March 10, 1959 M. M. BORDEN 2,876,789

APPARATUS FOR USE WITH LIQUID ENCLOSURES

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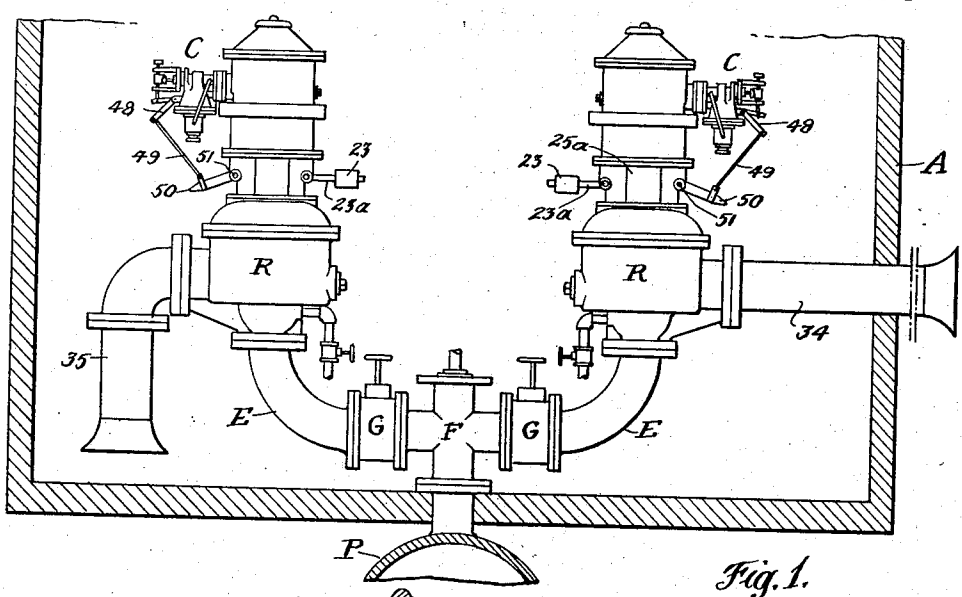


Fig. 1.

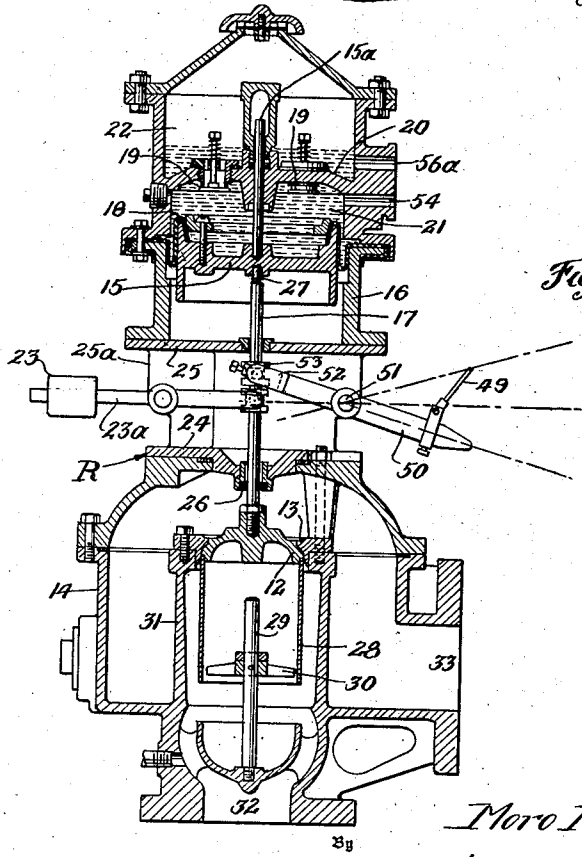


Fig. 2.

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Fig. 3.

