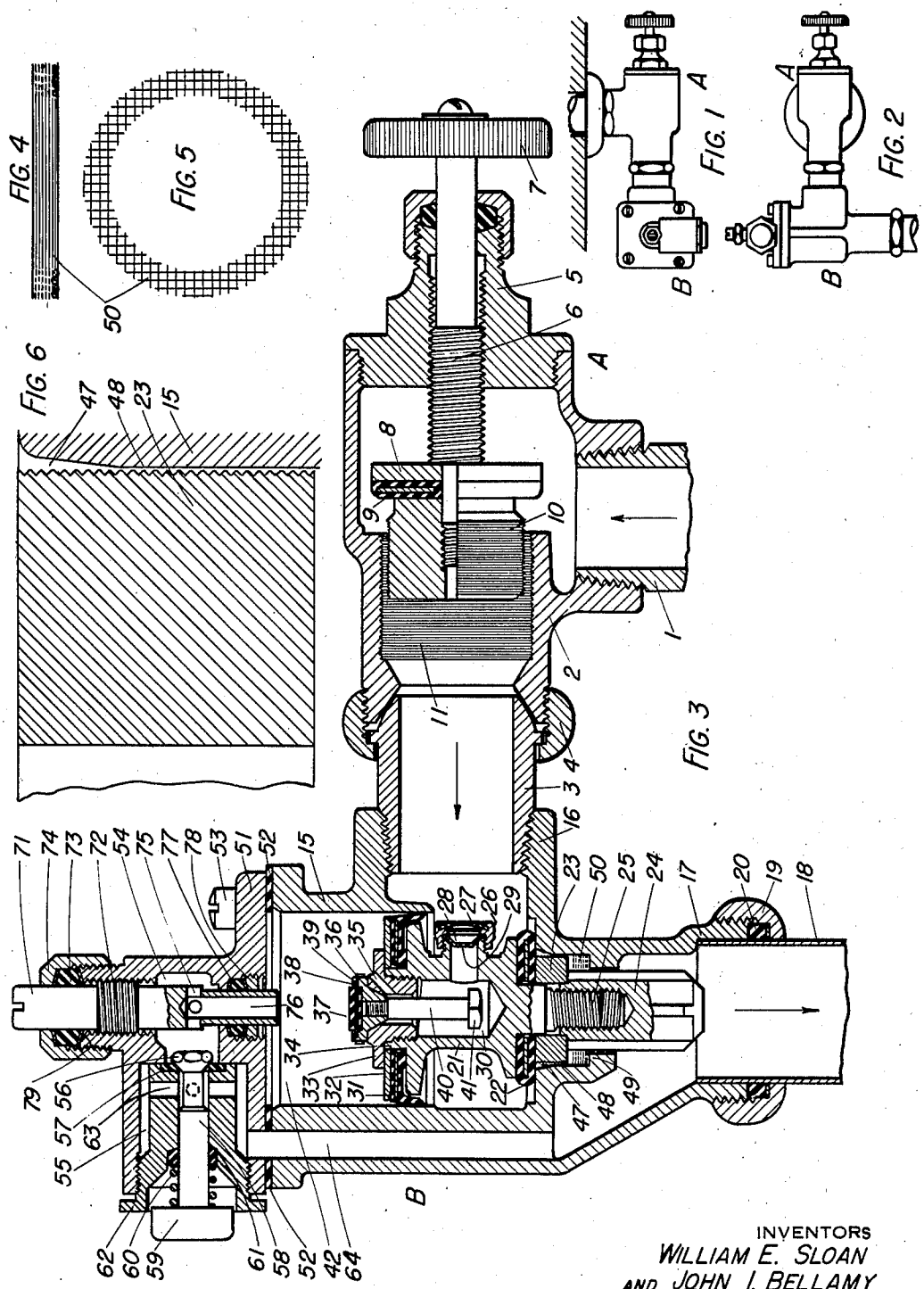
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FLUSH VALVE

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FLUSH VALVE

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The present invention relates to flush valves, and its general object is the production of a new and improved flush valve particularly useful in flushing a water closet requiring only a low rate of flow and thereby suitable for use in the average small home where only relatively low rates of flow can be obtained from the water-supply piping, although the invention is, for the most part, equally applicable to a flush valve designed for use where larger rates of flow are required.

