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ACTUATOR WITH SET FORCE PLUNGER

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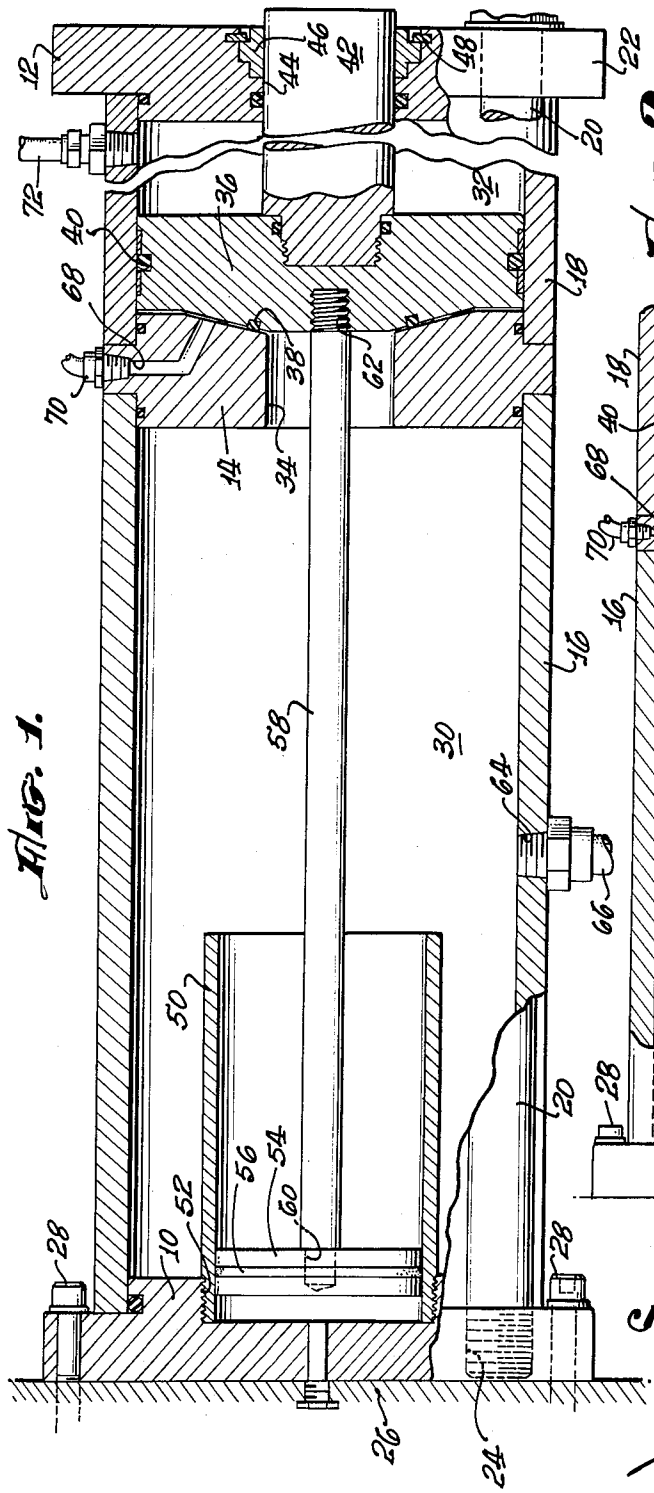


Fig. 1.

