BOOSTER ACTUATOR

Field of the Invention

The present invention relates to devices intended to be actuated by a low energy input, and which output a high energy to the device to be actuated. More particularly, the present invention relates to a booster actuator which uses mechanically stored energy to move an actuator shaft with a force and stroke sufficient to actuate various types of devices.

Background of the Invention

Those involved in system designs have long required devices which provide a boost or energy level increase to actuate a device. Electric energy input to a solenoid is directly proportional to the output force, which practically limits the use of solenoids in conventional low power electrical systems. A relatively small and inexpensive electrical solenoid may send a signal which will stroke a solenoid plunger, although the force and/or the stroke of the plunger in many cases is insufficient to activate the device intended. Accordingly, boosters have been used between such low energy products, such as solenoids, and a device to be activated to provide the desired energy level to actuate the intended device.

In the fire safety industry, various systems have been devised so that pressurized gas may be released when a device is manually or automatically actuated. In some applications, a booster or booster actuator may be positioned between a solenoid and a valve, with that valve in turn being actuated to release agents, such as CO_2 or a mixture of nitrogen, argon, and carbon dioxide, into the hazard area.

Prior art booster actuators have used magnetized components to hold the actuator in the set or armed position. Many of these actuators require an input force proportional to the desired output force, or require additional electrical circuitry to return the actuator to the set position.

Prior art actuators also include pressurized gas cartridges which are punctured, so that the release of the pressurized gas in response to the puncture may be used to activate a pneumatic device which releases the agent gas to the hazard area. Other types of actuators utilize explosive components to generate the increased energy to activate a valve or otherwise release the agent gas to the hazard area.

Many prior art boost devices have significant disadvantages which have limited their use. Prior art boost devices are relatively complex and/or are not highly reliable, and other devices cannot be easily reset. In still other booster devices, it is difficult to vary the force which activates the boost device and/or to vary the output force from the boost device. The disadvantages of the prior art are overcome by the present invention, and an improved booster actuator is hereinafter disclosed.

Summary of the Invention

In a typical application, the booster actuator of the present invention may be located between a solenoid and a valve. The actuator body houses a cam shaft or force input member which is biased by a coil spring to the initial input position. The body also houses an actuator shaft or force output member which is biased to the activated output position by a plurality of disk springs. A plurality of circumferentially spaced links engage the force

input member at one end and the force output member at the other end, and control of the release of the force from the disk springs to the output member in response to movement of the cam shaft. In another embodiment, an electrical coil is provided about the cam shaft, so that a combination solenoid and booster is provided.

It is an object of the present invention to provide a booster apparatus with a force input member and a force output member each movable relative to the actuator body, a biasing member for biasing the force output member to the activated output position and at least one linking member between the force input member and the force output member and pivotably movable with respect to the body from the engaged position to a disengaged position for releasing the force output member to the activated output position in response to the biasing member. The linking member engages both the force input member and force output member, and may cooperate with recesses in the input member and output member for achieving the desired function.

It is another feature of the invention to provide a booster actuator with a force input member, a low force biasing member for exerting a biasing force on the input member, a force output member, another biasing member for exerting a high biasing force on the force output member, and a linking member between the force input member and force output member. Control of the actuator may be reliably obtained by providing two biasing members each of which exert a force independent of the other biasing member on the input member or output member.

It is a feature of the present invention to provide a booster actuator wherein the output force from the actuator may be easily revised without redesigning the remainder of the

actuator. Moreover, the change in the output force is independent of the energy required to trigger activation of the booster, and the input energy required to trigger the actuator may be separately selected without regard to the output requirements from the actuator.

It is another feature of the invention that the booster actuator is highly reliable, and may be mechanically reset without the use of electrical devices. The reset may be accomplished quickly and easily, and no replacement of parts is necessary.

It is a further feature of the invention to provide a booster actuator wherein a solenoid coil is provided to control movement of the force input member relative to the actuator body.

It is an advantage of the present invention that the booster apparatus is highly reliable and may be economically manufactured. The booster body preferably seals the internal components from the environment.

These and further objects, features, and advantages of the present invention will become apparent from the following detailed description, wherein reference is made to the figures in the accompanying drawings.

Brief Description of the Drawings

Figure 1 is a simplified cross-sectional view of a booster actuator according to the present invention positioned between an electrically activated solenoid and a valve which is connected to a pressurized gas system.

Figure 2 is a cross-sectional view of a booster actuator generally shown in Figure 1. An internal portion of the body has been removed for clarity of the illustrated components.

Figure 3 is a cross-sectional view of the body generally shown in Figure 2.

