

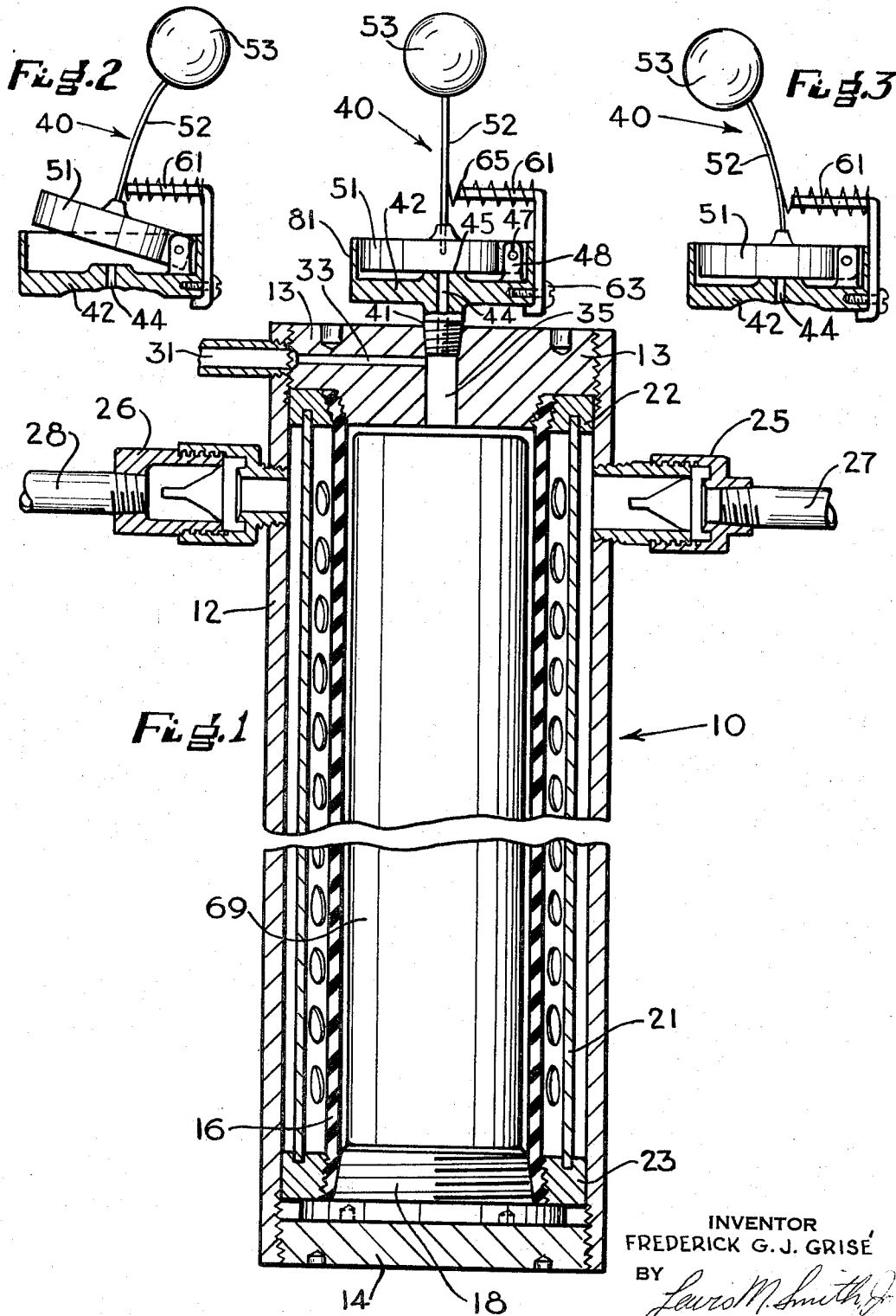
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FLUID ACTUATED PUMP

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The present invention relates to a fluid actuated pump, and more particularly to a pump through which a first fluid is pumped by a second fluid alternately confined under pressure within and released from an expansible chamber by a self-actuated control valve means alternately maintained closed and then maintained open by an inertial weight.