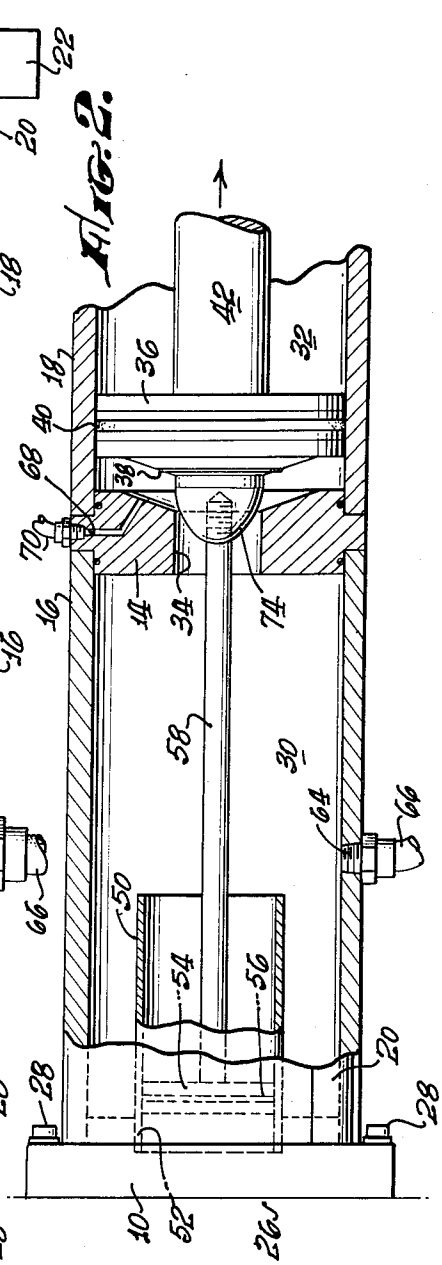


Fig. 2.

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ACTUATOR WITH SET FORCE PLUNGER

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The present invention relates generally to actuators; more particularly, the invention relates to an actuator wherein actuating pressure is very rapidly released upon an actuator piston.

The present invention provides high rate controlled output thrust or acceleration and is related to the inventions described and claimed in United States Patent No. 2,979,-938 to Jack Benton Ottestad, United States Patent No. 2,949,096 to Jack B. Ottestad and Samuel A. Skeen, and in the copending application of Jack Benton Ottestad and Samuel Arthur Skeen, Serial No. 690,774, filed October 17, 1957, now Patent No. 2,997,025. In each of the devices of the copending application and the patents, a set force urges an actuator piston toward an orifice wall to effect a positive pressure seal between a piston and a wall about the orifice by means of a sealing element. An actuating pressure acts through the orifice on an area of the actuator piston within the pressure seal to oppose the set force. The actuating pressure is very rapidly released through the orifice by impelling the release piston from the orifice wall, either by increasing the actuating pressure on the piston area within the seal to overbalance the set force, or by utilizing a separate triggering force to cooperate with the actuating pressure to overbalance the set force. The overbalancing unseats the release piston from the orifice wall, thereby eliminating the pressure seal and releasing the actuating pressure upon the actuator piston area outside the seal, thereby rapidly accelerating the actuator piston from the wall to produce useful output.

The devices of the aforementioned inventions are characterized by certain disadvantages. One disadvantage is that separate actuating and set pressures must be provided, thus requiring separate pressure supply systems. Another disadvantage is that special structure may be required for decelerating the release piston.

The present invention provides an actuator wherein an actuator piston confronts one side of an orifice wall and is rigidly connected by a rod which extends through the orifice to a plunger which is slidable in a cylinder. The actuator piston and the wall are adapted for cooperation to provide a pressure seal about the orifice. An actuating pressure is established to act upon the plunger to exert a set force urging the plunger away from the orifice wall and urging the actuator piston toward the wall to effect the pressure seal about the orifice. The same actuating pressure also acts through the orifice upon an actuator piston area defined by the pressure seal to exert a second force opposing the set force. The set force is overbalanced by means of a triggering force or pressure which cooperates with the second pressure force. The overbalancing unseats the actuator piston from the orifice wall and suddenly eliminates the pressure seal, thereby suddenly releasing the actuating pressure upon the actuator piston area outside the pressure seal to accelerate the actuator piston. The triggering force may be provided by applying a triggering pressure to the actuator piston area outside the pressure seal. The actuating pressure may be used as the triggering pressure. An output thrust-time pattern may be governed by utilizing a metering pin on the actuator piston, the metering pin extending into the orifice and cooperating with the orifice wall in regulating the release of pressure through the orifice to govern piston acceleration. The plunger assists in decelerating

the actuator piston to which it is connected, because of the continuous action of the actuating pressure on the plunger and the partial vacuum which can be produced on the opposite side of the plunger. Special structure need not necessarily be provided for decelerating the piston.

It is therefore an object of the present invention to provide a novel and improved actuator for production of controlled high rate output thrust.

An object of the invention is to alleviate the foregoing and other disadvantages by providing novel means for very rapidly releasing actuating pressure upon an actuator piston, wherein no pressure other than the actuating pressure is required for operation.

It is an object of the present invention to provide an improved actuator which achieves the objects of the prior inventions hereinbefore mentioned.