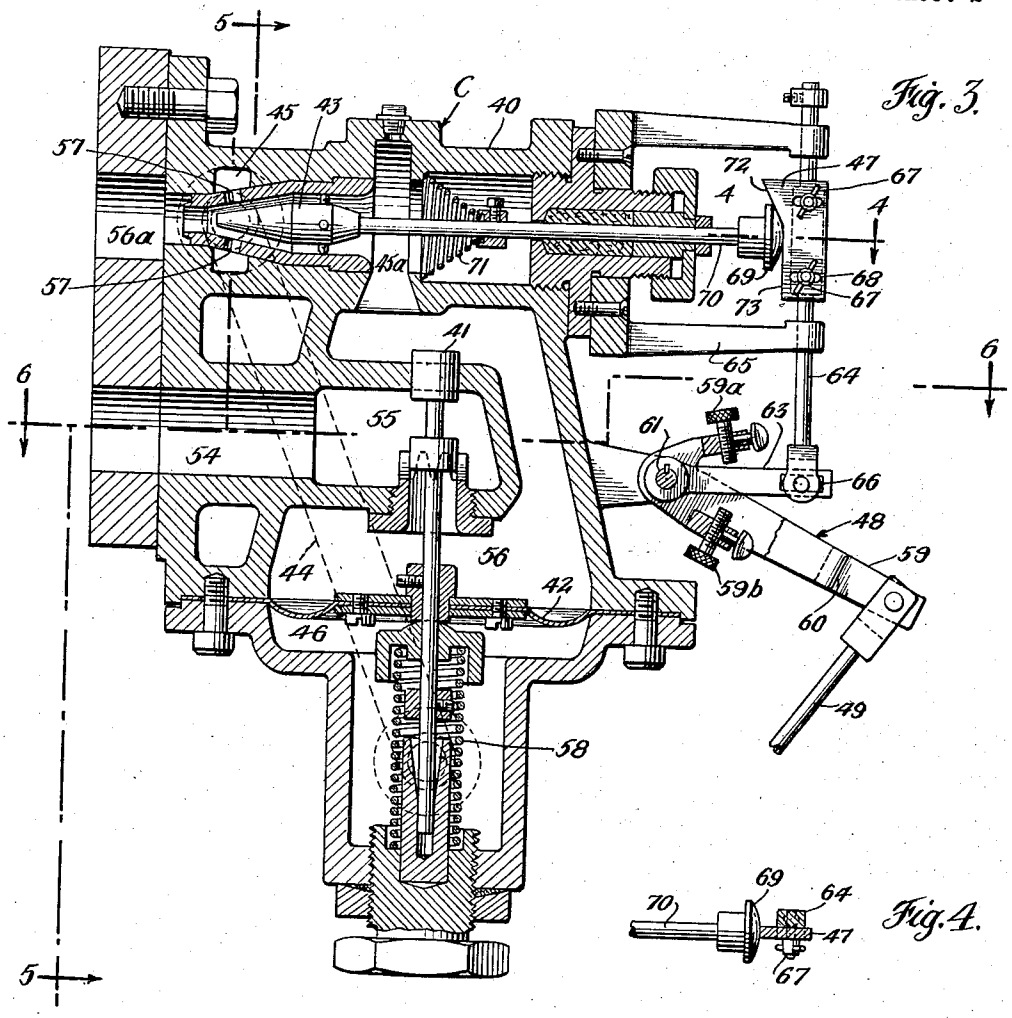


Fig. 4.

Fig. 7. Fig. 8. Fig. 9. Fig. 10. Fig. 11. Fig. 12.

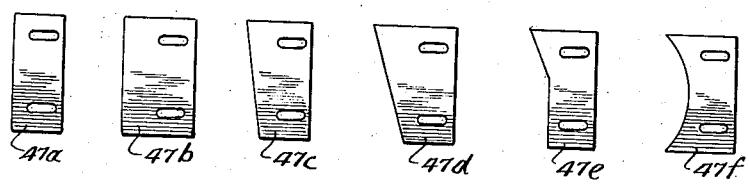
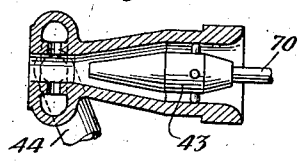


Fig. 13.



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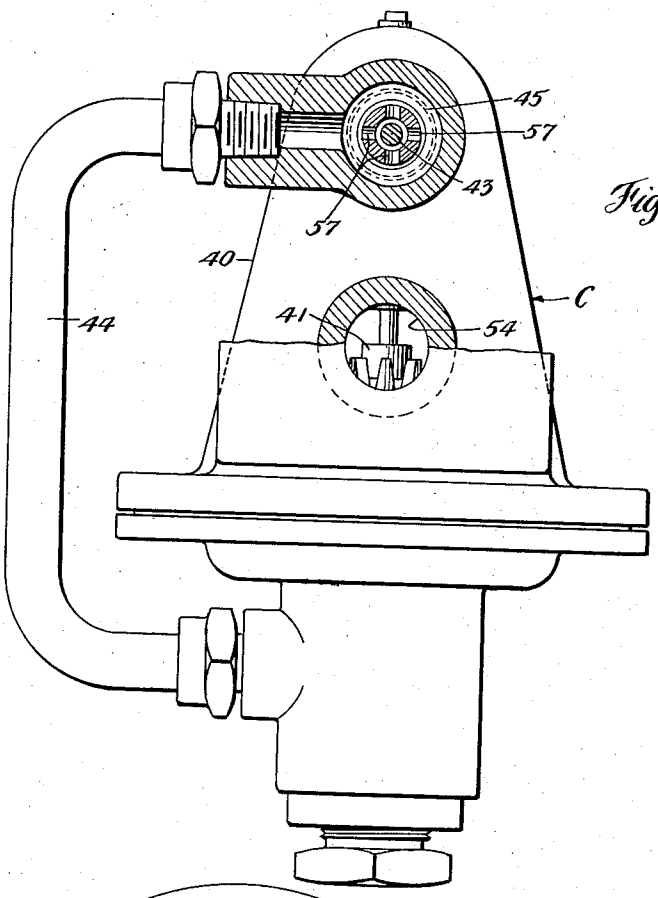


Fig. 5.

