

[54] ACTUATORS
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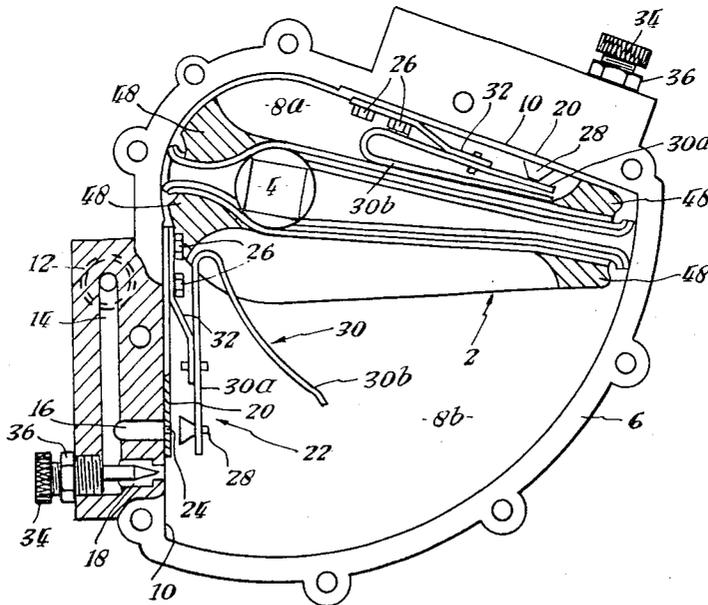
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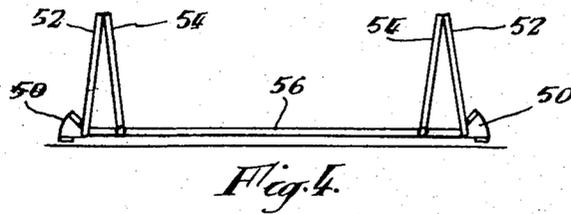
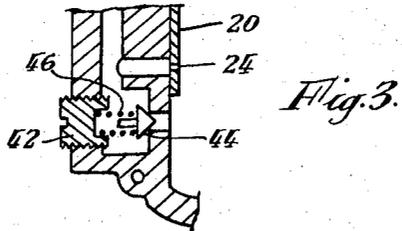
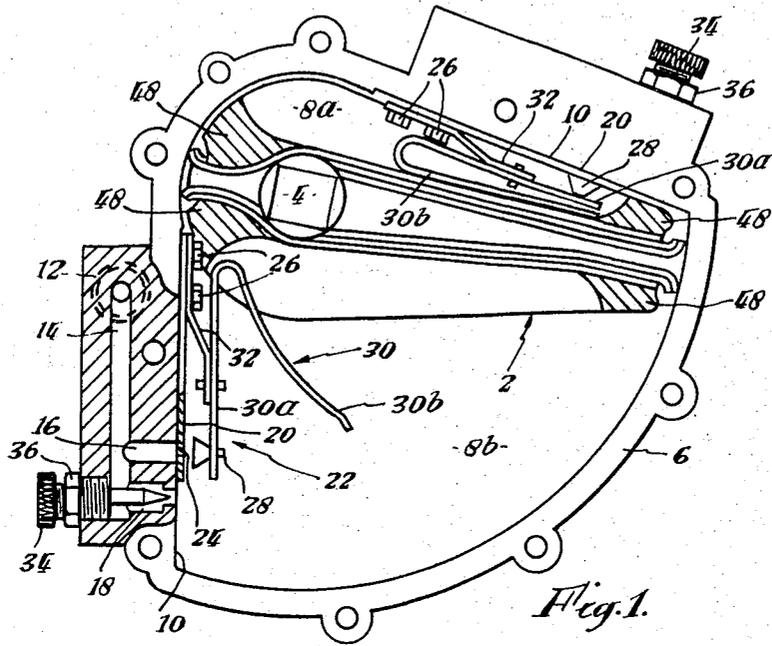
[57] ABSTRACT

A pressure-fluid operated actuator used, e.g. as a door opening and closing mechanism has restriction means limiting the flow of pressure fluid and so slowing down the rate of movement towards the end of a closing movement. The restriction means do not affect the initial part of the movement and allow free entry of fluid into the actuator for the reverse movement. The arrangement can include means which limit the degree of restriction offered.