The type of pump assembly including a rigid hollow container and a flexible membrane arranged to divide the space within the container into two variable volume chambers, one containing the pumped fluid and one containing the pumping fluid, is generally well known, but the rigid hollow container and the flexible membrane appear in many different configurations. Regardless of the configuration of these parts, the chamber for pumped fluid which they define generally receives and discharges the pumped fluid through a pair of check valves suitably oriented for their respective functions. On the other hand, various different arrangements including purely mechanical and other means are employed to produce cyclic variations of fluid pressure within the chamber containing pumping fluid.

The present invention contemplates a self-actuated control valve means which is compact, consists of a relatively simple mechanism, and is reliable in operation, so that it is particularly useful as the means of producing cyclic variations of fluid pressure within a chamber containing a suitable pumping fluid such as compressed air which may be supplied continuously from a remote source.

An object of the present invention is the provision of a fluid actuated pump suitable for safe operation in an environment rendered hazardous by explosive vapors.

Another object is the provision of a fluid actuated pump controlled by a simple and reliable self-actuating control valve means.

A further object is the provision of a fluid actuated pump incorporating means arranged to minimize the expenditure of pressurized pumping fluid required to operate the pump.

Still another object is the provision of a control valve means for a fluid actuated pump which can be arranged to operate in the desired cyclic manner in various different attitudes.

Yet another object is the provision of a self-actuated control valve means for a fluid actuated pump which is reliably self-starting when a pressurized pumping fluid is first supplied to the pump.

A final object of the present invention is the provision of a self-actuating control valve means incorporating an inertial weight alternately effective to maintain the control valve means closed and then to maintain said control valve means open.

Other objects and advantages of this invention will be apparent upon consideration of the following description and the showing in the accompanying drawings wherein:

FIG. 1 is a longitudinal section through a typical fluid actuated pump equipped with the preferred embodiment of the self-actuated control valve means incorporating the instant invention,

FIG. 2 is a partial section showing the control valve means illustrated in FIG. 1 moved to its extreme open position, and

FIG. 3 is a partial section showing the control valve means illustrated in FIG. 1 returned to its extreme closed position.

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Referring now to the drawings wherein like reference numerals refer to like or corresponding parts, FIG. 1 shows a typical fluid actuated pump generally designated by the reference numeral 10, including a rigid housing consisting of a hollow cylindrical barrel 12, an upper cap member 13, and a lower cap member 14, a flexible membrane in this case comprising a tube 16, of stretchable material of rubber or a suitable plastic or the like with one end fitted over a circular boss 17, dependent from the upper cap member 13 and having a tapered peripheral surface threaded or otherwise serrated for gripping engagement with the inner surface of tube 16, and with the other end fitted over a circular plug 18, also having a tapered peripheral surface threaded or otherwise serrated for gripping engagement with the inner surface of tube 16 and supported by the lower cap member 14; and a rigid perforate tube 21 for limiting expansion of the tube 16 maintained concentric with the barrel 12 and the tube 16 by a pair of grooved spacer rings 22 and 23 supporting the tube 21 as shown in FIG. 1 and also serving to secure the ends of the tube 16 by means of tapered inner surfaces threaded or otherwise serrated for gripping engagement with the outer surface of the tube 16.

As illustrated in FIG. 1, the pump 10 is equipped with an inlet flow control valve 25 and an outlet flow control valve 26 for the pumped fluid chamber, both valve 25 and valve 26 including flexible valve members supported by and cooperating with the elements of a rigid annular housing in the manner described and illustrated in my co-pending application Serial No. 437,463 entitled, Check Valve, filed March 5, 1965. Accordingly, whenever the fluid pressure to the right of the flexible valve member exceeds the fluid pressure to the left of the flexible valve member in valve 25 or valve 26 as shown in FIG. 1, a slit in the flattened tip end of the flexible valve member opens to pass the pumped fluid, either from the inlet pipe 27 into the pumped fluid chamber within barrel 12 through the inlet valve 25 or from the pumped fluid chamber within barrel 12 into the outlet pipe 28 through the outlet valve 28.