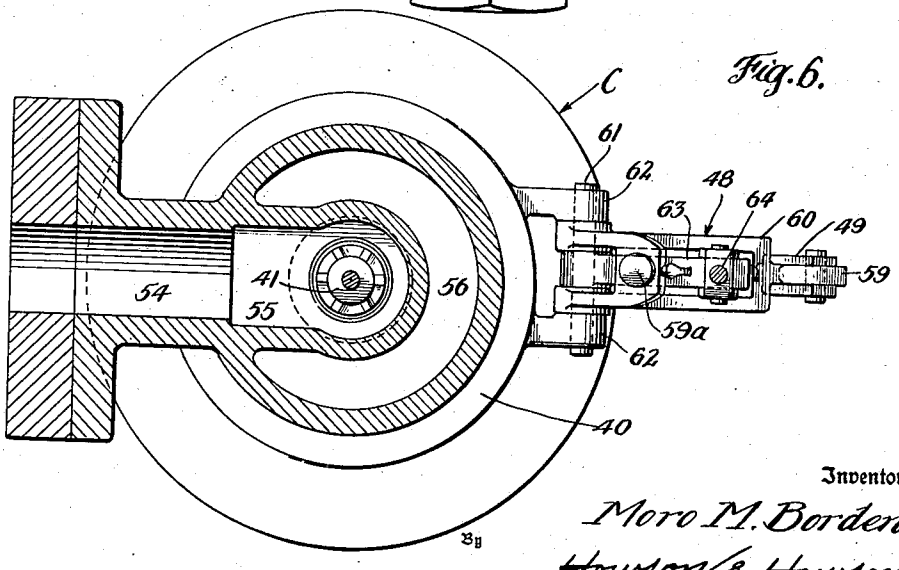


Fig. 6.

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2,876,789

APPARATUS FOR USE WITH LIQUID ENCLOSURES

Moro M. Borden, deceased, late of Collingswood, N. J., by Edward W. Borden, Upper Montclair, and Kennard F. Borden, Collingswood, N. J., and The Fidelity Philadelphia Trust Co., Philadelphia, Pa., executors, assignors to Simplex Valve and Meter Company, Lancaster, Pa., a corporation of Delaware

Application October 30, 1957, Serial No. 694,061

18 Claims. (Cl. 137—217)

This application is a continuation-in-part of the application of Moro M. Borden, Serial No. 432,265, filed May 25, 1954, now abandoned, and bearing the same title as this application.

The invention relates to apparatus for substantially eliminating or alleviating undesired conditions that may arise in liquid enclosures, particularly in water pipe lines and the like. The invention wll be described herein with reference to a water pipe line as it is primarily for use with such a line, but it is intended that the invention shall be applicable in any instance where it may serve its purposes.

In the case of a water pipe line, a sudden decrease in pressure will cause creation of an undesirable vacuous condition. This can be substantially prevented or alleviated by employing an air-vacuum valve in association with the pipe line. Such a valve operates, upon decrease of the pressure in the associated pipe line to a predetermined minimum value, to admit air to the pipe line to relieve the low-pressure or vacuous condition and thus avoid possible collapse of the pipe particularly if it is a thin wall pipe. The resultant rise in pressure in the pipe line causes the valve to close. Rapid closure of the valve, however, frequently causes a water hammer action which may be sufficiently severe to rupture the pipe even if it is a thick wall pipe.

The principal object of the present invention is to provide an apparatus which will overcome the above-mentioned objection.

Another object of the invention is to provide apparatus including an air-vacuum valve, wherein the rate of closure of the valve is automatically controlled independently and irrespective of the valve-closing pressure, so as to prevent objectionable water hammer.

Another object of the invention is to provide in such apparatus a controller for an air-vacuum valve employing means for controlling the rate of displacement of a buffing fluid.

A further object of the invention is to provide in such apparatus a controller having means whereby the rate of closing of the air-vacuum valve may be variably controlled.

A further object of the invention is to provide in such apparatus a controller wherein the control action is effected by means of a variable area Venturi device.

In accordance with this invention, the closing movement of an air-vacuum valve is impeded by a controlled damping or buffing action which governs the rate of closure of said valve independently and irrespective of the pressure acting to close the valve. In the preferred form of the invention, the damping or buffing action is effected through controlled flow of a buffing fluid in a closed circulating system which includes a rate controller that controls the rate of flow of the buffing fluid and thereby controls the rate of closure of the air-vacuum valve. Further, in the preferred form, the flow of the buffing fluid is controlled by a rate sensing device, preferably in

the form of a Venturi device, and by a flow control means under control of the sensing device. Within the scope of the invention either the rate controller or a flow control at the sensing device may be used to achieve the specific advantages of one but not the other. If desired, provision may be made for varying the rate of closure of the air-vacuum valve according to the instantaneous position of the valve. This is achieved, in the preferred embodiment, by providing an adjustable Venturi device and means for adjusting the same according to the instantaneous position of the air-vacuum valve during its closing movement.

The invention may be fully understood from the following detailed description with reference to the preferred embodiment illustrated in the accompanying drawings.

In the drawings,

Fig. 1 is a sectional elevational view illustrating a dual arrangement connected to a water pipe line or conduit and located in a pit above the pipe line, such dual arrangement comprising two air-vacuum valves and associated controllers;

Fig. 2 is a vertical section through one of the air-vacuum valves and the associated super-structure forming part of the controller;

Fig. 3 is a larger scale vertical section through the flow-controlling portion of the controller;

Fig. 4 is a detail sectional view on the line 4—4 of Figure 3;

Fig. 5 is a vertical cross section on the line 5—5 of Fig. 3;

Fig. 6 is a sectional view on the line 6—6 of Fig. 3;

Figs. 7 to 12 inclusive are side views of various cam plates that may be employed in the controller; and

Fig. 13 is a fragmentary vertical section showing a modified form of the Venturi device.

