttling of a given actuating pressure to provide control of the dynamic net force on the piston as a function of piston displacement. This is accomplished by adjustment of the net flow area between plug portion **112** of the adjustment needle and the orifice plate **68** to govern the pressure drop across orifice **72** as a function of piston displacement. Adjustment needle **108** is axially adjustable so that head **112** may be selectively positioned relative to orifice plate **68** to provide a selected flow area between the head and the orifice plate. As shown in FIGURES 3, 4, and 5, the net flow area is progressively decreased by progressive extension of plug **112** toward the orifice. Reduction in net flow area results in increased velocity through the orifice at any given point of piston displacement. The increased velocity results in increased pressure drop across the orifice and in greater throttling or limiting effect on the acceleration-displacement envelope.

In FIGURE 6 are shown acceleration-displacement curves for different positions of adjustment needle **108** utilizing the same actuating pressure; in FIGURE 7 are shown corresponding output velocity-displacement curves. Curves **118** and **130** represent the acceleration and velocity patterns on the piston which are produced with the adjustment plug fully withdrawn from the orifice. They therefore represent the envelopes within which desired output patterns may be produced by selective adjustment of needle **108**. Curves **120** and **132** represent the patterns which are produced with plug **112** in an intermediate position. Curves **122** and **134** represent the patterns resulting from the positioning of plug **112** in relatively close proximity to the orifice plate.

From the foregoing description, it will be appreciated that the adjustment means of this invention may be utilized for the adjustment of the time-duration of an output stroke. Selection of an acceleration and velocity pattern will predetermine the stroke time. It has been found in practice that by means of the adjustment needle **108**, the stroke time can be selectively varied between a few milliseconds and approximately 100 milliseconds.

It will be understood that the present invention is capable of providing an output wherein a selected velocity is maintained over a selected displacement. It will also be understood that the present invention provides means for predetermining the time-duration of an output stroke. Further, it will be appreciated that this invention permits the predetermination of a force-displacement output pattern.

An important feature of the present invention is the provision of a coaxial construction, as hereinbefore shown and described, which facilitates the positioning of adjustment needle **108** in an operative position relative to the orifice. Coaxial construction effects a substantial saving in space, which is important in many applications.

In order to prepare the actuator for repeat operation, the piston **22** must be re-seated against the orifice plate to re-establish pressure sealing between the piston and the plate by means of resilient seal **76**. On re-seating the piston by reducing the pressure in chamber **80** to a value slightly below that in chamber **78**, a pressure approximating this reduced pressure is trapped by circular seal **76** and by seal **24** between the piston and the orifice plate. If the trapped pressure were not relieved, it would tend to oppose the force exerted by the setting pressure on the opposite side of the piston.

Opening **86** in the inner cylinder, elbow coupling **88** and unidirectional check valve **90** provide means for automatically relieving this trapped pressure into chamber **80**. The valve is caused to open by a predetermined trapped pressure. The pressure is relieved into this chamber, because if it were released to the exterior atmosphere the actuating pressure which passes through the orifice to actuate the piston would obviously be released to the atmosphere.

In FIGURE 8 is shown a modified form of actuator according to the present invention, in which certain structural modifications are embodied. No flange portions are provided on base member **140** and end member **142**. Tie-bolts **144** are disposed within the chamber **80** and extend through openings in the body portion of the base member and cylindrical section **36** of the end member. The actuator housing assembly is secured by engagement of nuts **148** with threaded end portions of the tie-bolts. Seal washers **150** provide pressure sealing by means of annular seals **152** disposed in appropriate recesses in the washers, as shown.

The embodiment of FIGURE 8 provides more compactness and better appearance than the embodiment previously discussed, because of the internal disposition of the tie bolts.

FIGURE 8 illustrates the reversibility of the actuator to provide a pulling or tension force instead of a pushing or compression force. This reversibility is a feature of the embodiment of FIGURES 3 and 4, as well as of the modified form shown in FIGURE 8. To adapt the actuator for such reverse operation, the base member is first removed and the adjustment assembly **94** is disassembled from the base member. The bearing **46** is removed from the end member and is mounted in the opening from which the adjustment assembly has been removed. A sealing plug **156** is next mounted by threadedly engaging it with the opening **30** in the end member. The thrust column **28** is disengaged from piston **22** and its threaded end portion **32** is engaged with the piston from the opposite side, as shown in FIGURE 8, and is extended through the base member. The actuator is then reassembled with the tie-bolts.

With the actuator assembled for reverse operation, as shown in FIGURE 8, it will be observed that the adjustment assembly **94** is not available for external adjustment. The output waveform produced by the actuator is governed by the size of the thrust column which extends through orifice **72**. Therefore, the diameter of the thrust column is selected to predetermine the output waveform.