Referring again to the showing in FIG. 1, an inlet conduit 31 threadably engaged with the barrel 12 is provided to supply a suitable pressurized fluid to the pumping fluid chamber within the flexible tube 16 through a radial passage 33 and a central opening 35, both extending through the upper cap member 13. When the pressurized fluid supplied through the conduit 31 is air, for example, it may be delivered from a remotely located air compressor not illustrated because such equipment is well-known and because it forms no part of the present invention.

A control valve assembly generally designated in FIG. 1 and elsewhere by the reference numeral 40 is secured to the upper cap member 13 by means of a relatively reduced shank portion 41 threadably engaged with the upper end of the central opening 35. The shank portion 41 together with a relatively enlarged circular head portion 42 forms a valve body with a central passage 44 with an outlet opening at its upper end encircled by a raised portion of the valve body forming a valve seat 45. The valve body also supports a hinge means which may consist of a hinge pin 47 supported by a pair of lugs 48, only one of which is visible in FIG. 1 and elsewhere, which may be formed integral with the head portion 42 of the valve body. The hinge pin 47 also passes through and pivotally supports a relatively large flat generally circular valve member 51 supporting an elongated resilient member 52 fixedly secured at its lower end to the valve member 51 and provided at its upper end with a relatively concentrated weight 53 fixedly secured to the elongated resilient member 52.

As shown in FIG. 1 and elsewhere, the control valve assembly 40 is also equipped with a fixed stop member 61

secured to the valve body by any suitable attachment means such as the screw 63 shown as threadably engaged with the head portion 42 of the valve body. As illustrated, the fixed stop member 61 is positioned to be engaged by the elongated resilient member 52 to limit the displacement of the valve member 51 relative to the valve body. In order to provide a smoother cycle of operation for the control valve assembly 40, the fixed stop member 61 may also support a compressing spring member 65 self-biased into engagement with the elongated resilient member 52 near the end secured to the valve member 51, to cushion the movement of elongated resilient member 52 into engagement with fixed stop member 61.

Since the present invention is particularly useful for applications in which the pumping fluid used is air, a compressible fluid, the amount of pressurized air expended to operate the pump described above can be minimized by reducing to a minimum the volume within the pumping fluid chamber initially available to receive a pressurized pumping fluid before the flexible membrane is expanded. In the pump configuration illustrated in FIG. 1, this is accomplished by installing within the tube 16 a cylindrical filler member 69 of a size to fill almost all of the space between the upper cap member 13 and the circular plug 18 and within the tube 16. Without the filler member 69, the space it occupies would have to be filled with pressurized air each time the valve member 51 is closed while the pump 10 is operating. With the filler member 69 located as shown in FIG. 1, the quantity of pressurized air required to fill the space occupied by filler member 69 is saved once during each cycle of valve member 51 and substantially the entire amount of the pressurized air admitted through the inlet conduit 31 is effective to expand the tube 16.

In fluid actuated pumps of different configurations in which the flexible membrane defines a pumping fluid chamber with a substantial minimum volume, a corresponding saving of a compressible pumping fluid can be effected by installing a filler member of a suitable size and shape to fill substantially all of the minimum volume of the pumping fluid chamber.

Alternatively, the advantage of this feature may be provided by adopting a fluid actuated pump configuration in which the flexible membrane is so shaped and disposed that the pumping fluid chamber is almost entirely evacuated each time the pressurized fluid confined within the pumping fluid chamber is released.

The advantage in having a pumping fluid chamber which is almost entirely evacuated every time the pressurized fluid is released can be had by using a filler member 69 or by selecting a pump configuration with this characteristic without significantly affecting the performance of a fluid actuated pump so arranged, if the rigid surface of the filler member or its equivalent structure is slightly spaced from the entire inner surface of the flexible membrane in the manner illustrated in FIG. 1 by the exaggerated showing of a space between the tube 16 and the filler member 69. This spacing permits the pressurized pumping fluid to reach and act on the entire inner surface of the tube 16 as soon as the valve member 51 closes.