It is an object of the invention to provide a flush valve which is suitable for use on long runs of relatively small supply piping, as well as on short runs of such piping, and which operates in substantial silence, with no water noises caused directly by the flow of water through the flush valve, and no noises generated in the piping as a result of the opening and closing of the flush valve and the consequent pressure and flow changes in the supply piping.

An object of the invention secondary to the foregoing is the production of a flush valve wherein sudden changes in the area of water passage through the flush valve are entirely avoided, whereby the pressure changes in the piping system incident to the opening and closing of the flush valve are so gradual that the consequent stresses and surges set up in the piping system are kept below those at which the piping system emits audible sound.

A further object of the invention is to provide an improved arrangement for preventing the flush valve from being held in open position and to provide positive means for releasing the preventing means when the flush valve returns to closed position.

It is a still further object to provide means whereby the stroke of the flush valve, and thereby the quantity of water discharged, may be readily regulated, and to arrange such regulating arrangement so that it does not interfere with the arrangement for preventing the flush valve from being held in open position when the push button is held actuated.

General Description

Heretofore, flush valves have not been commonly used in single-family residences and other similar places where only small piping is installed to bring in water from the usual street main, for the rate of flow available from the piping system in the average small home is only about twelve gallons a minute, and the conventional water closet requires from eighteen to twenty-four gallons a minute or more for its flushing. This has resulted in the past in the installation of individual storage tanks for the water closets in small homes, and direct-connected flush valves have been largely limited to multiple-apartment buildings, large homes with sprinkler systems, public buildings, and the like. As a result, however, of the improved water closet disclosed in the co-pending application of William E. Sloan, Serial Number 247,791, filed November 22, 1938, water closets are now available which may be used in small homes in connection with direct-connected flush valves, for the water closet in the above mentioned Sloan application is capable of being satisfactorily and reliably flushed when supplied with a low rate of flow having an optimum value of about twelve gallons a minute.

When tests were made of existing flush valves to determine their suitability for use in the average small home in connection with the improved Sloan water closet mentioned above, and tests were run with the piping installed as it is in the average small home, it was found that the piping system was subject to undue vibration, chatter, and banging on the opening and closing of any existing flush valve otherwise apparently suitable for the purpose, and that the piping system was further subjected to great pressure surges caused by so-called water-hammer upon the closing movement of the flush valve. Investigation revealed that the reason for this is principally that the piping in the average small home is small within the residence, and is ordinarily equally small all the way from the residence to the street main. This piping is customarily of nominal three-quarter inch inside dimension, and in a long run of this three-quarter inch pipe (usually between fifty and one hundred feet in length between the street main and the flush valve), the conditions greatly favor water-hammer and similar disturbances. It is well known that the tendency toward water-hammer, with a given rate of flow, is directly proportional to the length of the run of pipe, multiplied by the square of the velocity at which the water flows through the pipe. A problem largely new to flush-valve operation was thus presented, of increasing the flow area through the flush valve so gradually upon the opening of the flush valve that the pressure reduction in the piping system due to the starting of the flow is only gradual, so that physical movement and vibration of the piping within the residence is substantially eliminated, and of reducing the flow area through the flush valve upon the closing movement of the flush valve so gradually as to so lower the tendency to water-hammer, and the tendency to physically vibrate and strain the piping, that it is no longer objectionable.

Along with the foregoing problem, there was the ever-present problem of arranging the flush valve so that the flow of water therethrough, particularly during the opening and closing

thereof, does not directly generate hissing and roaring sounds and does not vibrate the moving parts of the flush valve. All of these noise problems are highly important in small residences, for the occupants thereof are accustomed to demand quietness.

