Aug. 22, 1961 R. D. BENNETT ET AL 2,997,029

FLUID POWERED ACTUATOR

Filed June 20, 1958

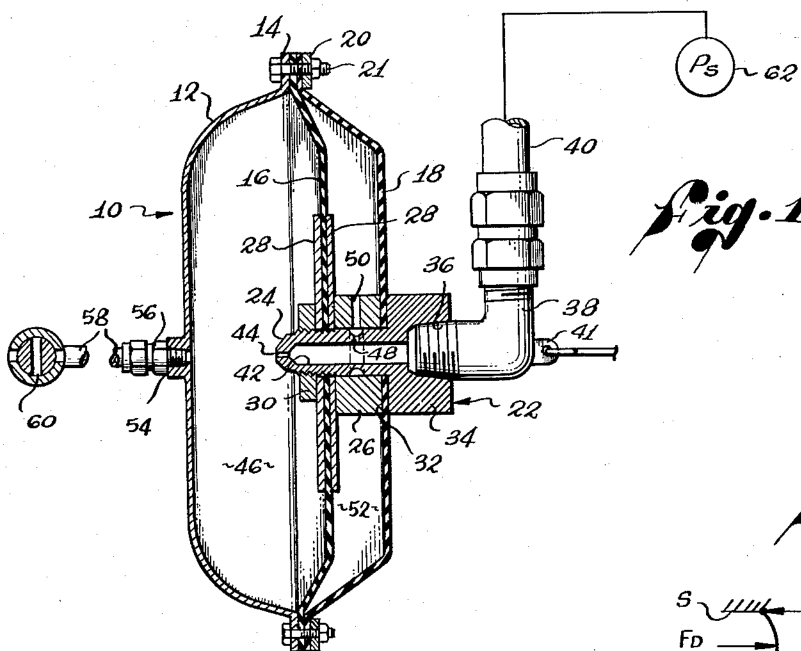


Fig. 1

Fig. 3

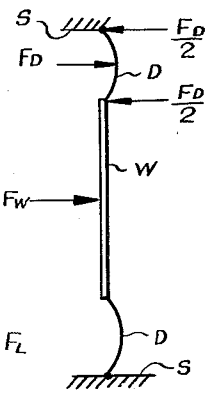
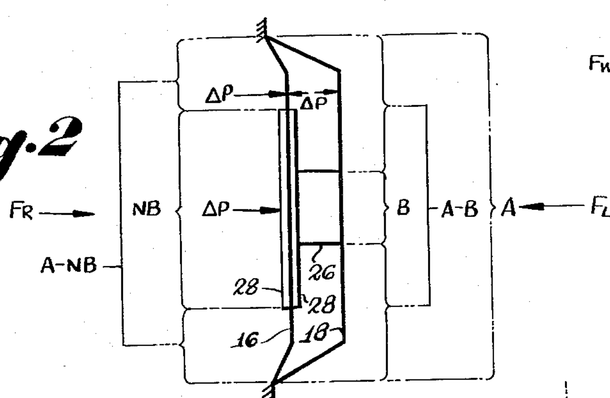


Fig. 2



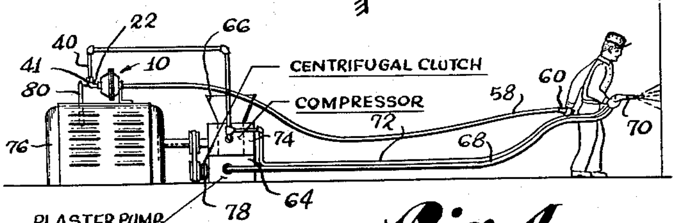


Fig. 4

INVENTORS

RICHARD D. BENNETT

MARVIN D. BENNETT

BY Forrest J. Lilly

Attorney

United States Patent Office 2,997,029
Patented Aug. 22, 1961

1

2,997,029

FLUID POWERED ACTUATOR

Richard D. Bennett, La Canada, and Marvin D. Bennett, Glendale, Calif., assignors to Thomsen Supply, Inc., Los Angeles, Calif., a corporation of California
Filed June 20, 1958, Ser. No. 743,328
3 Claims. (Cl. 121—48)

This invention relates to fluid pressure operated devices, and more particularly to a remotely controllable, fluid powered actuator.