Figure 4 is another cross-sectional view of the body, illustrating the spaced apart guides for receiving each of the four linking members.

Figure 5 is a side view of a suitable booster reset device.

Figure 6 is a side view of a portion of an alternate embodiment, with an electrical coil surrounding the cam shaft.

Detailed Description of Preferred Embodiments

Referring to Figure 1, the booster actuator 10 may be threadedly secured at one end to the body of a solenoid 12 or another electrically actuated device, and may be similarly connected at its opposed end to a valve 14, with the valve 14 intended to release gas to an area in response to a sensed hazardous condition. The booster apparatus thus may be used in conjunction with a relatively low energy electrical system which monitors the surrounding environment, and outputs an electrical signal to actuate the solenoid 12 in response to the sensed condition to release a selected gas, e.g., for extinguishing a fire. As shown in Figure 1, the solenoid 12 includes a plunger 13 which is movable relative to the body 20 of the booster actuator 10. The actuator 10 receives this low energy input and outputs a high energy to control plunger 15 of the valve 14, thereby activating the valve 14 to release the compressed gas to the environment.

The actuator 10 as shown in Figure 2 includes a body 20 having a force receiving input end 22 and a force delivery output end 24. Outer sleeve 25 may be provided for engagement with conventional seals 26 to seal the interior of the body. The cam shaft or force input member 28 is movable relative to the body from an initial input position as

shown in Figure 2 to an activated output position in response to movement of the solenoid plunger. The force output member 30 is similarly movable relative to the body from the initial output position as shown in Figure 2 to an activated output position. Four links 32 are equally spaced at 90° intervals about both the force input member and the force output member, and are each pivotable about the pin 34 which is supported on the body 20. The coil spring 46 biases the force input member to the initial input position, and a plurality of disk springs, such as disk springs 48, bias the output member 30 to the activated output position.

The force input member 28 is sealed with the body by a conventional O-ring 50, and in the initial input position is biased by the coil spring 46 to engage shoulder 52 on the body. Input member 28 includes an annular recess 54 for receiving the upper end of each of the linking members 32 when in the disengaged position, thereby allowing release of the force output member 30 normally held in the initial position by the lower end of each linking member. As indicated in Figure 2, an upper roller 56 may be provided at the upper end of each link 32, and a similar roller 58 may be provided at the lower end of each link. When the actuator is in the initial position, each of the upper rollers thus engages the cylindrical exterior surface 64 of the input member 28, while each lower roller 58 fits at least partially within annular recess 66 in the force output member 30. Each roller is rotatably mounted on a link with a respective pin 60 which is fixed to the link, and each link itself is pivotable about pin 34 which is supported on the actuator body 20. The position of the input member 28 thus retains each of the four links in the position as shown in Figure 2, which in turn

prevents downward movement of the force output member 30 in response to the disk springs 48.

A stop plate 62 has a central aperture therein sized to receive plunger 68 of the force output device 30, with the stop plate being interconnected with the body by threads 70. Conventional ports 72 may be provided in the stop plate for receiving a suitable tool to thread the stop plate in place, with the final position of the stop plate resting against snap ring 74. An O-ring 76 is held in position within the stop plate by a combination back-up ring and retaining ring 78, and provides sealing engagement between the plunger 68 and the stop plate 62.

It is a particular feature of the invention that the force required to move the input member 28 may be easily adjusted by varying the selection of the coil spring 46. The coil spring is sized so that the booster actuator will not inadvertently activate in response to vibration, jarring, and other forces commonly transmitted to a system. The selection of the number of coils and the material for the coils for the spring 46 are independent, however, of the selection of the biasing member 48, which preferably is a plurality of disk springs. The number of disk springs and the orientation of these springs with respect to each other affect the force and the stroke which will move the force output member to the activated position, thereby extending the plunger from the stop plate and, in an exemplary application, actuating the valve as shown in Figure 1. For this exemplary embodiment, it should be understood that the force output member may move from the initial position as shown in Figure 2 to a position wherein the surface 81 engages the snap ring 74. This movement of the force output member 30 to the activated output position thus results when each of the rollers 58 moves

out of engagement with the recess 66, so that each of the rollers 58 rolls out of the recess and into engagement with the cylindrical surface 67 on force output member 30. At the same time, upper rollers 56 roll out of engagement with the cylindrical surface 64 in the force input member and roll partially at least within the annular recess 54 sized to receive these rollers. This action thus causes pivoting of the links 32 to release the force output member to the activated position.