Referring first to Fig. 1, there is shown in cross-section a portion of a water pipe line or conduit P to which two air-vacuum valves R are connected, each being controlled according to the preferred form of the present invention. The dual arrangement shown is merely for the purpose of illustration, the main purpose being to shown different arrangements for air intake as hereinafter described. In practice, a single air-vacuum valve may be used, although of course more than one valve may be used if conditions require it.

The dual arrangement shown comprises a cross-fitting F connected to the top outlet of the pipe line, pipe elbows E, gate valves G between fitting F and elbows E, air-vacuum valves R and controllers C associated with the valves R. This assembly is located in a pit A located above the pipe line P.

Each air-vacuum valve R and the associated controller C is a complete operative combination. Fig. 2 shows one of the air-vacuum valves (the right hand one in Fig. 1) and the associated super-structure which forms part of the controller. Fig. 3 shows the buffing fluid controlling system which forms the other part of the same controller.

Referring to Fig. 2, the air-vacuum valve R and the associated super-structure comprise a vertically movable valve member 12 that seats upwardly in a valve seat 13 carried by the valve housing 14, a piston 15 located in an upper housing 16, a rod 17 extending upwardly from valve member 12 to thrust against the piston 15, a flexible diaphragm 18 secured to the piston 15 and piston housing 16, and spring-loaded upwardly-seating check valves 19 carried by a transverse wall 20 which divides the upper housing into a lower buffing fluid-delivery chamber 21 and an upper buffing fluid-receiving chamber 22, which communicate with the buffing fluid flow controlling system presently to be described. The transverse

wall also slidably retains the central stem 15*a* connected to piston 15 to guide the vertical movement of the piston. It will be seen that the piston 15 forms the bottom of the lower chamber 21, and the diaphragm 18 closes the space between the piston and the adjacent wall while permitting movement of the piston. The buffing fluid is shown in Fig. 2 but is omitted in Fig. 3 for the sake of clarity of illustration.

The diaphragm 18 is formed from a tube or sleeve of flexible material, such as rubber, which is bent or folded as shown. One part of the diaphragm sleeve is secured to the piston housing and is stationary, while the other part after folding is attached to the movable piston. With this type of diaphragm the effective area remains constant throughout the operating stroke of the piston, and furthermore the movement of the piston is substantially unimpeded.

The movable valve member 12 is partially counterbalanced by the counterweight 23 on pivoted arm 23*a* which has a bifurcated end engaging a collar fixed on rod 17. The rod is slidably supported by lower and upper plates 24 and 25 of intermediate section 25*a*, and a sealing ring 26 carried by the plate 24 surrounds the rod. The upper end of the rod thrusts against the piston 15 by means of a thrust button 27.

An open bottomed float 28 extends downwardly from the valve member 12 and is guided by a center rod 29 and a spider 30. The valve housing 14 is provided with a cylindrical wall 31 in spaced surrounding relation to the float 28, forming a float chamber having an inlet 32 which communicates with the pipe line P (Fig. 1) through elbow E, gate valve G and fitting F.

Under normal flow conditions in the pipe line P, water is present in the float chamber 31 and air trapped within the float is compressed somewhat giving buoyancy to the float, and the valve R is closed and is held closed while normal pressure conditions exist in the pipe line. The counterweight 23 is arranged so that a small depth of water around the open-ended float 28 will keep the valve closed, but in the absence of such water the valve will open by virtue of the weight of the movable assembly comprising member 12, rod 17 and float 28. When and if the water level falls and a low pressure or vacuous condition is created, the valve R opens and air enters through the valve past the float 28 and into the pipe line. This air enters the interior of the valve housing 14 by means of an opening 33 having a pipe connection 34 which may lead to a point outside the pit as indicated at the right-hand unit of Figure 1 or a pipe connection 35 directed within the pit as indicated at the left-hand unit of Figure 1. Increase of pressure causes closure of the valve but the rate of valve closure is controlled by the controller now to be further described. Prior to complete closure of the valve, air and water may flow out through the valve.

Referring now to Figures 3 to 6 and particularly Fig. 3, the rate-controlling portion of the controller C comprises in general a housing 40, a valve 41 actuated by a spring-biased pressure diaphragm 42, a Venturi device including an adjustable plug 43, an inter-connection 44 between the annular chamber 45 and the chamber 46 below the diaphragm 42, a control cam 47 for adjusting plug 43, and actuator means 48 for the cam 47.

The actuator means 48 is connected by a link 49 to a lever 50 pivoted at 51 (see Fig. 2) in the intermediate section 25*a* and having forked connection at 52 with a collar 53 carried by the rod 17 of the valve member 12.

The Venturi device, of which plug 43 is a part, establishes differential pressure on the diaphragm 42 according to the rate of flow of the buffing fluid, and the diaphragm controls the position of valve 41 to maintain a substantially constant rate of flow of the buffing fluid. Variation of the rate of flow is effected, during closing movement of valve member 12, by means of the cam 47 which may take any of various forms as shown in Figs. 7 to 12 and hereinafter described.