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10 Claims, 5 Drawing Figures





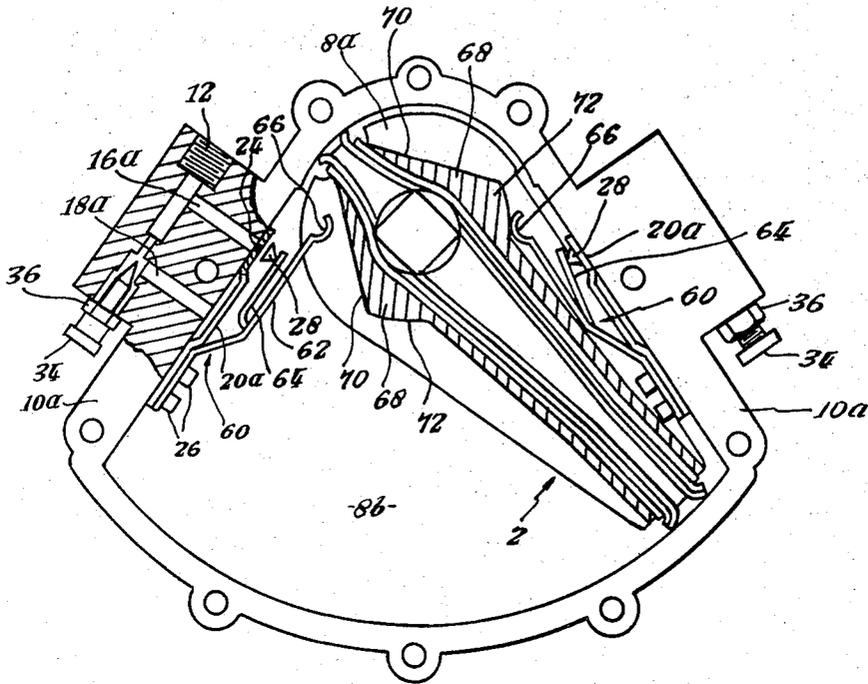


Fig. 5.

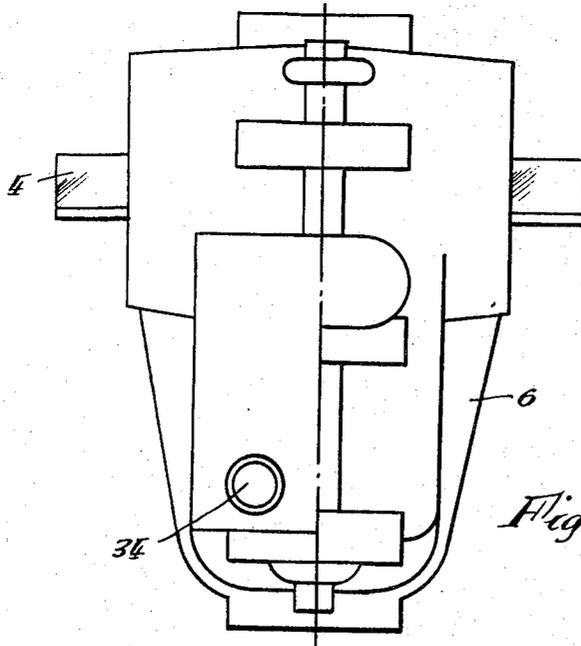


Fig. 2.

ACTUATORS

This invention relates to pressure-fluid operated actuators or motors (hereinafter referred to simply as "actuators") which are arranged for reciprocating movement, whether linear or angular.

When such actuators are used to displace relatively large masses, considerable inertia forces are developed and it may be difficult to dissipate these satisfactorily at the end of a working stroke when the moving mass must be arrested. For example, with a door being shut by such an actuator there can be a real risk of trapping or injuring a person passing through the doorway if the final closing movement is too violent. On the other hand, to produce a more gentle movement by reducing the operating pressure of the actuator can make it more difficult to close the door against any increased resistance e.g. due to the presence of foreign matter in the path of the door movement.