Flush valves are customarily made with a pre-entrant throttle portion, commonly referred to as the refill head, which enters the discharge port of the flush valve and reduces the area of the flow passage through the flush valve quite materially prior to final seating. The full flush rate is thereby reduced to a lower refill rate of flow, whereby the water closet is provided with a sufficient amount of water, following the main flushing operation, to cause an effective refilling of the bowl thereof preparatory to the next flushing operation. It is a special feature of the construction disclosed herein that the refill head serves to cooperate with the wall of the discharge port to secure a silent flow of water through the flush valve, as well as to provide for the gradual increase in discharge area upon the opening of the flush valve, and to provide for the gradual decrease of discharge area during the closing movement of the flush valve, as will be explained more in detail hereinafter.

A further special problem involved in the production of a flush valve for use in connection with a low-input-flow water closet such as is disclosed in the Sloan application previously mentioned is that the quantity of water delivered during the full flushing rate of flow must be fairly closely regulated, and the flush valve, if possible, must be so arranged that the user thereof cannot inadvertently or carelessly cause the flush valve to deliver a flushing quantity which departs materially from the quantity which the flush valve is regularly set to deliver. More particularly, it is highly desirable to arrange the flush valve so that the user thereof cannot prolong the delivery of water at the full flushing rate by either prolonged or repeated actuation of the relief valve.

In order that the flush valve cannot be held in its full-open position in the event that the relief valve is held actuated or is reactuated during the flushing operation, a limit valve carried by the flush valve closes the relief passage when the flush valve reaches its full open position, and thus discontinues the further flow of water from the upper or control chamber of the flush valve. This limit valve is provided with an accurate seat whereby it is held in position, independent of whether or not the push button is held actuated or is restored, all the while the flush valve is delivering water at the full flushing rate.

In order to restore the limit valve and thus prepare the mechanism for a succeeding flushing operation, the limit valve is provided with a pull-off stem extending loosely into the main flush valve, whereby the limit valve is pulled away from its seat and allowed to restore to normal position after the refill head has entered the discharge port and reduced the rate of flow from the full flushing rate to some reduced refill rate of flow, but before the flush valve has finally seated.

Other objects and features will become apparent upon a further perusal of the specification.

The drawing

Referring now to the accompanying drawing, comprising Figures 1 to 6, they show sufficient views of a flush-valve installation, including a flush valve constructed in accordance with the features of the invention, to enable the invention to be understood.

Figure 1 shows a top view of a flush-valve installation wherein the improved flush valve is indicated at B, and the associated throttle and shut-off valve is indicated at A;

Figure 2 is a front view of the installation illustrated at Figure 1;

Figure 3 is a sectional view taken along the front-to-rear vertical centerline of the improved flush valve B, and along the horizontal centerline of the associated throttle and shut-off valve A, the location of the inlet 16 of the flush valve B being shown at the rear thereof in Figure 3 for convenience of illustration in the sectional view, and the throttle valve A being rotated about its longitudinal axis ninety degrees to bring it into a better position for illustration in the same sectional view with the associated flush valve;

Figure 4 shows an enlarged sectional view of the silencing impact member 50 of Figure 3;

Figure 5 shows an enlarged plan view of the silencing member 50; and

Figure 6 shows a greatly enlarged sectional view of a portion of the pre-entrant throttle member or refill head 23 of Figure 3, together with a correspondingly enlarged view of the adjacent portion of the body 15 of the flush valve forming the cylindrical throat or discharge port 48, with its tapered entrance 47.

Detailed Description

The invention having been described generally, a detailed description of the construction and operation of the illustrated flush-valve installation will now be given.

The throttle or shut-off valve A

Valve A, associated with the improved flush valve B, is used to throttle the full flow of water through flush valve B when the supply pressure is normal and the supply line is comparatively short and unrestricted, as well as when the length of the supply line is normal and the supply pressure is comparatively high.

Throttle and shut-off valve A includes the body or casing 2 which is provided with a side-intake opening into which the end of the supply pipe 1 is threaded. The open outer end of the casing 2 is closed by the threaded bonnet member 5, which has a central opening for the stem 6, threaded in the bonnet member 5 to enable the valve to be opened and closed as desired when the handle 7 is turned.