Considering the operation of the controller as a whole, and assuming that the closing movement of valve member 12 is taking place, the piston 15 (Fig. 2) is moved upwardly and acts as a pump to force the buffing fluid under pressure from the lower buffing liquid chamber 21 through port 54 into the chamber 55 (Fig. 3) of the diaphragm-actuated valve 41 which has V ports. The valves 19 (Fig. 2) in the wall 20 are closed during this upward movement of the piston. The buffing fluid flows through the valve 41 into the chamber 56 above the diaphragm 42, into the entrance 45*a* of the Venturi device, through the latter and through port 56*a* into the upper receiving chamber 22. At the same time, the pressure at the downstream end of the Venturi device is communicated to the lower side of diaphragm 42 through ports 57, annular space 45 and conduit connection 44. The diaphragm 42 is biased upwardly by spring 58 which tends to maintain maximum opening of the throttle valve 41. The differential pressure on the diaphragm causes the latter to adjust the valve 41 to whatever setting is necessary to maintain or establish the rate of flow of the buffing fluid according to the adjustment of plug 43. When the valve R again opens, the piston 15 moves downward and the weight of the buffing fluid in chamber 22 causes the valves 19 to open, whereupon the buffing fluid flows into the delivery chamber 21 and the apparatus is ready for repeat operation.

It will be seen from the foregoing that the controller functions to control the rate of flow of the buffing fluid and thus controls the rate of closing of the valve member 12 independently and irrespective of the closing pressure exerted on the valve member 12 by the pressure in the pipe line P. Stated in another way, the controller constitutes a means of controlling the rate of closure of the valve member 12, independently of the closing pressure exerted on the valve member, by controlling the rate of displacement or transmission of the buffing fluid through the controller.

Reverting now to the actuating means 48 for the rate control cam 47, and referring particularly to Figs. 3 and 6, it will be seen that the actuating means comprises a lever 59 forked at 60 for pivotal connection by means of pin 61 to the ears 62 of the housing 40. The actuating mechanism further comprises a second lever 63 independently fulcrumed on pin 61 and engageable by adjustable screws 59*a* and 59*b* carried by lever 59, and a cam rod 64 mounted for vertical movement in a bracket 65 secured to the housing 40 and having pin and slot connection at 66 with the lever 63. The cam 47 is secured to the cam rod 64 by clamp screws 67, there being slots 68 in the cam to enable adjustment. The cam surface of the cam engages the knob 69 secured to the stem 70 of plug 43. The knob is maintained in engagement with the cam by a spring 71.

In Figure 3, the actuating means is shown in a mid-position in which the Venturi device is at maximum setting. As the cam 47 moves downward under the influence of the closing movement of the air-vacuum valve member 12, the inclined cam surface 72 of cam 47 causes movement of plug 43 toward the left to effect gentle seating of the valve member 12. The particular configuration of the cam 47 illustrated in Figure 3 is such that during the first portion of the closing movement of the valve member 12, the flat dwell 73 of the cam allows the Venturi device 43 to remain fully open, and during the remaining portion of the closing movement of the valve member 12 the Venturi device is actuated by the inclined surface 72 of the cam. As cam 47 pushes plug 43 into its Venturi passage, the throat area is reduced, the throat velocity momentarily increased and the pressure at the throat lowered, which condition will cause the throttling of valve 41 by the reduction of its V port area until a differential pressure which balances

the spring action of the spring 58 is present. Thus a similar velocity is present in the reduced Venturi area at the equilibrium of the diaphragm load and the spring reaction. Successive reductions of throat area and buffing liquid govern the rate of closure of valve member 12 by diminishing the volume of buffing liquid which is permitted to flow through the Venturi section.

Thus, the valve member 12 closes rapidly for a portion of its stroke and then slows down by reason of the throttling action caused by the cam. Adjustment for the throttling portion of the cam stroke is provided by means of the adjusting screw 59*a* carried by the lever 59, and adjustment for the return portion of the cam stroke is provided by means of the adjusting screw 59*b*.

By employing cams of different forms, such as cams 47*a* to 47*f* in Figs. 7 to 12 inclusive, various closing actions of the valve member 12 may be obtained. For example, by employing either of the cams 47*a* and 47*b* shown in Figs. 7 and 8, a single setting of the Venturi device may be obtained, with the rate of closure of the valve member 12 depending on such setting. Stated in another way, the Venturi device would be set to a fixed venturi area which would remain constant throughout the closing stroke of the valve member 12. The cam 47*c* illustrated in Fig. 9 would result in a gradual but uniform reduction of Venturi area, and the cam 47*d* of Fig. 10 would result in a greater uniform reduction in Venturi area. The cam 47*e* of Fig. 11 is similar to that of Fig. 3 but would hold the no reduction area for a longer period and would cause reduction of area more rapidly. The cam 47*f* of Fig. 12 would cause initial reduction of the Venturi area, then increase of the area, and finally decrease of the area.

Fig. 13 shows a modified form of the Venturi device where the downstream pressure is derived at a location beyond the end of plug 43. It should be noted that the ports through which the downstream pressure is derived may be disposed at the most advantageous angle. This applies to both of the embodiments shown in Figs. 3 and 13.