According to the present invention, there is provided a pressure-fluid operated actuator comprising an internal piston member dividing a chamber of the actuator into two mutually sealed spaces each provided with fluid porting, the piston member being movable between opposite end positions by the admission of pressure fluid through the porting in one space and the exhausting of fluid in the other space through the porting thereof, means arranged to be operative at said porting in at least one direction of travel of the piston member to restrict the outflow of fluid from the space and so to retard the movement of the piston member.

Such restriction of the outflowing fluid may be achieved by the provision of blocking means at said porting that can be displaced by the pressure of incoming fluid to allow that fluid to enter freely but that are operative in restricting the outflow of fluid already in the actuator chamber.

In order to provide a progressive increase in the resistance to the movement of the piston member during its travel, means are preferably provided to increase the restriction of the outflow from the contracting space after a predetermined part of the movement of the piston member. Such additional means may comprise a valve member held on a resilient mounting to be normally spaced from the associated porting and displaceable towards said porting by the piston member as it approaches its end position. If the valve member closes the porting, it can be arranged that there is additionally a bleed port, possibly with adjustable restriction means for the further outflow of fluid so that fluid still in the contracting space can yet escape therefrom. The valve member may, for example, be held on a cantilever spring and a resilient element attached to said spring can be arranged to be contacted by the piston member at a stage of its movement towards the valve member so as to deflect the cantilever spring and close said porting.

Embodiments of the invention will be more particularly described with reference to the accompanying drawings, wherein:

FIGS. 1 and 2 are a plan section and a side elevation respectively of a rotary actuator according to the invention,

FIG. 3 is a detail section of a modification of the actuator of FIGS. 1 and 2,

FIG. 4 illustrates an application of the actuator of the earlier figures in a door-closing mechanism, and

FIG. 5 is a plan section of an alternative rotary actuator according to the invention, which can also be employed in the mechanism of FIG. 4.

Referring more particularly to the embodiment of FIGS. 1 to 3 of the drawings, the construction of the actuator is similar in many respects to that described in the Complete Specification of British Pat. No. 1,023,232 to which reference can be made for details of the construction of piston 2 that is pivotable on shaft 4 in a casing 6, the interior of which is divided by the piston into two mutually sealed spaces 8a, 8b. The arrangement of the casing is symmetrical as seen in FIG. 1 about a line through the piston pivot axis and opposite side walls 10 have similar porting for the flow of working fluid, such as air, to and from the spaces 8a, 8b.

In each case, this porting comprises an external conduit connection 12 to a cross-bore 14 which is able to communicate with the chamber interior both through a main port 16 and an auxiliary port 18. Overlying the main port 16 there is a throttling plate 20 and a closure valve 22. The throttling plate is formed by a beryllium-copper spring strip in which a small aperture 24 is provided within the area of the end opening of the port 16. The plate is secured to the chamber side wall in cantilever manner by screws 26 at some distance from the port 16. Thus, with a flow of air out of the chamber through the port 16, the pressure holds the plate against the chamber side wall and the aperture 24 determines the effective cross-sectional area for the flow. When pressure air flows into the chamber through the port 16, however, the plate 22 is sufficiently resilient to be flexed by the pressure away from the chamber side wall so that a considerably larger cross-sectional area is available for the flow.

The valve 22 comprises a valve body 28 loosely held on one leg 30a of a hairpin spring 30 that is riveted to a further leaf spring 32 that is in its turn mounted to the casing by the screws 26. The other leg 30b of the spring 30 projects away from the adjacent side wall of the casing and can be contacted by the piston 2 considerably before the end of the piston stroke. The piston then displaces the spring 30 to swing the valve body against the aperture 24 to prevent further outflow therethrough. Because of the relatively loose mounting of the valve body 28 to the spring 30, the body will automatically align itself against the face of the plate 20 to seal the aperture 24.

A needle valve 34 has a screwed engagement with the casing to be located over the auxiliary port 18 and can be secured in a desired position of adjustment by a locknut 36 to determine the effective flow area of the port 18. The presence of the auxiliary port allows a limited outflow from a diminishing volume chamber space after the main port has been closed by the valve body 28.