Briefly stated, a fluid powered actuator is a fluid pressure operated device in which an operated member is moved in response to a change in the pressure differential across a movable pressure wall fixed to the member. Actuators of this type have many applications and are especially useful as remote control devices.

For illustrative purposes, the actuator of this invention will be described with reference to one of its typical uses, namely, as a remote control unit for the pump of a plaster spraying machine. In view of what has just been said, it should be understood that this use of the invention is intended to be illustrative rather than limiting in nature.

A broad object of the invention is the provision of an improved fluid powered actuator.

A more specific object is the provision of a fluid powered actuator in which the driven member is moved in opposite directions entirely by the action of pressure fluid.

Another object is the provision of an actuator of the character described which is designed to operate at substantially any fluid pressure.

Yet another object is the provision of an actuator of the character described which employs pneumatically unbalanced, flexible diaphragms as the pressure wall and as the fluid seal for the operated member so as to obtain substantially frictionless operation.

A further object is the provision of an actuator of the character described which is capable of being remotely controlled through a single fluid pressure control line.

Yet a further object is the provision of an actuator of the character described which is especially adapted for use on machines for pumping and spraying plaster and other semi-liquid material.

A still further object is the provision of an actuator for plaster spraying machines and the like, the controls for which actuator are entirely independent of any spray nozzle control means on the machine.

Other objects, advantages and features of the invention will become readily apparent as the description proceeds.

Briefly, these objects are attained by the provision of an actuator equipped with a hollow hermetic housing enclosing a movable pressure wall. The operated member of the actuator is attached to one side of this wall and extends to the outside of the housing for connection to a device to be operated.

The effective pressure or frontal area of said one side of the wall is less than the frontal area of the other side of the wall so that equalization of the pressures across the wall creates an unbalanced force on the member which moves the latter in one direction. When the pressure at said other side of the wall is reduced, an oppositely acting unbalanced force is exerted on the member which moves the latter in the other direction.

The actuator has a fluid inlet passage through which pressure fluid is supplied to both sides of the wall. A vent passage fitted with a control valve is provided for selectively venting pressure fluid from said other side of the wall. The pressures across the pressure wall may be selectively equalized or the pressure at said other side of the wall reduced, to cause movement of the operated member in one direction or the other, by operation of the control valve. This control valve may be connected to the actuator through a long control hose or line to permit remote control of the actuator.

2

In the illustrative embodiment of the invention, the pressure wall comprises a first flexible diaphragm. One side of the heremetic housing comprises a second flexible diaphragm through which the operated member extends and to which the member is fixed. These diaphragms are pneumatically unbalanced in such a way that equalization of the pressure across the first diaphragm moves the member toward the second diaphragm while venting of the actuator, in the mentioned manner, moves the member toward the first diaphragm.

A better understanding of the invention may be had from the following detailed description taken in connection with the annexed drawings, wherein:

FIG. 1 is a section through the illustrative embodiment of the present actuator;

FIGS. 2 and 3 are diagrammatic views showing the forces which act on the pressure wall means of the actuator; and

FIG. 4 illustrates one use of the actuator.

Referring now to these drawings, the hermetic housing of the present illustrative actuator 10 will be seen to comprise a hollow metal housing or cup 12 having an open forward side. This cup has an external flange 14 extending about its open side.

Extending across the open side of the cup is a first cupped diaphragm 16 which forms a primary pressure wall of the actuator. The periphery of this diaphragm overlies the housing flange 14.

Indicated at 18 is a second, cupped diaphragm which forms a side of the hermetic housing. Diaphragm 18 has its center portion spaced from the first diaphragm 16 and its periphery resting on the periphery of the first diaphragm. A clamping ring 20, overlying the periphery of the second diaphragm, is secured to the cup flange 14 by screws 21. The peripheries of the diaphragms are clamped between the flange and ring to provide a fluid-tight seal between the cup and diaphragms.