An object of the present invention is the provision of an actuator according to the foregoing object wherein an actuating pressure exerts a set force on a plunger connected with an actuator piston to urge the actuator piston toward an orifice wall to effect a pressure seal between the actuator piston and the wall, and wherein the actuating pressure also exerts an opposing force on an actuator piston area within the pressure seal, thereby preparing the actuator for operation by the application of a triggering force to the actuator piston to overbalance the set force.

It is an object of the invention to provide an actuator according to the foregoing objects which requires no special structure for decelerating the actuator piston.

An object of this invention is the provision of an actuator according to the foregoing objects wherein the triggering force is applied by introducing a triggering pressure to an area of the actuator piston.

It is an object of the present invention to provide an actuator wherein a thrust-time output pattern is controlled by cooperation between an orifice wall and a contoured metering member on an actuator piston.

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

FIGURE 1 is an elevational sectional view of a preferred embodiment of the actuator of the present invention; and

FIGURE 2 is a partial elevational view, partially in section, of a modified embodiment of the invention in a different stage of operation.

Referring to the drawing, and particularly to FIGURE 1, there is shown a preferred embodiment of the actuator of the present invention. The device includes a housing assembly comprising a base member 10, an end member 12, an orifice plate or wall 14, and cylindrical sections 16, 18, all of which are secured in clamped relation by tie-bolts 20. Each of the tie-bolts extends through an appropriate opening in a flange portion 22 of the end member 12 and is secured in a threaded opening 24 in the base member 10. The housing assembly is secured to a wall or foundation 26 by bolts 28 which extend through openings in a flange portion of the base member. The cylindrical housing is separated into an actuating pressure chamber 30 and a pressure chamber 32 by the orifice wall 14. An orifice 34 is provided in the orifice plate for a purpose hereinafter described. Pressure sealing is provided for chambers 30, 32 by resilient seal rings in appropriate grooves in the orifice wall 14, the base member 10, and the end member 12, as shown.

An actuator piston 36 is slidable in chamber 32 and confronts the orifice plate, as shown in FIGURE 1. A resilient annular sealing element 38 is secured as by bonding in a circular groove in the piston and is adapted

to seal against the orifice wall to provide a pressure seal between the piston and the wall about the orifice. A sealing ring 40 in a peripheral groove in the actuator piston provides pressure sealing between cylindrical section 18 and the piston. A thrust column 42 is threadedly secured in an axial opening in the actuator piston and extends through an axial opening 44 in end member 12. The column is slidably received in a bearing 45 secured within an enlarged portion of the opening by a locking ring 48, as shown. A sealing ring in an appropriate groove within the opening provides pressure sealing about the thrust column.

A cylinder member 50 is secured to the base member 10 by threaded engagement of its end portion in an axial opening 52 in the base member. A plunger 54 is slidable in the cylinder 50 and confronts the orifice wall. Pressure sealing is provided between the cylinder and the plunger by a resilient sealing ring 56 in a peripheral groove of the plunger. The plunger is rigidly interconnected with the actuator piston 36 by a rod 58 which extends through the orifice and which is secured in threaded axial openings 60, 62 in the plunger 54 and the piston 36, respectively.

The actuating pressure chamber 30 is interconnected with a source of actuating pressure (not shown) by an opening 64 in cylindrical section 16 and by a fluid coupling 66. A radial passage 68 in the orifice wall 14 and a fluid coupling 70 communicate between a source of triggering pressure (not shown) and the area of the actuator piston which is radially outside the sealing element 38 and which confronts the orifice wall, as shown. Another fluid coupling 72 provides for introducing pressure from another source (not shown) into chamber 32, for a purpose hereinafter mentioned.

To prepare the actuator for operation, a seating pressure is introduced into chamber 32 through the coupling 72 to seat the actuator piston against the orifice wall and establish the above-mentioned pressure seal about the orifice by means of the resilient sealing element 38. A relatively high actuating pressure is then established in the actuating presusre chamber 30. This actuating pressure acts upon the area of plunger 54 defined by its sealing ring 56. This same pressure acts through the orifice upon the actuator piston area defined within the pressure seal effected by the sealing element 38. The plunger area is larger than the actuator piston area within the pressure seal, as shown. The actuating pressure exerts a set force on the plunger urging it away from the orifice wall and urging the connected actuator piston toward the wall to establish the pressure seal. A second or opposing force is exerted by the actuating pressure on the actuator piston area within the seal. The plunger area being greater than this piston area, the set force exceeds the opposing force on the actuator piston. The sealing element 38 is therefore maintained in engagement with the wall to effect the pressure seal about the orifice. The seating pressure in chamber 32 is then preferably relieved, in order to reduce the decelerating forces on the actuator piston after it is accelerated in the manner hereinafter described.