In operation therefore, when the actuator piston moves from one end position to the other by the supply of pressure fluid to one side of the piston, a significant resistance against the movement can be arranged to be built up in the contracting space on the other side of the piston, so preventing the piston travelling too fast, by virtue of the restrictions offered by the aperture 24 and the needle valve 34. This resistance is increased in the later stages of the movement by the closure of the aperture 24, so further reducing the speed of the piston as it approaches its end position. If any unexpected ob-

struction to movement is encountered, the motion of the piston may stop but the force exerted against the obstruction will then increase as outflow continues through the auxiliary port 18 and/or the main port 16 so that there is no increased risk of jamming the actuator in a partly displaced position despite the reduction of the operating force under normal conditions.

If it is desired to prevent the pressure in the contracting space of the actuator from increasing beyond some determined limit, the needle valve may be modified in the manner indicated in FIG. 3, where screw adjustment member 42 is so connected to valve body 44 by a compression spring 46 that the valve opens at a given pressure differential. This has the effect also of reducing the possibility of piston bounce at the end of its movement. A feature that is similarly able to improve the characteristic of the actuator in this respect is the provision of filler pieces 48 for the purpose of reducing the dead air volume in the smaller space at the end of a stroke and thus reduce the possibility of bounce due to compressibility of the fluid remaining in that space.

The actuator described above can be employed in a variety of applications and can be of particular value in operating devices that have a relatively high inertia. As an example, it can be used to operate the access doors of a passenger transport vehicle, as is diagrammatically illustrated in FIG. 4. Here, two double-leaf folding doors are movable from opposite sides of the door opening by respective actuators 50 of the form already described, each actuator having its piston shaft connected to the outer leaf 52 of the associated door. The inner leaves 54 of the doors have rollers running in a guide track 56 across the width of the doorway. The two actuators are operated simultaneously by a single remote air valve (not shown) of conventional form which supplies air, e.g. at 100 p.s.i.g. to one or other side of the actuator pistons.

In operation, the restriction arrangement will normally keep the pressure in the exhausting space to perhaps some 70-80 p.s.i.g. and is able to prevent the doors shutting too sharply, and may also be arranged to cause a momentary arrest of the motion at some predetermined angle, e.g. some 10° to 25° from an approaching end position. Thus, it functions to reduce the risk of trapping the limbs of a passenger, since if a passenger is then obstructing the closing door the force of contact will be reduced. Any obstruction due to foreign matter, in the guide track for example, could still be overcome by the actuators since the lessened force that is exerted when a door is arrested in mid-movement will quickly build up as air continues to flow from that space of the actuator connected to exhaust and reduces the back pressure therein.

It may be noted that in the arrangement shown in FIG. 4, the restriction of movement is mainly required in only one direction of operation of each actuator, i.e. that associated with door-closing. Since the two actuators have opposite directions of movement, however, it is convenient to use a symmetrical, double-sided arrangement, as shown in FIGS. 1 and 3, for simplicity. It will be appreciated, however, that the invention is not restricted to such double-sided arrangements.

The further example of actuator shown in FIG. 5 is also a symmetrical arrangement and at each of the opposite side walls 10a, similarly to the first example, there is an external conduit connection 12 able to com-

municate with the chamber interior through a main port 16a and an auxiliary port 18a. Overlying the main port (but offset from the auxiliary port) there is a throttling plate 20a with aperture 24. The plate is entirely analogous to the plate 20 of the first example and is of cranked form to reduce the possibility of foreign matter being trapped under it. As before, an externally adjustable needle valve 34 is associated with the auxiliary port 18a.

A closure valve overlying the main port 16a comprises a spring plate 60 of rather different form from the equivalent plate 30 of the first example, but having a similar valve body 28 loosely mounted on it. The plate 60 is secured directly by the screws 26 holding the throttling plate 20a and extends in cantilever manner over the main port opening. It is made of a length of strip but is effectively of bifurcated form: that is to say it has the central part of its main portion 62 bent out to form a cantilevered secondary limb 64 to the free end of which is riveted the valve body 28. The free end 66 of the plate 60 has a curved profile to allow it to ride smoothly over the profiled face of an adjacent filler piece 68 secured to the piston 2 to extend over substantially the full axial length of the piston.