A nipple 22, which is the operated member of the actuator, has a reduced inner end 24 which extends through aligned central openings in the diaphragm 16 and 18. Received on this reduced end of the nipple, between the diaphragms, is a relatively thick washer 26. Also received on the reduced end 24 of the nipple, at the inside of the first diaphragm 16 and between the outside of the latter and the inner end of the washer 26, are a pair of relatively thin washers 28. The washers 28 will be seen to have an appreciably greater diameter than the washer 26.

The inner terminal end of the nipple 22 is threaded for receiving a nut 30. The centers of the diaphragms 16 and 18 and the washers 26 and 28 are tightly clamped between the nut 30 and a shoulder 32 on the enlarged outer end 34 on the nipple 22 to provide air-tight seals between the nipple and diaphragms.

The outer end 34 of the nipple has approximately the same diameter as the washer 26 and is axially bored and threaded at 36 for engagement with a threaded coupling 38 on an air hose 40. Coupling 38 carries coupling means 41 for connecting the coupling to a member to be operated by the actuator, as will be presently described.

Extending axially through the nipple is an air inlet passage 42 which opens at its outer end to the bore 36. The inner end of the passage 42 is reduced to form an orifice 44 which opens into the chamber 46 at the inner side of the first diaphragm 16. Aligned radial ports 48 and 50 in the nipple 22 and washer 26 communicate the nipple passage 42 with the chamber 52 between the diaphragms 16 and 18.

Cup 12 mounts a fitting 54 having a central, threaded vent passage which communicates to the chamber 46.

Fitting **54** receives a coupling **56** on an air line **58**. This air line serves as and will be hereinafter referred to as a control line. Control line **58** may be of any desired length, depending on the maximum distance from which the actuator is to be controlled, and terminates in a two-way remote control valve **60**.

Valve **60** has an open position in which the control line, and hence the diaphragm chamber **46**, are vented to atmosphere. In the second position of the valve **60**, the latter is closed and the chamber **46** becomes hermetically sealed.

In operation, the air line **40** is connected to a supply **62** of pressure air. The pressure of the supply is relatively unimportant, as will become clear as the description proceeds. Attention is here called to the fact that the mention herein of air as the operating fluid for the actuator is purely illustrative since it is obvious that other operating fluids may be used.

Referring now to FIG. 1, it will be seen that when the control valve **60** is closed, the air pressure in the two diaphragm chambers **46** and **52** is equal to the pressure p_s of the supply **62**. This pressure p_s, in turn, is equal to $p_a + \Delta p$, *where* p_a is atmospheric pressure and Δp is the amount the supply pressure is greater than atmospheric pressure. A pressure gauge on the supply, of course, would indicate only the pressure differential Δp. Obviously, only atmospheric pressure p_a acts on the outside of the diaphragm **18**.

Under these conditions, it is clear that the force developed by the supply pressure p_s, tending to move the diaphragms **16** and **18** and the nipple **22** to the right, as viewed in FIG. 1, is greater than the force, developed by atmospheric pressure, tending to move the diaphragms and nipple to the left. The diaphragms and nipple are, therefore, moved in a right-hand direction to their positions of FIG. 1. To put it in another way, the tendency is for the diaphragms (and nipple) to move in a direction to increase the volume of the pressure chamber which, in this case, is diaphragm chamber **46**.

As will presently be explained, the diaphragms **16** and **18** are pneumatically unbalanced in such a way that the supply pressure p_s in the diaphragm chamber **52** actually develops a force which aids the tendency of atmospheric pressure to move the diaphragms to the left. The force to the right on the diaphragms is, however, greater than the total force to the left, so that the diaphragms move to the right, as just mentioned.

When the control valve **60** is open, diaphragm chamber **46** is vented to atmosphere. Accordingly, air flow occurs from the hose **40**, through the orifice **44**, into the chamber **46**, and thence through the control line **58** to atmosphere. The orifice **44** drops the pressure of the air flowing therethrough so that the air in the vented diaphragm chamber **46** is approximately at atmospheric pressure. The air in the diaphragm chamber **52**, however, is still at the supply pressure p_s.