To operate the actuator, a triggering pressure is introduced through the coupling 70 and the passage 68 to the actuator piston area outside the pressure seal and the sealing element 38. This triggering pressure is predetermined to overbalance the set force by cooperating with the force of the second or opposing force of the actuating pressure on the piston area within the seal. The overbalancing action unseats the actuator piston and the sealing element 38 is disengaged from the wall. With the pressure seal thus eliminated, the high actuating pressure is released substantially instantaneously through the orifice upon the entire area of the actuator piston outside the pressure seal and confronting the orifice wall. The actuator piston is suddenly impelled with great force from the orifice wall to produce high level actuator output, as indicated in FIGURE 2.

The actuator shown in FIGURE 2 differs from that of FIGURE 1 in that a metering member 74 is utilized. The metering member is mounted on the actuator piston 36 and is contoured to control the output thrust-time pattern of the actuator. The operation is identical to that of the actuator of FIGURE 1 except that, upon the elimination of the pressure seal about the orifice by the initial movement of the actuator piston, the actuating pressure is released through a net orifice area which is governed by the metering member. A pressure drop is effected across the orifice and varies according to the net effective orifice area. The net output pressure and the force produced on the actuator piston vary in accordance with the net flow area. Selected thrust-time patterns may be produced by appropriate metering pins. The manner of determining appropriate metering pin contours for selected output patterns is described in the above mentioned Patent No. 2,949,096.

Deceleration of the actuator piston is at least partially effected by the continuous action of the actuating pressure in chamber 30 on the plunger 54 and by a partial vacuum produced on the opposite side of the plunger by its movement. In addition, compression in chamber 32 effected by the movement of the actuator piston assists in deceleration. Special structure is not necessarily required to effect actuator piston deceleration.

To prepare the actuator for repeat operation, the actuator piston 36 is reseated against the orifice wall 14. Reseating may be effected by mechanical force on the thrust column 42 or by the introduction into chamber 32 of a seating pressure through the coupling 72. The actuating pressure in chamber 30 may be relieved to facilitate reseating, if necessary. After reseating, the pressure in chamber 32 is preferably relieved.

Upon the reseating of the actuator piston, the trapping of pressure in the space refined by the orifice plate, the actuator piston 36. The resilient sealing element 38, and the sealing ring 40 is prevented by relieving pressure through the passage 68 and the coupling 70. Pressure trapped in this space would act upon the actuator piston and oppose the set force exerted oppositely on the piston. A relatively low pressure in chamber 30 would then effect movement of the actuator piston from the orifice wall. This would prevent effective triggering and would cause prematurely relatively slow movement of the actuator piston, thus preventing effective operation 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.

The inventor claims:

1. An actuator comprising housing means, a wall defining an orifice within the housing means, an actuator piston confronting the wall and adapted for cooperation therewith to provide a pressure seal therebetween about said orifice, a plunger connected with the actuator piston and disposed on the opposite side of the wall therefrom, means slidably mounting the plunger, means for applying an actuator pressure to the plunger and for applying the actuating pressure through the orifice to the actuator piston, said actuating pressure exerting a set force on the plunger to urge the actuator piston toward the wall to effect said pressure seal, said actuating pressure thereby exerting a second force on an actuator piston area within said pressure seal to oppose said set force, and means for applying a triggering force to the actuator piston to cooperate with said second force in overbalancing the set force to eliminate the pressure seal and expose an increased area of the actuator piston to the actuating pressure, whereby the actuator piston is accelerated from the wall.