It will be obvious to those skilled in the art that either a control involving the rate sensing device or a rate controller including the rate sensing device only may be used each to achieve limited advantages not available in the prior art. Since only omission of parts is required, neither modification need be shown and either may be readily understood from the drawings in the present case. Thus, a control using the rate sensing device would omit the valve 41, or at least not make it adjustable in accordance with pressure changes, as well as omitting its adjusting structure including diaphragm 42. Moreover, chambers 45 and 46 and their interconnection 44 would be unnecessary. The results of these omissions would be to have the plug 43 repositioned in accordance with the pattern of cam 47 depending upon the position of the valve. The effect would be to provide different amounts of restriction to the flow of the buffing fluid in different positions of the valve.

On the other hand, the cam 47, cam follower knob 69, the spring 71, and the moving parts having to do with the repositioning of plug 43 in response of the position of the valve might be omitted, and the plug 43 fixed in position or made manually adjustable. The effect of this arrangement would be to establish a predetermined rate of flow by the sensing means and to keep that rate of flow constant.

In the use of the apparatus provided by this invention, any suitable buffing fluid may be used. Such fluid should have no corrosive effect on metals and no destructive effect on rubber; it should be non-freezing; and its viscosity should be substantially unaffected by temperature changes. Liquids having these properties commonly used in liquid pressure systems may be used When the apparatus is first put into operation, the buffing fluid is poured in through the chamber 22 (Fig. 2), after removing the cover, until the fluid occupies all of the controller except the greater part of the upper chamber 22 which receives the displaced fluid during operation as above described.

For proper operation of the apparatus, it is important that the counterbalancing of the valve member 12 and the associated elements is such that there is enough unbalanced weight to effect quick opening of the valve but not enough unbalanced weight to adversely affect the closing of the valve. It should be noted that in the arrangement shown, the link 49 and lever 59 effect some counterbalance, and the weight 23 provides the rest of the required counterbalance.

From the foregoing description, it will be seen that the invention provides apparatus wherein an air-vacuum valve is quick opening to quickly relieve any low pressure or vacuous condition that may develop in the associated pipe line or liquid enclosure, and wherein the closing of the valve is controllably impeded by the buffing means associated with said valve. The controlled closure of the valve alleviates or substantially eliminates water hammer.

While a preferred embodiment of the invention and certain modifications have been illustrated and described, the invention is not limited thereto but contemplates such further modifications and embodiments as may occur to those skilled in the art.

What is claimed is:

1. In an apparatus for use with a liquid conduit, an air-vacuum valve adapted to be connected to such conduit and having a valve member movable upwardly by pressure in said conduit to valve-closing position and free to move downwardly by gravity upon decrease of pressure in said conduit, a first stationary buffing fluid chamber above said valve and having a piston movable upwardly by said member, a second stationary buffing fluid chamber above said first chamber, valve means between said chambers permitting downward movement of buffing fluid from the second to the first chamber but preventing upward movement of the buffing fluid, means providing a flow path for the buffing fluid from the first chamber to the second chamber, the upward movement of said piston causing flow of buffing fluid through said flow path, means in said flow path for continuously sensing the rate of flow, and means responsive to said sensing means for controlling the flow of the buffing fluid to obtain predetermined demanded rates of flow thereby to control the rate of closure of said air-vacuum valve.

2. In an apparatus for use with a liquid conduit, an air-vacuum valve adapted to be connected to such conduit and having a valve member movable upwardly by pressure in said conduit to valve-closing position and free to move downwardly by gravity upon decrease of pressure in said conduit, a first stationary buffing fluid chamber above said valve and having a piston movable upwardly by said member, a constant-area diaphragm closing the space about said piston and allowing unrestrained movement of the piston, a second stationary buffing fluid chamber above said first chamber, valve means between said chambers permitting downward movement of buffing fluid from the second to the first chamber but preventing upward movement of the buffing fluid, means providing a flow path for the buffing fluid from the first chamber to the second chamber, the upward movement of said piston causing flow of buffing fluid through said flow path, means in said flow path for continuously sensing the rate of flow, and means responsive to said sensing means for controlling the flow of the buffing fluid to obtain predetermined demanded rates of flow thereby to control the rate of closure of said air-vacuum valve.

3. In an apparatus for use with a liquid conduit, an air-vacuum valve adapted to be connected to such conduit and having a valve member movable upwardly by pressure in said conduit to valve-closing position and

free to move downwardly by gravity upon decrease of pressure in said conduit, a first stationary buffing fluid chamber above said valve and having a piston movable upwardly by said member, a second stationary buffing fluid chamber above said first chamber, valve means between said chambers permitting downward movement of buffing fluid from the second to the first chamber but preventing upward movement of the buffing fluid, means providing a flow path for the buffing fluid from the first chamber to the second chamber, the upward movement of said piston causing flow of buffing fluid through said flow path, means for controlling the flow of the buffing fluid thereby to control the rate of closure of said air-vacuum valve, means in said flow path for continuously sensing the rate of flow, and means responsive to said sensing means for varying the rate of flow of the buffing fluid to obtain predetermined demanded rates of flow and consequently the rate of closure of said air-vacuum valve according to the instantaneous position of said valve.

4. In an apparatus for use with a liquid conduit, an air-vacuum valve adapted to be connected to such conduit and having a valve member movable upwardly by pressure in said conduit to valve-closing position and free to move downwardly by gravity upon decrease of pressure in said conduit, a first stationary buffing fluid chamber above said valve and having a piston movable upwardly by said member, a second stationary buffing fluid chamber above said first chamber, valve means between said chambers permitting downward movement of buffing fluid from the second to the first chamber but preventing upward movement of the buffing fluid, means providing a flow path for the buffing fluid from the first chamber to the second chamber, the upward movement of said piston causing flow of buffing fluid through said flow path, a Venturi device to sense rate of flow of the buffing fluid, and means under control of said device for governing the rate of flow of the buffing fluid thereby to control the rate of closure of said air-vacuum valve.