Operation of the pump 10 is initiated by supplying a pressurized fluid, for example compressed air, through the inlet conduit 31, the radial passage 33, and the central opening 35 to the chamber formed by the tube 16, the upper cap member 13 and the circular plug 18. With the valve member 51 positioned as shown in FIG. 1 so that it closes and seals the central passage 44, the pressurized pumping fluid confined within the chamber communicating with central passage 44 expands stretchable tube 16 against the rigid perforate tube 21 to force some of the pumped fluid occupying the space between the tube 16 and the barrel 12 through outlet flow control valve 26 into the outlet pipe 28.

When the force exerted against the underside of the

valve member 51 by the pressurized pumping fluid builds up sufficiently to do so, it displaces the valve member 51 from the valve seat 45. The resulting rotation of the valve member, clockwise as seen in FIG. 2, is limited by the engagement of the elongated resilient member 52 with the fixed stop member 61. The subsequent overtravel of the yieldably supported inertially biased weight 53, illustrated in FIG. 2, holds the valve member 51 open long enough to release the pressurized pumping fluid.

With release of the pumping fluid, the tube 16 contracts to draw more pumped fluid into the space between tube 16 and the barrel 12 through the inlet flow control valve 25 from the inlet pipe 27.

At this point in the operating cycle, the elongated resilient member 52, previously deflected to the right as seen in FIG. 2 by the overtravel of the inertial weight 53, moves the weight 53 in the opposite direction permitting the valve member 51 to rotate into its closed position. The subsequent counterclockwise overtravel of the yieldably supported inertially biased weight 53 illustrated in FIG. 3 holds the valve member 51 closed long enough for the pressurized fluid to fully expand the tube 16 to displace some of the pumped fluid from its chamber.

Thereafter, the elongated resilient member 52, previously deflected to the left as seen in FIG. 3 by the overtravel of the inertial weight 53, moves the weight 53 in the original direction permitting the valve member 51 to be rotated out of its closed position to release the pressurized pumping fluid.

A fluid actuated pump equipped with a control valve assembly 40 of the type described and illustrated herein will operate satisfactorily notwithstanding substantial variations both in the pressure level and in the volume of the pressurized pumping fluid. For example, a fluid actuated pump so equipped may be adjusted to be operated by a pumping fluid at a pressure of about thirty pounds per square inch and still operate when the pumping fluid pressure is reduced below ten pounds per square inch. Similarly, a fluid actuated pump so equipped will continue to operate satisfactorily despite variations in the supply of pressurized pumping fluid between a full flow through the inlet conduit 31 and a sharply reduced flow.

The control valve assembly 40 is always a self-starting mechanism wherever a pumping fluid is admitted to the pump 10 at or above the minimum pressure necessary to open the valve member 51 for the first time. However, when the pressurized pumping fluid is first admitted to the pump and especially under marginal operating conditions as when the pressure and the volume of flow of the pumping fluid are relatively low, the valve member 51 may dither for a short time before regular cyclic movement of the valve member is established. This delay in starting can be eliminated by providing a shroud ring 81 either attached to or formed integrally with the head portion 42 of the valve body as shown in the drawings. For maximum effect, the shroud ring 81 should encircle the valve member 51 with the minimum clearance required to permit unrestricted displacement of the valve member 51 without constraint from the shroud 81. Effective use of the shroud 81 also requires that clearance around the hinge means for the valve member 51 be minimized, as by including on the valve member 51 portions extending over the tops of the lugs 48 with outer edges conforming to the inner surface of the shroud ring 81.