2. An actuator comprising housing means, a wall defining an orifice within the housing means, a plunger confronting a first side of the wall, means slidably mounting the plunger, an actuator piston confronting a second side of the wall and adapted for cooperation therewith to provide a pressure seal therebetween about said orifice, means comprising a rod extending through said orifice and rigidly interconnecting the plunger and the actuator piston, means for applying an actuating pressure to the plunger and for applying the actuating pressure through the orifice to the actuator piston, said actuating pressure exerting a set force on the plunger to urge the actuator piston toward the wall to effect said pressure seal, said actuating pressure thereby exerting a second force on an actuator piston area within said pressure seal to oppose said set force, and means for applying a triggering force to the actuator piston to cooperate with said second force in overbalancing the set force to eliminate the pressure seal and expose an increased area of the actuator piston to the actuating pressure, whereby the actuator piston is accelerated from the wall.

3. An actuator comprising housing means, a wall defining an orifice within the housing means, a plunger confronting a first side of the wall, means slidably mounting the plunger, an actuator piston confronting a second side of the wall, means rigidly interconnecting the actuator piston and the plunger, a resilient sealing element positioned between the actuator piston and the wall for effecting a pressure seal therebetween about said orifice, said sealing element defining an actuator piston area smaller than the plunger area confronting the wall, means for applying an actuating pressure to said plunger and for applying the actuating pressure through the orifice to the actuator piston, said actuating pressure exerting a set force on the plunger to urge the actuator piston toward the wall to effect said pressure seal, said actuating pressure acting on said smaller actuator piston area defined by the sealing element to exert a second force opposing said set force, and means for applying a triggering force to the actuator piston to cooperate with said second force in overbalancing the set force to eliminate the pressure seal and expose an increased area of the actuator piston to the actuating pressure, whereby the actuator piston is accelerated from the wall.

4. An actuator comprising housing means, a wall defining an orifice between first and second pressure chambers within the housing means, cylinder means disposed in said first chamber, a plunger slidable in the cylinder means, an actuator piston positioned in the second chamber and confronting the wall, means rigidly interconnecting the actuator piston and the plunger, a resilient sealing element positioned between the actuator piston and the wall for effecting a pressure seal therebetween about said orifice, said sealing element defining an actuator piston area smaller than the plunger area confronting the wall, means for establishing in the first chamber an actuating pressure to act on the plunger and to act through the orifice on the actuator piston, said actuating pressure exerting a set force on the plunger to urge the actuator piston toward the wall to effect said pressure seal, said actuating pressure acting on said smaller actuator piston area defined by the sealing element to exert a second force opposing said set force, and means for applying a triggering force to the actuator piston to cooperate with said second force in overbalancing the set force to eliminate the pressure seal and expose an increased area of the actuator piston to the actuating pressure, whereby the actuator piston is accelerated from the wall.

5. An actuator comprising housing means, a wall defining an orifice within the housing means, an actuator piston confronting the wall and adapted for cooperation therewith to provide a pressure seal therebetween about said orifice, a plunger connected with the actuator piston and disposed on the opposite side of the wall therefrom, means slidably mounting the plunger, means for applying an actuating pressure to the plunger and for applying the actuating pressure through the orifice to the actuator piston, said actuating pressure exerting a set force on the plunger to urge the actuator piston toward the wall to effect said pressure seal, said actuating pressure thereby exerting a second force on an actuator piston area within said pressure seal to oppose said set force, and means for introducing a triggering pressure to an actuator piston area outside said pressure seal and confronting the wall to cooperate with said second force in overbalancing the set force to eliminate the pressure seal and expose said piston area outside the seal to the actuating pressure, whereby the actuator piston is accelerated from the wall.

6. An actuator comprising housing means, a wall defining an orifice within the housing means, a plunger confronting a first side of the wall, means slidably mounting the plunger, an actuator piston confronting a second side of the wall, means rigidly interconnecting the actuator piston and the plunger, a resilient sealing element positioned between the actuator piston and the wall for effecting a pressure seal therebetween about said orifice, said sealing element defining an actuator piston area smaller than the plunger area confronting the wall, means for applying an actuating pressure to said plunger and for applying the actuating pressure through the orifice to the actuator piston, said actuating pressure exerting a set force on the plunger to urge the actuator piston toward the wall to effect said pressure seal, said actuating pressure acting on said smaller actuator piston area defined by the sealing element to exert a second force opposing said set force, and means for introducing a triggering pressure to an actuator piston area outside said sealing element and confronting the wall to cooperate with said second force in overbalancing the set force to eliminate the pressure seal and expose said piston area outside the seal to the actuating pressure, whereby the actuator piston is accelerated from the wall.