5. In an apparatus for use with a liquid conduit, an air-vacuum valve adapted to be connected to such conduit and having a valve member movable upwardly by pressure in said conduit to valve-closing position and free to move downwardly by gravity upon decrease of pressure in said conduit, a first stationary buffing fluid chamber above said valve and having a piston movable upwardly by said member, a constant-area diaphragm closing the space about said piston and allowing unrestrained movement of the piston, a second stationary buffing fluid chamber above said first chamber, valve means between said chambers permitting downward movement of buffing fluid from the second to the first chamber but preventing upward movement of the buffing fluid, means providing a flow path for the buffing fluid from the first chamber to the second chamber, the upward movement of said piston causing flow of buffing fluid through said flow path, a Venturi device to sense rate of flow of the buffing fluid, and means under control of said device for governing the rate of flow of the buffing fluid thereby to control the rate of closure of said air-vacuum valve.

6. In an apparatus for use with a liquid conduit, an air-vacuum valve adapted to be connected to said conduit and having a valve member movable upwardly by pressure in said conduit to valve-closing position, a first stationary buffing fluid chamber above said valve and having a piston movable upwardly by said member, a second stationary buffing fluid chamber above said first chamber, valve means between said chambers permitting downward movement of buffing fluid from the second to the first chamber but preventing upward movement of the buffing fluid, means providing a flow path for the buffing fluid from the first chamber to the second chamber, the upward movement of said piston causing flow of buffing fluid through said flow path, an adjustable Venturi device to sense rate of flow of the buffing fluid, means under control of said device for governing the rate of flow of the buffing fluid so as to control the rate of closure of said air-vacuum valve, and means for varying the adjustment of said device and consequently the rate of flow of the buffing fluid according to the instantaneous position of said valve.

7. In an apparatus for use with a liquid conduit, an air-vacuum valve adapted to be connected to said conduit and having a valve member movable upwardly by pressure in said conduit to valve-closing position, a first stationary buffing fluid chamber above said valve and having a piston movable upwardly by said member, a second stationary buffing fluid chamber above said first chamber, valve means between said chambers permitting downward movement of buffing fluid from the second to the first chamber but preventing upward movement of the buffing fluid, means providing a flow path for the buffing fluid from the first chamber to the second chamber, the upward movement of said piston causing flow of buffing fluid through said flow path, an adjustable Venturi device to sense rate of flow of the buffing fluid, means under control of said device for governing the rate of flow of the buffing fluid so as to control the rate of closure of said air-vacuum valve, movable cam means for adjusting said device, and means operable by said valve member to move said cam means, thereby to effect control of the rate of flow of the buffing fluid according to the instantaneous position of said valve member.

8. In an apparatus for use with a liquid enclosure, an air-vacuum valve adapted to be connected to such enclosure for the alleviation of undesirable pressure conditions therein, said air-vacuum valve being free to open upon decrease of pressure in said enclosure and being closed by pressure in said enclosure, a stationary buffing fluid cylinder, means providing a flow path for buffing fluid externally of said cylinder from one portion to another portion thereof, means operable by closing movement of said air-vacuum valve to effect flow of the buffing fluid in said flow path, means in said flow path continuously sensing the rate of flow, means responsive to said sensing means for controlling the rate of flow of the buffing fluid to obtain predetermined demanded rates of flow so as to control the speed of closing of said air-vacuum valve.

9. In an apparatus for use with a liquid enclosure, an air-vacuum valve adapted to be connected to such enclosure for the alleviation of undesirable pressure conditions therein, said air-vacuum valve being free to open upon decrease of pressure in said enclosure and being closed by pressure in said enclosure, a stationary buffing fluid cylinder, means providing a flow path for buffing fluid externally of said cylinder from one portion to another portion thereof, means operable by closing movement of said air-vacuum valve to effect flow of the buffing fluid in said flow path, means in said flow path continuously sensing the rate of flow, means responsive to said sensing means for controlling the rate of flow of the buffing fluid to obtain predetermined demanded rates of flow so as to control the speed of closing of said air-vacuum valve, and means for varying the predetermined rates of flow of the buffing fluid and consequently the rate of closure of said air-vacuum valve according to the instantaneous position of the valve.

10. In an apparatus for use with a liquid enclosure, an air-vacuum valve adapted to be connected to such enclosure for the alleviation of undesirable pressure conditions therein, said air-vacuum valve being free to open upon decrease of pressure in said enclosure and being closed by pressure in said enclosure, a pair of intercommunicating stationary buffing fluid chambers, valve means between said chambers to limit flow of buffing fluid directly therebetween to one direction, means providing a flow path for the buffing fluid between said chambers, means operable by closing movement of said air-vacuum

valve to effect flow of the buffing fluid in said flow path, means in said flow path continuously sensing the rate of flow, and means responsive to said sensing means for controlling the rate of flow of the buffing fluid to obtain predetermined demanded rates of flow so as to control the speed of closing of said air-vacuum valve.