The actuator of FIGURE 8 utilizes a modified apparatus for relieving pressure which may be trapped between the piston and the orifice plate upon re-seating of the piston. A passage **158** in the base member and an opening **160** in the orifice plate accommodate a tubular member **162**, thereby providing communication between the piston and a fluid coupling **164**, which is connected with a manually-operated valve **166**. Upon re-seating of the piston, valve **166** is operated to release the pressure trapped between the piston and the orifice plate into chamber **80** through T-connection **170**. It will be understood that the elements utilized with the embodiment previously discussed for relieving pressure trapped between the piston and the orifice plate may be utilized with the embodiment of FIGURE 8, instead of the external elements shown, for further enhancing the compactness and appearance of the actuator.

Although specific embodiments of the present invention have been described and illustrated in detail, it is to be clearly understood that the same are by way of illustration and example only; it is to be understood that the invention is not limited thereto, as many variations will be readily apparent to those versed in the art and the invention is to be given its broadest possible interpretation within the terms of the appended claims.

I claim:

1. An actuator comprising housing means, a wall defining an orifice between first and second pressure chambers within said housing means, a piston positioned in said first chamber and having a surface adapted to closely confront the wall, sealing means positioned between the piston and the wall for effecting positive pressure sealing therebetween about said orifice, means for exerting a predetermined setting force urging the piston into close proximity with said wall to cover the orifice and effect said pressure sealing, means for establishing in said second chamber an actuating pressure correlated with the setting force to act upon a portion of said piston within the sealing means substantially to balance and to overbalance said force to disengage said sealing means and suddenly expose an increased area of the piston to the actuating pressure, and means cooperating with said orifice to define a constant restriction to release of said pressure upon said piston.

2. An actuator comprising housing means defining inner and outer chambers, a wall defining an orifice between said chambers, a piston positioned in said first chamber and adapted to closely confront the wall, sealing means positioned between the piston and the wall for effecting pressure sealing therebetween about the orifice, means for exerting a setting force urging the piston into close proximity with the wall to cover the orifice and effect said pressure sealing, means for establishing in said second chamber an actuating pressure correlated with the setting force to act upon a portion of the piston within the sealing means first substantially to balance and then to overbalance said setting force and suddenly expose an increased area of the piston to the actuating pressure, and an adjustment element mounted on said housing means for selective positioning relative to said wall to predetermine a net flow area therebetween, thereby providing predetermined restriction to the release of said actuating pressure to said piston upon said overbalancing of said force by said actuating pressure to disengage said sealing means, whereby an actuator output pattern is predetermined.

3. An actuator comprising housing means including an outer cylinder closed by end members, an inner cylinder coaxial with the outer cylinder and cooperating therewith to define a pressure chamber, a wall defining an orifice at an end of the inner cylinder, means defining at least one passage communicating between said pressure chamber and the orifice, a piston positioned within said inner cylinder and confronting said wall, a resilient pressure seal for effecting pressure sealing between the piston and said wall about said orifice, means establishing a setting pressure within the inner cylinder to exert a force urging the piston toward the wall to cover said orifice and effect said pressure sealing, and means for establishing an actuating pressure in said pressure chamber to act upon a portion of the piston covering the orifice to overbalance said force and expose an increased area of the piston to the actuating pressure, whereby an output thrust pattern is produced on the piston.

4. An actuator comprising housing means including an outer cylinder closed by end members, an inner cylinder coaxial with the outer cylinder and cooperating therewith to define a pressure chamber, a wall defining an orifice at an end of the inner cylinder, means defining at least one passage communicating between said pressure chamber and the orifice, a piston positioned within said inner cylinder and confronting said wall, a resilient pressure seal for effecting pressure sealing between the piston and said wall about said orifice, means establishing a setting pressure within the inner cylinder to exert a force urging the piston toward the wall to cover the orifice and effect said pressure sealing, means for establishing an actuating pressure in the pressure chamber to act upon a portion of the piston covering said orifice to overbalance said force and expose an increased area of the piston to the actuating pressure, and means defining a predetermined restriction to release of said pressure upon the piston through said orifice for predetermining the output pattern of the actuator.

5. An actuator comprising housing means including an outer cylinder closed by end members, an inner cylinder coaxial with the outer cylinder and cooperating therewith to define a pressure chamber, a wall defining an orifice at an end of the inner cylinder, means defining at least one passage communicating between said pressure chamber and the orifice, a piston positioned with said inner cylinder and confronting said wall, a resilient pressure seal for effecting pressure sealing between the piston and said wall about said orifice, means establishing a setting pressure within the inner cylinder to exert a force urging the piston toward the wall to cover the orifice and effect said pressure sealing, means for establishing an actuating pressure in the pressure chamber to act upon a portion of the piston covering said orifice to overbalance said force and expose an increased area of the piston to the actuating pressure, and an adjustment element for governing release of the actuating pressure against the piston upon disengagement of said sealing means by the actuating pressure, said adjustment element being threadedly mounted on said housing for selective positioning relative to the wall to predetermine restriction to flow between the wall and the adjustment element to the piston, whereby a predetermined output velocity pattern is produced on the piston.