7. An actuator comprising housing means, a wall defining an orifice within the housing means, a plunger confronting a first side of the wall, means slidably mounting the plunger, an actuator piston confronting a second side of the wall, means rigidly interconnecting the actuator piston and the plunger, a resilient sealing element positioned between the actuator piston and the wall for effecting a pressure seal therebetween about said orifice, said sealing element defining an actuator piston area smaller than the plunger area confronting the wall, means for applying an actuating pressure to said plunger area and for applying the actuating pressure through the orifice to the actuator piston, said actuating pressure exerting a set force on the plunger to urge the actuator piston toward the wall to effect said pressure seal, said actuating pressure acting on said smaller actuator piston area defined by the sealing element to exert a second force opposing said set force, means for applying a triggering force to the actuator piston to cooperate with said second force in overbalancing the set force to eliminate the pressure seal and expose an increased area of the actuator piston to the actuating pressure, thereby accelerating the actuator piston from the wall, and a contoured metering member on the actuator piston for regulating flow through the orifice to produce a predetermined thrust-time output pattern on the actuator piston.

8. An actuator comprising housing means, a wall defining an orifice within the housing means, a plunger confronting a first side of the wall, means slidably mounting the plunger, an actuator piston confronting a second side of the wall, means rigidly interconnecting the actuator piston and the plunger, a resilient sealing element positioned between the actuator piston and the wall for effecting a pressure seal therebetween about said orifice, said sealing element defining an actuator piston area smaller than the plunger area confronting the wall, means for applying an actuating pressure to said plunger and for applying the actuating pressure through the orifice to

the actuator piston, said actuating pressure exerting a set force on the plunger to urge the actuator piston toward the wall to effect said pressure seal, said actuating pressure acting on said smaller actuator piston area defined by the sealing element to exert a second force opposing said set force, and means for applying a triggering force to the actuator piston to cooperate with said second force in overbalancing the set force to eliminate the pressure seal and expose an increased area of the actuator piston to the actuating pressure, thereby accelerating the actuator piston from the wall, and an output thrust column attached to the actuator piston.

9. An actuator comprising housing means, a wall defining an orifice between first and second pressure chambers within the housing means, cylinder means on a base member confronting the orifice wall, a plunger slidable in the cylinder means, an actuator piston positioned in the second chamber and confronting the wall, means comprising a rod extending through said orifice and rigidly interconnecting the plunger and the actuator piston, a resilient sealing element positioned between the actuator piston and the wall for effecting a pressure seal therebetween about said orifice, said sealing element defining an actuator piston area smaller than the plunger area confronting said wall, means for establishing in said first chamber an actuating pressure to act on the plunger and to act through the orifice on the actuator piston, said actuating pressure exerting a set force on the plunger to urge the actuator piston toward the wall to effect said pressure seal, said actuating pressure acting on said smaller actuator piston area defined by the sealing element to exert a second force opposing said set force, means for introducing a triggering pressure to an actuator piston area outside said sealing element and confronting the wall to cooperate with said second force in overbalancing the set force to eliminate the pressure seal and expose said piston area outside the seal to the actuating pressure, whereby the actuator piston is accelerated from the wall.

10. An actuator comprising housing means, a wall defining an orifice between first and second pressure chambers within the housing means, cylinder means on a base member confronting the orifice wall, a plunger slidable in the cylinder means, an actuator piston positioned in the second chamber and confronting the wall, means comprising a rod extending through said orifice and rigidly interconnecting the plunger and the actuator piston, a resilient sealing element positioned between the actuator piston and the wall for effecting a pressure seal therebetween about said orifice, said sealing element defining an actuator piston area smaller than the plunger area confronting said wall, means for establishing in said first chamber and actuating pressure to act on the plunger and to act through the orifice on the actuator piston, said actuating pressure exerting a set force on the plunger to urge the actuator piston toward the wall to effect said pressure seal, said actuating pressure acting on said smaller actuator piston area defined by the sealing element to exert a second force opposing said set force, means for introducing a triggering pressure to an actuator piston area outside said sealing element and confronting the wall to cooperate with said second force in overbalancing the set force to eliminate the pressure seal and expose said piston area outside the seal to the actuating pressure, thereby accelerating the actuator piston from the wall, a contoured metering member on the actuator piston for regulating flow through the orifice to produce a predetermined thrust-time pattern on the actuator piston, and an output thrust column attached to the actuator piston.

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