Figure 3 shows in greater detail the construction of a suitable actuator body 20, and particularly the cavity 80 for receiving the disk springs 48. The uppermost disk spring as shown in Figure 2 thus rests against the surface 82 as shown in Figure 3. Figures 3 and 4 also depict four pairs of circumferentially spaced guide plates 86 and 88, thereby providing a slot 90 therebetween for receiving a suitable link 32. Figure 4 also depicts the aligned throughports 92 in each pair of guide plates for receiving a suitable link pin 34. The lower flange 94 of the body 20 may have a suitable exterior configuration, such as a hex configuration, for engagement with a conventional tool to facilitate threadably connecting the body 20 to a solenoid.

It is a feature of the invention that the interior of the body 20 and thus each of the movable components within the body is sealed from the surrounding environment, with this objective being accomplished by the conventional seals 26 which seal between sleeve 25 and the body, and by the seals 50 and 76 which seal with the force input member and the force output member, respectively. A sufficient seal may be created between the body 20 and the stop plate 62 due to interference of the threads although, if desired, another O-ring seal could be provided for sealing between the stop plate and the body.

In preferred embodiments, at least three linking members are circumferentially arranged about the force input member and the force output member. Three linking members at 120° interval spacing provide high reliability by distributing the applied forces equally about the input member and the output member. A preferred embodiment as shown in the figures utilizes four linking members spaced at 90° intervals. The rollers 56 and 58 provided at the end of the linking members reduce frictional forces when the linking members are moved from an engaged position as shown in Figure 2 for retaining the force output member 30 in the initial output position to a disengaged position which releases the force output member to the activated output position. In alternate embodiments, the rollers may be eliminated, or may be replaced with other conventional members intended to reduce friction with the force input and force output members.

Coil spring 46 acts between the force output member 30 and the force input member 28. The force of this spring may be easily altered without modifying other components of the booster actuator in order to change the force required to activate the booster 10. Similarly, the size, orientation, and number of disk springs 48 may be altered to effect the stroke length and/or the force which will be output by the plunger 68 when moved to the activated output position. Alternative types of springs or other biasing members may be utilized.

The booster actuator of the present invention provides a mechanical separation of the input member and the output member. The coil spring 46 biases the input member to the initial position, but this exerts a small force on the output member compared to the bias of the springs 48. By providing no direct mechanical connection between the input member

and the output member, the reactive forces on the valve which are transmitted back to the force output member during actuation of the booster are prevented from being transmitted to the force input member and then to the solenoid. The coil spring thus isolates the reactive force on the output member from the forces applied to the input member, and a latching solenoid mechanism may thus be used to activate the booster without fear of damage from these reactive forces.

Once the booster is activated, the booster may be easily reset without use of electrical devices, and without replacement of parts. After the valve 14 has been removed from the booster body, reset device 94 as shown in Figure 5 may be connected to the threads 70 on the body. After the reset outer body 96 bottoms out against the stop plate 62, the bolt 98 may be rotated relative to outer body 96 to project the tip 97 toward the stop plate 62. The tip 97 is thereby forced into engagement with the end of the plunger 68, thereby forcing the force output member 30 back to the initial position as shown in Figure 2. The return of the force output member to the initial position also increases the force on the coil spring to return the force input member to the initial position.

Figure 6 depicts another embodiment of the invention, wherein a combination solenoid and booster actuator is provided. That portion of the booster 10 to the right of the force input member 128 may be as described above. In this embodiment, however, an extension of the force input member is provided so that the extended length force input member 128 is positioned within a solenoid coil 114. The solenoid coil may also be referred to as a magnetic latch subassembly, which receives electrical power to selectively move the input member 128. Those skilled in the art will appreciate that an extended length force

input member may be used, as shown, or a two-piece or multi-piece mechanical interconnection made between the solenoid plunger and the force input member. Activation of the coil 114 thus initiates movement of the solenoid plunger, which in this case is the force input member 128. Force input member 128 includes a stop 130 for engagement with the surface 132 to limit the travel of the force input member. Figure 6 depicts sleeve 134 enclosing the solenoid 114, and body 136 which connects sleeve 134 with sleeve 25.

While a preferred embodiment of the present invention has been illustrated in detail, it is apparent that modifications and adaptations of the proposed embodiment will occur to those skilled in the art. However, it is to be expressly understood that such modifications and adaptations are within the spirit and scope of the present invention as set forth in the following claims.