Under these conditions, the diaphragms again tend to move in a direction to enlarge the pressure chamber which, in this case, is diaphragm chamber **52**. A study of FIG. 1 will show that the diaphragm chamber **52** is enlarged by left-hand movement of the diaphragms. Accordingly, the diaphragms **16** and **18** and the nipple **22** move to the left when the control valve is open.

A more rigorous analysis of the actuator operation will now be set forth by reference to the schematic illustrations of FIGS. 2 and 3. In FIG. 2, the letter A denotes the total effective pressure or frontal area of each diaphragm. The total frontal areas of the diaphragms, of course, are the same.

The letter B denotes the area of the washer **26**. The area of the washers **28** is greater than the area B of the washer **26** by some factor N and has, therefore, been denoted by the symbol NB.

It will be apparent that since the diaphragms and washers are tightly clamped together, the diaphragms **16** and **18** (i.e., the flexible portions of the diaphragms) are, in

effect, annular diaphragms which have their inner and outer annular edges attached to the washers and actuator housing, respectively. These annular diaphragms have total effective frontal areas (A—NB) and (A—B), respectively, as indicated in the drawings.

In the following discussion, F_R denotes the previously mentioned right-hand force on the diaphragms, F_L denotes the left-hand force, and F_T denotes the unbalance or resultant force. Forces acting to the right will be considered to be positive, while forces acting to the left will be considered to be negative. Only the pressure differential Δp, i.e., gauge pressure, of the supply will be considered since it is obvious that the forces developed by atmospheric pressure will cancel out.

Referring first to FIG. 3, it will be seen that when air pressure acts on an annular diaphragm D, secured along its outer edge to a stationary support S and along its inner edge to a rigid washer W, such as is the case in the present actuator, approximately one-half of the total load or force F_D on the diaphragm is carried by the structure S and the other half of the load is carried by the washer W. The force F_W resulting from air pressure acting on the area of the washer, however, is carried entirely by the washer. The resultant force tending to move the washer in the direction in which the pressure acts, i.e., to the right, is equal therefore to

$$\frac{F_D}{2} + F_w$$

With this discussion in mind, reference is again made to FIG. 2, wherein it will be seen that when the control valve **60** is closed, so that the pressure in both the diaphragm chambers is equal to Δp, the force F_R tending to move the diaphragms **16** and **18** and the nipple to the right is:

$$F_R = \Delta p\left(\frac{A-NB}{2}\right) + \Delta p(NB) + \Delta p\left(\frac{A-NB}{2}\right)$$

$$= \Delta p\left(A + \frac{NB}{2} - \frac{B}{2}\right)$$

The force F_L tending to move the diaphragms and nipple to the left is:

$$F_L = -\left[\Delta p\left(\frac{A-NB}{2}\right) + \Delta p(NB-B)\right]$$

$$= -\Delta p\left(\frac{A}{2} + \frac{NB}{2} - B\right)$$

The resultant force F_T on the diaphragms and nipples is:

$$F_T = F_R + F_L$$

$$= \Delta p\left(\frac{A+B}{2}\right)$$

Since this resultant force is positive, it moves the diaphragms and nipple to the right, as previously mentioned.

When the control valve **60** is open, the pressure in the diaphragm chamber **46** will be assumed to be atmospheric. Under these conditions, the force F_R is:

$$F_R = \Delta p\left(\frac{A-B}{2}\right)$$

Similarly, the force F_L is:

$$F_L = -\left[\Delta p\left(\frac{A-NB}{2}\right) + \Delta p(NB-B)\right]$$

The resultant force F_R in this case is, therefore:

$$F_T = F_R + F_L$$

$$= \Delta p\left(\frac{B-NB}{2}\right)$$

Since N is greater than 1, this resultant force is negative and hence moves the diaphragms and nipple to the left, as previously mentioned.

It will be clear, therefore, that the operating member or nipple 22 can be remotely controlled for movement to the right or to the left by either opening or closing the control valve 60.

As preliminarily mentioned, the present actuator has numerous uses, one of which is a remote control device for a machine for pumping and spraying plaster, cement, and the like. FIG. 4 diagrammatically illustrates a machine of this character on which the present actuator may be used.