When a pressurized pumping fluid is first admitted to a fluid actuated pump such as pump 10 illustrated in FIG. 1 equipped with the control valve assembly 40 shown in FIGS. 1, 2 and 3, the valve member 51 remains closed until the pressure within the pumping fluid chamber builds up sufficiently to lift the valve member 51 off of the valve seat 45 by acting on the small central portion of the underside of valve member 51 covering the outlet opening at the top of the central passage 44. As soon as the

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valve member is lifted from the valve seat 45 sufficiently to permit the passage of the pressurized pumping fluid into the space encompassed by the upper surface of the head portion 42 of the valve body, the inner surface of the shroud ring 81, and the underside of the valve member 51, the pressurized pumping fluid acts on the much larger surface comprising the entire underside of the valve member 51 to accelerate displacement of the valve member relative to the valve body very substantially, thus assuring the immediate establishment of the regular cycle of movement for the valve member 51, the elongated resilient member 52, and the weight 53 between the two extreme positions shown in FIGS. 2 and 3, respectively.

While the shroud ring is particularly useful to assure prompt establishment of steady state cyclic operation of the control valve assembly 40, it also accelerates the displacement of the valve member 51 each time it starts moving toward its open position so that the effect of the inertially biased yieldably supported weight 53 is increased when the elongated resilient member 52 strikes the fixed stop member 61. This produces a snappy cyclic movement of the valve member 51 to assure efficient operation of a fluid actuated pump equipped with a control valve assembly 40 including a shroud ring 81.

As noted above, it will be evident that the self-actuated control valve assembly 40 is also suitable for use with fluid actuated pumps of various different configurations other than that shown in FIG. 1. Moreover, while the control valve assembly 40 described and illustrated herein is generally circular, it may be shaped and arranged otherwise as required for various different applications.

The control valve assembly may also be mounted in various different attitudes as required for various applications. For example, the valve body may be so disposed that the valve member 51 is dependent from the hinge means substantially in a vertical plane with the elongated resilient member 52 extending substantially horizontally when the valve member 51 is closed. The valve body may even be disposed in a horizontal position inverted from that shown in FIGS. 1, 2, and 3, provided that the elongated resilient member 52 is arranged to support the weight 53 on the opposite side of the hinge means from the valve member 51 to serve also as a counterweight effective to support the valve member 51 in its closed position.

The disposition of the valve body so that the valve member 51 is closed in either of the attitudes referred to immediately above may suggest the elimination of the fixed stop member 61, since the valve member 51 will be returned to its closed position by the force of gravity. A control valve assembly 40 in which the valve body and the valve member 51 are so disposed is capable of being cycled under some operating conditions without the use of a fixed stop member 61, but the elimination of this member would substantially diminish both the adaptability and the performance of the control valve assembly. The adaptability of the control valve assembly 40 is in part dependent upon the fact that its various elements particularly including the fixed stop member 61 can be either modified or adjusted to provide peak performance of the control valve assembly under different operating conditions. Hence, an important feature of this adaptability is lost when the fixed stop member 61 is eliminated. More important, elimination of the fixed stop member 61 eliminates the holding effect of the inertially biased yieldably supported weight 53 on the valve member 51 when it reaches its extreme open position. Consequently, the rate of displacement of the valve member 51 differs substantially between the opening and the closing portions of its cycle, with the result that the operating cycle of the control valve assembly 40 is erratic and inefficient. Accordingly, some form of fixed stop equivalent to fixed stop member 61 is considered an essential feature of the control valve assembly 40.

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The fixed stop member 61 may be positioned so that it engages the rigid valve member 51 itself rather than the elongated resilient member 52 as shown in the drawings. However, such an arrangement may necessitate more frequent modification or adjustment of the position of the fixed stop member 61 than is the case with the embodiment illustrated in the drawings in which the relatively stiff but yieldable elongated resilient member 52 acts as a self-adjusting stop engaging means for the valve member 51 to which it is secured.

The initial clearance between the peripheral surface of the valve member 51 and the inner surface of the shroud ring 81 can be minimized without interfering with the displacement of the valve member 51 relative to the head portion 42 of the valve body by shaping these surfaces so that they are complementary slight tapers or suitable toroidal sections.

The exact location of the hinge pin 47 is not critical, so that hinge means may be modified to minimize interference with the function of the shroud ring 18. For example, the hinge pin 47 may be supported either above or radially beyond the shroud ring 81 on bridging members respectively connected to the head portion 42 of the valve body and to the valve member 51.