The casing 2 is provided with a cylindrical throttle throat 11, having a seating surface around one end thereof upon which the seat washer 9 rests when the valve is shut off. The seat washer 9, with its supporting back plate 8, is held in position on the stem 6 by the throttle plug 10, which is threaded onto the reduced end portion of the stem 6, as illustrated. The cylindrical outer surface of the plug 10 is provided with roughening which may conveniently take the form of circular scoring, or of threads, having a pitch of from thirty to eighty to the inch. The inside cylindrical surface of the throat 11 is similarly provided with a roughened surface, and the spacing between the two may be such that there is a clearance all around the plug 10 of about .015 inch, this spacing being more or less as desired.

The valve A is illustrated as exemplary of a device capable of quietly throttling the rate of flow to hold it close to twelve gallons a minute

when the pressure is high or the supply pipe is short, without introducing water noises as a result of such throttling. Any other suitable construction of a quiet throttle device may be used if desired.

Valve A is connected to the threaded inlet of the flush valve B through the union nipple 3 and the union coupling nut 4.

Construction of the improved flush valve B

The flush valve B includes the body portion or casing 15 having an inlet opening 16 and a discharge opening 17. A discharge tube 18 is secured in the outlet 17 by the coupling nut 19 and gasket 20.

Inside the vertically disposed main opening in the casing 15 is the piston 21, having the main seat 22 thereon which makes sealing engagement with the seating surface provided around the tapered entrance 47 to the cylindrical throat 48. The main seat 22 is maintained centralized with the piston by the depending stem portion 25. The pre-entrant throttle plug 23 is assembled below the main seat 22 and is likewise maintained centralized on the dependent stem 25, and the parts 25 and 23 are held in assembled position by the winged guide stem 24, which is threaded onto the lower end of the fastening stem 25. The refill head 23 and the guide stem 24 are kept accurately aligned with one another because a portion of the guide stem 24 of reduced diameter passes within the inside diameter of the refill head 23. An accurate alignment of parts 23 and 25 is quite essential, as will appear more fully hereinafter.

The throat 48 extends downwardly to the internal annular shoulder or ledge 49 which has a discharge opening therethrough which accommodates the four guide wings of the stem 24.

The silencing annular impact member 50 fits snugly within the throat 48, and lies on the annular ledge 49. Its inside diameter is sufficiently larger than the inside diameter of the opening through ledge 49 that member 50 is out of engagement with the guide wings of stem 24.

Member 50, as is more clearly shown in Figures 4 and 5, is composed of several layers of woven material, whereby the member is highly porous. Commercial 30-mesh wire gauze or screen has been found to be highly satisfactory.

The stem 24 is illustrated as having a central core portion to which four equally spaced guide wings are attached, and the space between the guide wings is just sufficient to give the desired full passageway through the flush valve, between the guide stem 24 and the central opening through the shoulder or ledge 49, when the piston of the flush valve is raised sufficiently that the refill head 23 is withdrawn substantially from the mouth of the throttling cylinder 48. This discharge or control area around the guide wings may be varied somewhat without materially upsetting the desired operation, but it is preferably of about two-tenths of a square inch in the illustrated flush valve, designed for an optimum full flushing flow of about twelve gallons a minute. This discharge or control area is sufficient that it does not unduly restrict the flow when the supply pressure is comparatively low, and yet it provides a sufficient drop in pressure through the flush valve to assure proper functioning.