6. An actuator comprising housing means including an outer cylinder closed by end members, an inner cyclinder coaxial with the outer cylinder and cooperating therewith to define a pressure chamber, a wall defining an orifice at an end of the inner cylinder, means defining at least one passage communicating between said pressure chamber and said orifice, a piston positioned within said inner cylinder and confronting said wall, a resilient pressure seal for effecting pressure sealing between said piston and said wall about said orifice, means establishing a setting pressure within said inner cylinder to exert a force urging said piston toward said wall to cover said orifice and effect said pressure sealing, and an output thrust column attached to the piston and extending through the orifice, said thrust column providing predetermined restriction to release of the actuating pressure to the piston, whereby a predetermined output pattern is produced on the piston.

7. An actuator comprising coaxial outer and inner cylinders, each of the cylinders being closed at a first end thereof by a common end member to define a pressure chamber between the cylinders, a plate defining an axial

orifice at a second end of the inner cylinder, a base member closing a second end of said outer cylinder, said base member cooperating with the orifice plate to define at least one passage communicating between said pressure chamber and the orifice, a piston positioned within the inner cylinder and confronting said orifice plate, means establishing a setting pressure in the inner cylinder to exert a force urging the piston toward the orifice, a resilient pressure seal surrounding said orifice and disposed between the piston and the orifice plate for effecting a pressure seal therebetween, means for establishing an actuating pressure in said pressure chamber to act upon a portion of the piston within said seal to overbalance said force and expose an increased area of the piston to the actuating pressure, an adjustment needle for restricting the release of the actuating pressure against the piston upon overbalancing of said force by the actuating pressure to disengage said sealing means, said adjustment needle having a plug portion adapted for extension toward said orifice plate to define a net flow area therebetween, and a shank portion on the adjustment needle, said shank portion threadedly engaging said base member, whereby the output velocity pattern of the actuator may be predetermined.

8. An actuator comprising coaxial outer and inner cylinders, each of the cylinders being closed at a first end thereof by a common end member to define a pressure chamber between the cylinders, a plate defining an axial orifice at a second end of the inner cylinder, a base member closing a second end of said outer cylinder, said base member cooperating with the orifice plate to define at least one passage communicating between said pressure chamber and the orifice, a piston positioned within the inner cylinder and confronting said orifice plate, means establishing a setting pressure in the inner cylinder to exert a force urging the piston toward the orifice, a resilient pressure seal surrounding said orifice and disposed between the piston and the orifice plate for effecting a pressure seal therebetween, means for establishing an actuating pressure in said pressure chamber to act upon a portion of the piston within said seal to overbalance said force and expose an increased area of the piston to the actuating pressure, and adjustment means on said base member for selective predetermination of a restriction to release of said pressure to the piston, whereby a predetermined output thrust pattern is produced on the piston.

9. An actuator comprising coaxial outer and inner cylinders, each of the cylinders being closed at a first end thereof by a common end member to define a pressure chamber between the cylinders, a plate defining an axial orifice at a second end of the inner cylinder, a base member closing a second end of said outer cylinder, said base member cooperating with the orifice plate to define at least one passage communicating between said pressure chamber and the orifice, a piston positioned within the inner cylinder and confronting said orifice plate, means establishing a setting pressure in the inner cylinder to exert a force urging the piston toward the orifice, a resilient pressure seal surrounding said orifice and disposed between the piston and the orifice plate for effecting a pressure seal therebetween, and means for establishing an actuating pressure in said pressure chamber to act upon a portion of the piston within said seal to overbalance said force and expose an increased area of the piston to the actuating pressure, whereby output thrust is produced on the piston.

10. An actuator comprising coaxial outer and inner cylinders, each of the cylinders being closed at a first end thereof by a common end member to define a pressure chamber between the cylinders, a plate defining an axial orifice at a second end of the inner cylinder, a base member closing a second end of said outer cylinder, said base member cooperating with the orifice plate to define at least one passage communicating between said pressure chamber and the orifice, a piston positioned within the inner cylinder and confronting said orifice plate, means establishing a setting pressure in the inner cylinder to exert a force urging the piston toward the orifice, a resilient pressure seal surrounding said orifice and disposed between the piston and the orifice plate for effecting a pressure seal therebetween, means for establishing an actuating pressure in said pressure chamber to act upon a portion of the piston within said seal to overbalance said force and expose an increased area of the piston to the actuating pressure, and an adjustment element for governing release of the actuating pressure against the piston upon disengagement of said pressure seal by the actuating pressure, said adjustment element being threadedly mounted on said base member for selective positioning relative to said wall to predetermine restriction to flow therebetween to the piston, whereby a predetermined output pattern is produced on the piston.