What is claimed is:

1. A booster actuator for receiving a low energy input and outputting a high energy output to operate a device, the booster comprising:

a body having a force receiving input end and force delivery output end;

a force input member movable relative to the body in response to the low energy force input from an initial input position to an activated input position;

a force output member movable relative to the body in response to movement of the force input member from an initial output position to an activated output position;

a biasing member for biasing the force output member to the activated output position; and

a linking member between the force input member and the force output member and pivotally movable with respect to the body from an engaged position for retaining the force output member in the initial output position to a disengaged position for releasing the force output member to the activated output position, the linking member having an input end engaging the force input member and an output end engaging the force output member.

2. The booster actuator as defined in Claim 1, further comprising:

another biasing member for biasing the force input member to the initial input position.

3. The booster actuator as defined in Claim 1, wherein the force output member

includes an output member recess for receiving a lower end of the linking member when in the engaged position.

4. The booster actuator as defined in Claim 3, wherein the force input member includes an input member recess for receiving an upper end of the linking member when in the disengaged position, thereby allowing disengagement of the lower end of the linking member from the output member recess.

5. The booster actuator as defined in Claim 1, wherein at least three linking members each pivotable with respect to the body are circumferentially arranged about the force input member and the force output member.

6. The booster actuator as defined in Claim 5, wherein four linking members are spaced circumferentially at approximately 90° intervals about the force input member and force output member.

7. The booster actuator as defined in Claim 1, further comprising:

the biasing member comprises a plurality of disk springs; and

another biasing member for biasing the force input member to the initial input position.

8. The booster actuator as defined in Claim 1, further comprising:

an electrical coil surrounding the force input member, such that a change in electrical energy to the coil moves the force input member to the activated input position.

9. The booster actuator as defined in Claim 1, wherein each of the input end and output end of the linking member is provided with a roller for engaging the force input member and the force output member, respectively.

10. The booster actuator as defined in Claim 1, wherein the force delivery output end of the body includes threads, and a reset member threaded to the delivery output end is rotated relative to the body to forceably engage the force output member to move the force output member from the activated position to the initial position.

11. A booster actuator for receiving a low energy force and outputting a high energy force output to operate another device, the booster comprising:

a body having a force receiving input end and force delivery output end;

a force input member linearly movable relative to the body in response to the low energy force input from an initial input position to an activated input position;

a first biasing member for biasing the force input member to the initial input position;

a force output member linearly movable relative to the body in response to movement of the force input member from an initial output position to an activated output position;

a second biasing member for biasing the force output member to the activated output position; and

a linking member between the force input member and the force output member and movable from an engaged position for retaining the force output member in the initial output position to a disengaged position for releasing the force output member to the activated output position.

12. The booster actuator as defined in Claim 11, wherein at least three linking members each pivotable with respect to the body are circumferentially arranged about the force input member and the force output member.

13. The booster actuator as defined in Claim 11, wherein the first biasing member is a coil spring, and the second biasing member comprises a plurality of disk springs.

14. The booster actuator as defined in Claim 11, further comprising:

an electrical coil surrounding the force input member, such that a change in electrical energy to the coil moves the force input member to the activated input position.

15. The booster actuator as defined in Claim 11, wherein each of the input end

and output end of the linking member is provided with a roller for engaging the force input member and force output member, respectively.

16. A booster actuator for receiving a low energy input from an electrically activated device and outputting a high energy to activate a release of pressurized gas to a hazard area, the booster comprising:

a body having a force receiving input end and force delivery output end;

a force input member linearly movable relative to the body in response to the low energy force input from an initial input position to an activated input position;

a force output member linearly movable relative to the body in response to movement of the force input member from an initial output position to an activated output position;

a first biasing member for biasing the force output member to the activated output position;

a second biasing member for biasing the output force member to the activated output position;

a plurality of linking members each between the force input member and the force output member and pivotally movable relative to the body from an engaged position for retaining the force output member in the initial output position to a disengaged position for releasing the force output member to the activated output position, the linking members being circumferentially arranged about the force input member and the force output member

and each having an input end engaging the force input member and an output end engaging the force output member; and

the force output member includes an output member recess for receiving a lower end of each of the linking members when in the engaged position.

17. The booster actuator as defined in Claim 16, wherein the force input member includes an input member recess for receiving an upper end of the linking member when in the disengaged position, thereby allowing disengagement of the lower end of the linking member from the output member recess.

18. The booster actuator as defined in Claim 16, wherein a central axis of the force input member is substantially aligned with a central axis of the force output member.

19. The booster actuator as defined in Claim 16, further comprising:
the second biasing member comprises a plurality of disk springs.

20. The booster actuator as defined in Claim 16, wherein the force delivery output end of the body includes threads, and a reset member threaded to the delivery output end is rotated relative to the body to engage the force output member to move the force output member from the activated position to the initial position.