At the widened portion of piston 21, near the top thereof, there is provided a cup packing 31, illustrated as being of molded rubber with a suitable stiffening insert in the body portion thereof. This cup packing defines the upper chamber 42, which is the control chamber of the flush valve. The cup packing 31 is centrally located with respect to the piston by the annular lip 34 upstanding around the top end of the central opening 30 in the piston. Cup packing 31 is braced by the stiffening back plate 32, and the back plate and packing member are both held in assembled position by the gland 33, threaded into the top portion of the central opening 30. It is an important feature of this construction that the upstanding lip 34 serves as a positive stop or locking member for the gland 33, whereby a uniform compression is imparted to the portion of the cup packing gripped between the back plate 32 and the flat shelf portion of the piston. The height of lip 34 is preferably such that there is a small uniform compression of the gripped portion of packing 31 for sealing purposes when the gland 33 is turned tightly against the top surface of the upstanding lip 34. Also, the thickness of the outer flat portion of the cup packing is reduced by an offset occurring on the lower surface at some distance from the skirt portion, whereby all the compression occurs in the central portion. The tendency toward compressional distortion of the skirt portion is thus further reduced. This offset could be made, with similar effect, in the contiguous portion of the metal supporting ledge. Outwardly from the point of said offset, the ledge formed on the piston does no actual supporting of the flat surface of the packing, but the periphery of the ledge is useful to ensure that the skirt of the packing is not unduly deformed inwardly in the handling of the assembled piston.

With the described provisions, the nut 33 cannot be turned in so tightly as to provide so much compression of the gripped portion of the cup packing as to cause bulging of the skirt portion of the packing. Such bulging, where allowed to occur, causes undue friction and thus interferes with the functioning of the valve, either preventing the main valve from reaching the top of its stroke when the rate of flow tends to be low, or unduly prolonging the length of the flush when the piston does rise to the top. All these troubles are effectively eliminated by the illustrated improved construction.

The metering orifice, or so-called by-pass opening through which water from the supply line is allowed slowly to refill the upper chamber 42 after the flush valve has been opened, is accurately punched and sized at 29 in the center of the cupped by-pass disc 28. This by-pass disc is held tightly in sealing engagement with the exposed annular face of the illustrated outside-threaded boss of the piston, and is held in this position by the retaining nut 26, which has a large central opening therethrough. Across this central opening, there is a plate 27 with a large number of punched openings therein which are separately smaller than the by-pass opening 29, whereby the water supplied to the by-pass opening is effectively screened. Accidental clogging of this by-pass opening is thereby avoided.

Water passed through the by-pass opening 29 and into the central opening 30 within the piston reaches the upper chamber 42 by proceeding upwardly through the central opening in gland 33. This water may pass up around the stem 40 of the limit valve 36 directly into the upper chamber 42, except when the limit valve is in the illustrated position at rest on top of the piston, in which position there is some likeli-

hood that the communication between opening 30 and upper chamber 42 will be sealed off, particularly when the piston is at the top of the stroke. To avoid this possible difficulty, the diagonal supply opening 35 is provided through the gland 33. It is to be noted that the square pull-off head on the lower end of the stem 41 is of smaller diameter than the inside diameter of the flared lower entrance to the main vertical opening through the gland 33, whereby the head 41 cannot block communication between central opening 30 and upper chamber 42 when the limit valve 36 is fully raised with respect to the piston 21.

The limit valve 36 is composed of the main body portion 36 into which there is threaded the stem 40, with its head 41, previously referred to. The valve 36 is provided preferably with a molded rubber seat 37 having a metal insert disc 38 to which the disc is vulcanized during molding. The insert disc is of somewhat larger diameter than the main portion of the molded rubber, and this insert lies on a slightly raised annular shoulder in the top of the piece 36. The outside portion of the body 36 in spun-over, as at 39, to grip and hold the outer portion of the insert piece 38, so as to retain the molded seat in place. This positive holding of the seat 37 is desirable to prevent it from being pulled off during the operation of the flush valve.

The periphery of the body portion 36 may be provided with coin knurling, as indicated, whereby the part 36 may be firmly gripped in the fingers while the stem 40 is being screwed into place by means of the square head 41.

The cover 51 is secured to the casing 15 by means of screws 53, an effective seal being established between the two by cover-gasket 52. Communication between upper chamber 42 in the casing 15 and the relief-intake chamber 54 in the cover 51 is provided through the central opening 76 and the four cross holes 75, in the regulating stem 71. Rubber seat 37 of the limit valve 36 seats around the bottom end of vertical passage 76 in stem 71 to close this communication when the flush valve reaches the top of its stroke.