As shown, the machine comprises a pump 64 which is supplied with material to be pumped from a hopper 66. The pump discharges the material to a hose 68 which may or may not have a spray nozzle 70 at its end. When the nozzle 70 is used, an air line 72 leads from the nozzle to an air compressor 74 in the machine. During a spraying operation of the machine, air is delivered to the nozzle through line 72 for dispersing the plaster or other material issuing through the nozzle into a spray.

The pump 64 is driven by a gasoline engine 76 through a centrifugal clutch 78. This clutch is designed to engage when the engine attains a predetermined speed and disengage when the engine drops below that speed. Compressor 74 is driven directly from the engine 76, as illustrated.

Engine 76 has a conventional throttle arm 80. Movement of the throttle arm to the left in FIG. 4 accelerates the engine while movement of the arm to the right decelerates the engine. The present actuator 10 is mounted on the engine with the coupling means 41 on the nipple connected to the throttle arm 80. Engine 76 may embody, in the conventional manner, a governor (not shown) having a spring (not shown) for biasing the throttle arm to its high speed position.

The parts are arranged so that movement of the nipple 22 in response to opening of the control valve 60 of the actuator decelerates the engine while movement of the nipple in response to closing of the control valve accelerates the engine. When the engine decelerates, the clutch 78 disengages and the pump 64 is stopped. When the engine accelerates, the clutch engages to drive the pump. Compressor 74, of course, is operated continuously during operation of the engine.

When the engine is stopped, the throttle arm 80 is biased to the left to its high speed position by the governor spring (not shown). This facilitates subsequent starting of the engine.

It will be apparent, therefore, that there has been described and illustrated an actuator which is fully capable of attaining the objects preliminarily set forth.

Numerous modifications in design and arrangement of parts of the invention are, of course, possible within the scope of the following claims.

We claim:

1. A diaphragm actuator comprising a hollow housing open at one side, a pair of inner and outer flexible, pneumatically unbalanced diaphragm means sealed about their edges to said housing about said open side and defining between them a first chamber, a member rigidly connecting the centers of said diaphragm means whereby the member moves with the diaphragm means during flexing of the latter, the pneumatic unbalance of said diaphragm means remaining relatively constant during flexing of the diaphragm means and creating an unbalanced force tending to move said diaphragm means and member toward the housing when said chamber is pressurized, said housing and inner diaphragm means defining therebetween a second chamber, said diaphragm means and member being moved away from said housing when the pressures in said first and second chambers are equalized and greater than ambient pressure acting on the outside of the outer diaphragm means, said member having an inlet passage opening to the outside of the outer diaphragm means for connection to a source of pressure air and having a relatively unrestricted communication to said first chamber and a restricted communication to said second chamber, and means including a control valve for selectively venting said second chamber.

2. The subject matter of claim 1 wherein said member extends through said outer diaphragm means to the outside of the latter and said inlet passage opens through the outer end of the member, and an operating link secured to the outer end of the member.

3. A diaphragm actuator comprising a hollow housing, a pair of diaphragm means in said housing and defining a first chamber between the diaphragm means, said diaphragm means comprising rigid center portions and outer annular flexible portions sealed along their outer edges to said housing and about their inner edges to their respective center portions, a member rigidly connecting said center portions, said outer portions having approximately the same outer diameter and said center portions having different diameters whereby said flexible portions have different effective areas which remain fixed during flexing of the diaphragm means and pressurizing of said chamber produces an unbalanced force tending to move the member and diaphragm means in the direction of the diaphragm means having the center portion of larger diameter, said housing and latter diaphragm means defining a second chamber, said diaphragm means and member moving in the opposite direction when the pressures in said chambers are equalized and greater than the ambient pressure acting on the side of the other diaphragm means opposite the first chamber, said actuator including an inlet passage opening to the outside of the actuator for connection to a source of pressure air and having relatively unrestricted communication with said first chamber and relatively restricted communication with the second chamber, and a valved vent passage opening to said second chamber.

References Cited in the file of this patent

UNITED STATES PATENTS

1,753,469	Melas	Apr. 8, 1930
2,411,748	Kelley	Nov. 26, 1946
2,825,361	Seljos	Mar. 4, 1958
2,839,086	Engelberger	June 17, 1958