11. An actuator comprising coaxial outer and inner cylinders, each of the cylinders being closed at a first end thereof by a common end member to define a pressure chamber between the cylinders, a plate defining an axial orifice at a second end of the inner cylinder, a base member closing a second end of said outer cylinder, said base member cooperating with the orifice plate to define at least one passage communicating between said pressure chamber and the orifice, a piston positioned within the inner cylinder and confronting said orifice plate, means establishing a setting pressure in the inner cylinder to exert a force urging the piston toward the orifice, a resilient pressure seal surrounding said orifice and disposed between the piston and the orifice plate for effecting a pressure seal therebetween, means for establishing an actuating pressure in said pressure chamber to act upon a portion of the piston within said seal to overbalance said force and expose an increased area of the piston to the actuating pressure, and an output thrust column attached to the piston and extending through the orifice and through an opening in the base member, said thrust column providing predetermined restriction to release of the actuating pressure to the piston, whereby a predetermined output pattern is provided on the piston.

12. In an actuator having a piston movable within a housing by an actuating pressure to produce an output thrust pattern and having a wall defining an orifice adapted to be sealed by a predetermined setting force urging the piston into close proximity with the wall to engage pressure sealing means positioned between the orifice wall and an end surface of the piston to provide a positive pressure seal between the wall and an end surface of the piston, an adjustment element mounted on said housing for selective positioning relative to said wall to predetermine a net flow area therebetween, thereby providing predetermined restriction to the release of said actuating pressure suddenly upon an increased area of said piston end surface upon the overbalancing of said force by increasing said actuating pressure to suddenly disengage said sealing means, whereby said output pattern is predetermined.

13. In an actuator having a piston movable within a housing by an actuating pressure to rapidly produce an output pattern and having a wall defining an orifice adapted to be positively sealed by a predetermined setting force urging a piston surface into close proximity with the wall to engage pressure sealing means positioned between the orifice wall and an end surface of the piston, an adjustment needle threadedly engaging said housing, a head portion on the adjustment needle, said head portion being adapted for extension toward said wall to define a net flow area therebetween, and tool-engaging means on the adjustment needle exterior of the actuator for selectively positioning the head portion to predetermine said net flow area, thereby providing predetermined restriction to the release of said actuating pressure to said piston upon the balancing and the overbalancing of said setting force by said actuating pressure to suddenly disengage

said sealing means, whereby an output velocity pattern of the actuator may be predetermined.

14. In an actuator having a piston movable within a housing by an actuating pressure to rapidly produce an output thrust pattern, and having a wall defining an orifice adapted to be positively sealed by a predetermined setting force urging a surface of the piston into close proximity with the wall to engage pressure sealing means interposed between said wall and the end surface of the piston, an adjustment needle for restricting the release of the actuating pressure upon an increased area of the piston upon first the substantial balancing and then the overbalancing of said force by said actuating pressure to suddenly disengage said sealing means, said adjustment needle having a plug portion adapted for extension toward the wall to define a net flow area therebetween, a shank portion on the adjustment needle, said shank portion threadedly engaging said housing, and tool-engaging means on the shank portion exterior of said actuator for selective rotation of the adjustment needle to predetermine said net flow area, whereby an output velocity pattern of the actuator is predetermined.

15. In an actuator having a housing with a wall therein defining an orifice and having a piston movable within the housing by an actuating pressure, a thrust-generating apparatus comprising sealing means positioned between an end of the piston and the wall for effecting a pressure seal therebetween about said orifice, setting pressure means for exerting a predetermined setting force urging the piston into proximity with the wall to cover the orifice, means for establishing said actuating pressure to act upon a portion of the piston covering said orifice first to balance and then to overbalance said force to suddenly expose an increased area of the piston to the pressure, and adjustment means on said housing for selective predetermination of a restriction to release of said pressure to an increased area of said piston, whereby a predetermined output thrust pattern is produced on the piston.

16. In an actuator having a housing with a wall therein defining an orifice and having a piston movable within the housing by an actuating pressure, a thrust-generating apparatus comprising sealing means positioned between an end of the piston and the wall for effecting a pressure seal directly therebetween about said orifice, means for exerting a predetermined force urging the piston into proximity with the wall to cover the orifice, means for establishing said actuating pressure to act upon a portion of the piston covering said orifice to first substantially balance and then to overbalance said force to suddenly expose an increased area of the piston to the pressure, an adjustment needle threadedly mounted on said housing, and means for selectively positioning a head portion of the adjustment needle relative to said wall to predetermine a net flow area therebetween, whereby release of the actuating pressure against the piston is restricted to produce a predetermined output velocity pattern on the piston.

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