The length of the stroke taken by piston 21 upon an actuation of the push button 59 is regulated by longitudinal adjustment of regulating stem 71. Stem 71 is provided with an enlarged threaded portion 72 which cooperates with the illustrated threaded top opening in the cover 51 to enable stem 71 to be turned up or down as desired. The passage of water to the outside around stem 71 is prevented by packing 73, held by gland 74, and passage of water from control chamber 42 to the relief-intake chamber 54 around the outside of the reduced lower portion of stem 71 is prevented by packing 77, held in place by gland 78.

The upper limit of the adjustment stroke of stem 71 is reached when the enlarged threaded portion 72 contacts the packing-retaining disc 79, while the lower limit of the adjustment stroke is reached when the shoulder surrounding the reduced lower portion of stem 71 contacts the machined bottom of the relief-intake chamber 54.

The relief valve 56 is normally held in sealing contact with the seat gasket 57 to keep the water from flowing out of the upper or control chamber 42, being held to the seat 57 by water pressure and by the restoring spring 60.

The relief valve is contained in the assembly plug 62, whereby it can be accurately assembled outside of the cover 51 and then placed in position, and can be readily removed later for inspection. The seat gasket 57 lies in a circular recess in the end of plug 62 and is of slightly greater thickness than the depth of the recess, whereby it is compressed around the outside portion to serve as a sealing gasket when the plug 62 is drawn up tightly, metal to metal.

The inner portion of assembly plug 62 is of reduced diameter, leaving a space 55, termed the relief-discharge chamber. Packing 61, held compressed by spring 60, prevents leakage around stem 58. The threads by means of which assembly plug 62 is held in position may be leaded or otherwise treated to make this connection tight.

Operation of the flush valve B

The construction of the illustrated equipment having been described, the operation thereof will now be explained.

The flush valve B is normally in its illustrated closed position, being held in this position by the supply pressure, transmitted to the upper chamber 42 from the inlet of the flush valve, through by-pass opening 29, central opening 30 in the piston 21, and diagonal passageway 35. The supply pressure in the upper chamber 42 holds the piston of the flush valve down in spite of the upward pressure in the supply chamber, because the upward pressure is exerted over a much smaller area (the area outside of the main seat 22) than the full area over which the downward pressure is exerted in the upper chamber 42.

When the push button 59 is actuated, the pressure in the upper chamber 42 is lowered by the outflow of water from the upper chamber, through vertical passageway 76 in regulating stem 71 and cross openings 75, into the relief-intake chamber 54, and thence around the actuated relief valve 56, and through cross openings 63 to the relief-discharge chamber 55. From the chamber 55, the water flows through the relief passage 64 to the outlet of the flush valve.

Upon the lowering of the pressure in the upper chamber 42, the piston 21 rises as a result of the upward pressure exerted on it by the pressure of the water reaching the piston through the supply nipple 3. This movement continues until the piston reaches its uppermost position.

Quiet opening

The opening of the flush valve is accomplished smoothly and without noticeable noise of any kind, the operation being accomplished in successive stages as follows:

Upon the first slight upward movement of the piston of the flush valve, the main seat 22 is raised out of seating engagement with the flat surface surrounding the throttling throat 48. This movement of valve seat 22 immediately opens a passageway for the flow of water under the valve seat and between the refill head 23 and the inside wall of the throttling throat 48. The rate of flow through this passageway is very small, and of itself occurs silently, as will be subsequently discussed more fully in connection with the description of the reclosing of the valve. No audible reaction results in the supply piping, from the unseating of the main valve 22, even though the supply piping be long and the pressure high, for the unseating opens such a small passageway between the refill head 23 and the inside of the throttling throat 48 that the rate of flow is initially very small. Refill head 23 is

preferably only about .005 inch smaller than the straight portion of the throat **48**. The resulting pressure drop in the supply piping is so small that the tendency for the piping to shrink or move suddenly by virtue of this decrease in pressure, or responsive to the starting into motion of the column of water contained therein, is reduced below the point of audibility.