11. In an apparatus for use with a liquid enclosure, an air-vacuum valve adapted to be connected to such enclosure for the alleviation of undesirable pressure conditions therein, said air-vacuum valve being free to open upon decrease of pressure in said enclosure and being closed by pressure in said enclosure, a pair of intercommunicating stationary buffing fluid chambers, valve means between said chambers to limit flow of buffing fluid directly therebetween to one direction, means providing a flow path for the buffing fluid between said chambers, means operable by closing movement of said air-vacuum valve to effect flow of the buffing fluid in said flow path, means in said flow path continuously sensing the rate of flow, means responsive to said sensing means for controlling the rate of flow of the buffing fluid to obtain predetermined demanded rates of flow so as to control the speed of closing of said air-vacuum valve, and means for varying the predetermined rates of flow of the buffing fluid and consequently the rate of closure of said air-vacuum valve according to the instantaneous position of the valve.

12. In an apparatus for use with a liquid enclosure, an air-vacuum valve adapted to be connected to such enclosure for the alleviation of undesirable pressure conditions therein, said air-vacuum valve being free to open upon decrease of pressure in said enclosure and being closed by pressure in said enclosure, a stationary buffing fluid cylinder, means providing a flow path for buffing fluid externally of said cylinder from one portion to another portion thereof, means operable by closing movement of said air-vacuum valve to effect flow of the buffing fluid in said flow path, a Venturi device in said flow path for sensing the rate of flow of the buffing fluid therein, and means under control of said device for governing the rate of flow of the buffing fluid thereby to control the rate of closure of said air-vacuum valve.

13. In an apparatus for use with a liquid enclosure, an air-vacuum valve adapted to be connected to such enclosure for the alleviation of undesirable pressure conditions therein, said air-vacuum valve being free to open upon decrease of pressure in said enclosure and being closed by pressure in said enclosure, a stationary buffing fluid cylinder, means providing a flow path for buffing fluid externally of said cylinder from one portion to another portion thereof, means operable by closing movement of said air-vacuum valve to effect flow of the buffing fluid in said flow path, an adjustable Venturi device in said flow path for sensing the rate of flow of the buffing fluid therein, means under control of said device for governing the rate of flow of the buffing fluid thereby to control the rate of closure of said air-vacuum valve, and means for varying the adjustment of said device and consequently the rate of flow of the buffing fluid according to the instantaneous position of said air-vacuum valve.

14. In an apparatus for use with a liquid enclosure, an air-vacuum valve adapted to be connected to such enclosure for the alleviation of undesirable pressure conditions therein, said air-vacuum valve being free to open upon decrease of pressure in said enclosure and being closed by pressure in said enclosure, a pair of intercommunicating stationary buffing fluid chambers, valve means between said chambers to limit flow of buffing fluid directly therebetween to one direction, means providing a flow path for the buffing fluid between said chambers, means operable by closing movement of said air-vacuum valve to effect flow of the buffing fluid in said flow path, a Venturi device in said flow path for sensing the rate of flow of the buffing fluid therein, and means under control of said device for governing the rate of flow of the buffing fluid thereby to control the rate of closure of said air-vacuum valve.

15. In an apparatus for use with a liquid enclosure, an air-vacuum valve adapted to be connected to such enclosure for the alleviation of undesirable pressure conditions therein, said air-vacuum valve being free to open upon decrease of pressure in said enclosure and being closed by pressure in said enclosure, a pair of intercommunicating stationary buffing fluid chambers, valve means between said chambers to limit flow of buffing fluid directly therebetween to one direction, means providing a flow path for the buffing fluid between said chambers, means operable by closing movement of said air-vacuum valve to effect flow of the buffing fluid in said flow path, an adjustable Venturi device in said flow path for sensing the rate of flow of the buffing fluid therein, means under control of said device for governing the rate of flow of the buffing fluid thereby to control the rate of closure of said air-vacuum valve, and means for varying the adjustment of said device and consequently the rate of flow of the buffing fluid according to the instantaneous position of said air-vacuum valve.

16. In an apparatus for use with a liquid conduit, an air-vacuum valve adapted to be connected to such conduit and having a valve member movable upwardly by pressure in said conduit to valve-closing position and free to move downwardly by gravity upon decrease of pressure in said conduit, a first stationary buffing fluid chamber above said valve and having a piston movable upwardly by said member, a second stationary buffing fluid chamber above said first chamber, a valve means between said chambers permitting downward movement of buffing fluid from the second to the first chamber but preventing upward movement of the buffing fluid, means providing a flow path for the buffing fluid from the first chamber to the second chamber, the upward movement of said piston causing flow of buffing fluid through said flow path, means in said flow path for controlling the flow of the buffing fluid thereby to control the rate of closure of said air-vacuum valve, said means including an adjustable member for adjusting the rate of flow, and a coupling to a portion of the movable part of the valve whereby in the successive positions of the valve the adjustable member is located in a predetermined position.

17. The apparatus of claim 16 in which the adjustable portion of the rate controlling means is spring biased against a cam member which determines the rate of flow which it permits and the position of the cam member is adjusted in response to the position of the valve.

18. The apparatus of claim 17 in which the cam member is interchangeable with other cams to provide a selection of patterns of rate of valve closure.

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