The profile of the filler piece includes a first portion 70 that is at an increasing radial distance from the pivot axis of the piston as it approaches a second portion 72 which is at a constant radius to the piston pivot axis. As the piston swings to an end position, it approaches the associated spring plate 60 and the free end 66 of the plate contacts the first portion 70 of the filler piece profile. This acts as a continuously rising cam while the piston continues its motion and the spring plate is thus flexed to bring the valve body 28 against the throttling plate aperture. The valve body is maintained against the aperture during any residual movement of the piston after the spring plate runs off the cam portion 70, the second portion 72 of the profile then bearing on the spring plate. The deflection of the spring plate is not increased further by the second portion 72 so that the stress in the plate is not increased at this stage.

In the return motion of the piston in the example of FIGS. 1 to 3 the pressure of incoming air flexes the leg 30a of the spring 30 sufficiently to allow air to enter through the port 16, independently of the setting of the needle valve 34 of FIGS. 1 and 2. In the example of FIG. 5 it is the secondary limb 64 that is flexed, independently of the spring plate 60. In both instances, therefore, the movement of the piston away from an end position can be accelerated relatively quickly, whatever the setting of the needle valve 34 or an equivalent bleed aperture.

In all other respects, the operation of this actuator is the same as that of the first-described example. Although the connections 12 and needle valves 34 are shown differently arranged, it will be appreciated that the two different forms of actuator can be arranged to have corresponding external configurations.

What I claim and desire to secure by Letters Patent is:

1. A rotary actuator for use with a source of compressible fluid under pressure comprising, in combination, a casing, a chamber within said casing, a pivotally mounted piston member within said chamber dividing the chamber of the actuator in two mutually sealed spaces, respective porting means provided leading from the exterior of the actuator to each space for the inflow

of pressure fluid from said source and for the outflow of fluid from said spaces, the piston member being pivotable between opposite end positions in the chamber by the admission of pressure fluid through the porting means of one space and the exhausting of fluid from the other space through the porting means thereof, restriction means within the chamber arranged in conjunction with at least one said porting means to be operative in at least one direction of travel of the piston member by the displacement of the piston member to restrict the outflow of fluid from the contracting space in order to retard the movement of the piston member after a predetermined part of the contraction of said space, said restriction means comprising a valve member, a spring member supporting said valve member so that it is normally spaced from the associated porting, a resilient element integral with or attached to said spring member being arranged to be contacted by the piston member at an intermediate stage of the contraction of said space so as to deflect the spring member and move the valve member towards the porting of said space as the piston member approaches its end position.

2. An actuator according to claim 1 wherein said restriction means further comprises a blocking device at said porting means that is displaceable by the pressure of incoming fluid to allow that fluid to enter the associated chamber space freely but that is operative in restricting the outflow of fluid from said space.

3. An actuator according to claim 1 comprising a hairpin spring one arm of which forms said resilient element on the other arm of which has the valve member mounted upon it, a cantilever spring supporting said hairpin spring and being attached to said hairpin spring at a point spaced from the valve member.

4. An actuator according to claim 1 wherein the spring member is bifurcated, one branch carrying the valve member and the other branch forming said resil-

ient element.

5. An actuator according to claim 1 wherein said restriction means comprises a blocking device at said porting means that is displaceable by the pressure of incoming fluid to allow that fluid to enter the associated chamber space freely but that is operative in restricting the outflow of fluid from said space and wherein the blocking device and the spring member are secured to a wall of the actuator casing by common attaching means.

6. An actuator according to claim 1 wherein the piston member has surfaces extending obliquely to its direction of travel for engagement with said resilient element such that said obliquity determines the rate of closure of the valve member relative to movement of the piston member.

7. An actuator according to claim 6 wherein said surfaces include a portion over which there is no movement of the resilient element with continuing movement of the piston member towards the end of its stroke.

8. An actuator according to claim 6 comprising at least one member on which said surfaces are formed, said member acting as a filler to reduce the free fluid volume in the contracted space of the chamber said member extending substantially the full axial length of the piston member in its region.

9. An actuator according to claim 1 comprising a bleed port associated with said porting means of the chamber spaces and arranged to provide an alternative path for the outflow of fluid.

10. An actuator according to claim 9 wherein resilient biasing means act on said bleed valve to urge it to a closed position whereby it can be opened by an increase of pressure in the contracting space of the actuator chamber.

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