As the piston moves upwardly, the refill head **23** is drawn further and further out of the cooperating throat, and the lower portion thereof begins to leave the straight portion **48** and enter the tapered portion **47**, shown more clearly in Figure 6. The angle of the tapered portion **47**, together with the length of the tapered portion, was determined by experiment. A suitable angle was found to be about seven degrees from vertical, as illustrated. The length of the tapered portion need be only about three thirty-seconds of an inch in the construction shown. As a result of the provision of this tapered portion, the small effective opening, existing immediately upon the removal of main seat **22** from its seated position, is gradually increased as the bottom portion of the refill piece **23** is withdrawn from the tapered portion **47**. There is thus no sudden increase in the rate of flow when the piece **23** is fully withdrawn from the tapered throat portion **47**. This tapered provision not only prevents pipe noises which might otherwise result from a sudden enlargement of the discharge area, but also is advantageous in avoiding the generation of water noises during the transition period from the slight flow to the full flow, as will be more fully explained in connection with the description of the quiet closing of the flush valve.

With the refill head **23** fully withdrawn from the tapered portion **47** of throat **48**, the discharge area through the flush valve is controlled by the space provided around the wings of the guide stem **24**. As previously discussed, this area may be on the order of two-tenths of a square inch for the described flush valve, which area is in excess of the area ordinarily effective through the throttle valve A in the illustrated partially throttled position. The throttle valve is preferably set in some partially throttled position which will reduce the rate of flow to the desired value (about twelve gallons a minute for the purpose described), being set in a fully opened position only when the supply pressure and length of piping is such that the maximum unthrottled rate of flow is not excessive.

Closing the limit valve 36

When the piston **21** reaches the top of its stroke (a second or so after the push button **59** is actuated), the valve **36** closes, when the seat **37** comes into seating engagement with the lower end of regulating stem **71**. When this occurs, the upper chamber **42** is effectively isolated from the relief-intake chamber **54**, and the further escape of water from the upper chamber is thus prevented, independent of whether or not the push button **59** is held actuated or is released.

The piston slowly returns

Upon the seating of the limit valve **36** upon the end of regulating stem **71**, the slow inflow of water to the upper chamber through the bypass opening **29** results in the slow refilling of upper chamber **42** and the consequent slow descent of the piston **21** to eventually return the main seat **22** into seating engagement around the discharge port **47**.

Prolonged flushing avoided

The limit valve **36**, by seating against the end of regulating stem **71**, not only prevents prolonging of the flushing operation in the event that the push button **59** is held actuated unduly long, but it also effectively prevents a prolonging of the flushing operation in the event that the push button **59** is released and reactuated before the main flushing operation has been completed. It will be apparent that the limit valve **36** is held up by pressure against its seat to seal off the opening **76** as long as the push button **59** is held actuated. The limit valve **36**, because of its tight rubber seat **37**, remains in tight sealing engagement with the seat at the bottom entrance to passageway **76** even after push button **59** is released. The relieved pressure in the relief-intake chamber **54** cannot be restored so long as valve **36** remains firmly seated, and the pressure differential holds the limit valve seated. With this arrangement, until the limit valve **36** is later pulled away from its seat, the push button **59** can be released and reactuated as often as desired without affecting the downward movement of the main valve.

The quiet approach operation

With the illustrated construction, the flush valve descends and gradually reduces the rate of flow from the full flushing rate to a slow refill rate and finally closes off with no audible piping disturbance and with no direct water noise other than a slight and almost inaudible fleeting hiss, just as the bottom portion of the refill head **23** enters the tapered portion **47** in the throttling throat **48**.

With the throttling device A set to quietly throttle and limit the maximum rate of flow to about the optimum value, there is little or no tendency toward generation of noise in the flush valve while it is fully open. The passageway through the flush valve at this time is sufficiently large that the pressure and velocity of the water flowing through the flush valve are both relatively low, and only low pressures are present in the flush valve. But, near the end of the downward movement of the piston, after the refill head **23** has entered the throttling throat, the pressure in the supply nipple **3** and above the main seat **22** of the flush valve rises very nearly to the full line pressure, which may be as high as one hundred pounds to the square inch, or higher, in certain installations. The velocity of flow from any pressure in excess of, say, twenty pounds to the square inch tends to cause generation of disagreeable water noises, as is well known.