Thus, the present invention provides a simple and reliable fluid actuated pump featuring a self-starting control valve assembly operable satisfactorily under relatively widely variant operating conditions in various different attitudes and with a minimum expenditure of a compressible pressurized pumping fluid.

The description provided herein and the showing in the accompanying drawings are to be considered as illustrative of this invention rather than in a limiting sense, since various modifications of this device may be made within the scope of the appended claims.

What is claimed is:

1. A self-cycling control valve assembly rhythmically operable to confine and then release a pressurized fluid, comprising a valve body arranged to be mounted in the wall of a container, a passage through said valve body terminating in an outlet opening, a valve member mounted for reciprocating movement into and out of a position in engagement with said valve body in which the outlet opening is closed and sealed by said valve member, an elongated resilient member fixedly secured to and projecting from said valve member, an inertial weight secured to said elongated resilient member remote from said valve member, and a fixed stop means mounted so that it limits displacement of said valve member from its position in engagement with said valve body in which the outlet opening is closed and sealed by said valve member, said elongated resilient member being arranged when movement of said valve member relative to said valve body is arrested first to yield to and then to recover from the continued relative movement of said inertial weight to reverse the direction of movement of the inertial weight after a predetermined time delay.

2. A control valve assembly as described in claim 1, wherein a hinge means pivotally interconnects said valve body and said valve member, and said inertial weight is supported by said elongated resilient member in such a position relative to said hinge means that said inertial weight acts to maintain said valve member in its position in engagement with said valve body in which the outlet opening is closed and sealed by said valve member until a fluid confined by said control valve assembly reaches a predetermined pressure.

3. A self-cycling control valve assembly rhythmically operable to confine and then release a pressurized fluid, comprising a valve body arranged to be mounted so that it extends through the wall of a container, an opening through said valve body extending from the interior of a container in which said control valve assembly is mounted to an outlet through a raised portion of said valve body which serves as a valve seat, a valve member mounted

for reciprocating movement into and out of a predetermined position in engagement with said valve body in which the outlet is closed and sealed by the engagement of one side of said valve member with the raised valve seat portion of said valve body, a hinge means pivotally interconnecting said valve body and said valve member, an elongated resilient member with one end fixedly secured to the other side of said valve member and with the other end remote from said valve member, an inertial weight secured to the other end of said elongated resilient member, and a stop means mounted in fixed relation to said valve body so that it limits displacement of said valve member from its position in engagement with the raised valve seat portion of said valve body in which the outlet is closed and sealed by said valve member, said elongated resilient member being arranged when movement of said valve member in either direction relative to said valve body is arrested first to yield to and then to recover from the continued relative movement in the same direction of said inertial weight, thereby reversing the direction of movement of the inertial weight after a predetermined time delay.

4. A self-actuated control valve assembly as described in claim 3, wherein said stop means is so fixedly mounted relative to said valve body that it is engaged by said elongated resilient member to limit displacement of said valve member relative to said valve body.

5. A pump assembly including a rigid hollow container, a flexible membrane forming a first variable volume chamber within the container for a pumped fluid and a second variable volume chamber within the container for a pressurized pumping fluid, pumped fluid inlet and outlet openings communicating with the first chamber, an inlet for a pressurized pumping fluid communicating with the second chamber, and a self-actuated control valve assembly cyclically operable to confine and then release a pressurized fluid, said control valve assembly comprising a valve body arranged to be mounted sealably in the container so that a passage through said valve body communicates with the second chamber and terminates outside of the container in an outlet opening, a valve member mounted for movement into and out of a position in engagement with said valve body in which the outlet opening is closed and sealed by said valve member, an elongated resilient member fixedly secured to and projecting from said valve member, an inertial weight secured to said elongated resilient member remote from said valve member, and a stop mounted in fixed relation to said valve body so that it limits displacement of said valve member from its position in engagement with said valve body in which the outlet opening is closed and sealed by said valve member, whereby a pressurized pumping fluid is alternately confined within and then released from the second variable volume chamber so that the volumes of the first and second chambers are alternately increased and decreased to apply a pumping action to a pumped fluid.

6. Apparatus as described in claim 5, wherein the portion of said valve body adjoining the outlet opening is raised relative to the outer surface of said valve body so that it serves as a valve seat surrounding the outlet opening sealably engaged by said valve member when said valve member is positioned in engagement with said valve body.

7. Apparatus as described in claim 5, and, in addition, a rigid filler member located within and of a shape and size substantially to fill the second variable volume chamber when the pressurized pumping fluid has been released through the outlet opening to allow the volume of the second chamber to decrease.

8. Apparatus as described in claim 7, wherein the flexible membrane is an elongated tube of resilient material secured at both ends to the rigid hollow container to enclose the second variable volume chamber, and the

rigid filler member is an elongated cylindrical plug located concentrically within said elongated tube and substantially filling the second chamber when it is not closed to confine a pressurized pumping fluid.

9. Apparatus as described in claim 5, wherein the volume within the second variable volume chamber which is available to receive a pressurized pumping fluid approaches zero whenever a pressurized pumping fluid is released from the second variable volume chamber to decrease its volume.

10. A pump assembly including a rigid hollow container, a flexible membrane mounted within said rigid hollow container so that it forms a first variable volume chamber within said container for a pumped fluid and a second variable volume chamber within said container for a pressurized pumping fluid, an inlet opening through which a pumped fluid is admitted to said first chamber when its volume is increased, an outlet opening through which a pumped fluid is discharged from said first chamber when its volume is decreased, an inlet through which a pressurized pumping fluid is continuously admitted to said second chamber, and a self-cycling pump control means rhythmically operable first to confine a pressurized pumping fluid within said second chamber to increase its volume and then to release a pressurized fluid from within said second chamber to decrease its volume, said flexible membrane being so shaped and disposed that the volume within said second chamber available to receive a pressurized pumping fluid closely approaches but does not reach zero each time a pressurized pumping fluid is released from said second chamber to decrease its volume.

11. A control valve assembly cyclically operable to confine and then release a pressurized fluid, comprising a valve body arranged to be mounted in the wall of a container, a passage through said valve body terminating in an outlet opening, a valve member mounted for movement into and out of a position in engagement with said valve body in which the outlet opening is closed and sealed by said valve member, hinge means pivotally interconnecting said valve body and said valve member, an elongated resilient member fixedly secured to and projecting from said valve member, an inertial weight secured to said elongated member remote from said valve member and in such a position relative to said hinge means that said inertial weight acts to maintain said valve member in its position in engagement with said valve body in which the outlet opening is closed and sealed by said valve member until a fluid confined by said control valve assembly reaches a predetermined pressure, a fixed stop means mounted upon said valve body so that it limits displacement of said valve member from its position in engagement with said valve body by engagement with said elongated resilient member, and a spring means supported upon said fixed stop means and self-biased into engagement with said elongated resilient member.

12. A self-actuated control valve assembly cyclically operable to confine and then release a pressurized fluid, comprising a valve body arranged to be mounted so that it extends through the wall of a container, an opening through said valve body extending from the interior of a container in which said control valve assembly is mounted to an outlet through a raised portion of said valve body which serves as a valve seat, a valve member mounted for movement into and out of a predetermined position in engagement with said valve body in which the outlet is closed and sealed by the engagement of one side of said valve member with the raised valve seat portion of said valve body, a hinge means pivotally interconnecting said valve body and said valve member, an elongated resilient member with one end fixedly secured to the other side of said valve member and with the other end remote from said valve member, an inertial weight secured to the other end of said elongated resilient mem-

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ber, a stop means so fixedly mounted relative to said valve body that it is engaged by said elongated resilient member to limit displacement of said valve member from its position in engagement with the raised valve seat portion of said valve body in which the outlet is closed and sealed by said valve member, and a spring means supported by said stop means so that said spring means is self-biased into engagement with said elongated resilient member and is arranged to yield as said elongated resilient member is moved toward said stop means by displacement of said valve member relative to said valve body.

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