When the lower corner of the refill head **23** begins to get close to the entrance to the throttling throat and pressures capable of causing noise-generating velocities begin to be built up, the resulting jets are directed onto the annular impact assembly **50**, and this assembly receives the impact of these jets and quietly breaks up the jets and delivers them into the discharge portion of the flush valve as a quiet slow-moving stream. The quietness of the approach operation is greatly enhanced by the tapered entrance **47** to the throttling throat **48**, by means of which the flow is more smoothly directed into an annular jet, and the comparatively vigorous annular jet thus formed is more

effectively directed onto the impact member **50**. Additionally, by means of the tapered entrance **47** to the straight portion **48**, abrupt reduction in the discharge area through the flush valve is effectively prevented, whereby the momentum of the column of water travelling through the supply pipe **1** (particularly when this supply pipe is long) is gradually dissipated and is prevented from building up pressure at the inlet of the flush valve in excess of the supply pressure.

The quiet refill flow

The refill flow, occurring after the refill head **23** has entered the straight portion **48**, is rendered particularly quiet by virtue of the relatively close fit between the outside surface of piston **23** and the inside surface **48**, and the consequent slowing of the velocity of flow far below the noise making value.

Quietness during the approach, refill, and closing operations is enhanced by the illustrated fine circular scoring on the outside surface of piece **23**. This scoring may take the form of about eighty ninety-degree ridges to the inch, with the top of the ridges comparatively sharp, although finer or coarser scoring may be used with good results, and the sides of the ridges may form an angle of more or less than ninety degrees, if so desired.

Silencing the flow during what is referred to as the "approach" (when the bottom of refill head **23** is approaching and entering the throttling throat) proved to be more difficult, but has been almost completely accomplished, even with the very highest pressures used, in the illustrated arrangement.

Attention is particularly called to the lowermost scoring ridge on the refill head **23**, seen best in Figure 6. It has been found that the approach operation is much more nearly completely quiet when this ridge is sharp as shown, preferably extending outwardly to the full diameter of the refill head and having the refill head terminate sharply and present a flat end surface beginning about the peak of this bottom ridge. It is to be noted that the topmost ridge is similarly formed and that the two ends of the refill head **23** are otherwise the same, whereby this piece is reversible.

Releasing the limit valve 36

After the refill head **23** has reached or entered the straight portion **48** of the throttling throat, and the rate of flow through the flush valve has therefore been cut to a very small value, considerably below the value required to induce or maintain syphonic action in a water closet, the head **41** affixed to the stem **40** of the limit valve **36** is engaged by the bottom portion of the gland **33** to physically pull the valve **36** away from its seat around the lower end of regulating stem **71**. If the push button **59** has been released by this time (as it ordinarily will have been), the limit valve is immediately pulled away from its seat when the head **41** is thus engaged. The limit valve **36** thereupon drops to its illustrated position on the piston of the flush valve, and the downward movement of the flush valve toward its closed position continues unchecked.

On the other hand, if the push button **59** is still being held operated when head **41** is engaged, the descent of the piston of the flush valve is arrested. The arresting of the movement of the piston **21** occurs when the seating member **37** is only very slightly separated from the annular seating surface at the bottom of stem **71**. When this condition obtains, the resulting escape of water from upper chamber **42** through the open relief valve **56** lowers the pressure in the upper chamber just sufficiently that the piston of the flush valve remains stationary. The limit valve **36** is held in this position of close proximity to its seat so long as the push button **59** remains operated. The flush valve is thus held in its partly closed position, with water flowing therethrough at the small refill or trickle rate.

When the push button **59** is subsequently released, the pressure in relief-intake chamber **54** immediately rises to equal the pressure in upper chamber **42**, whereupon limit valve **36** drops. The flush valve now resumes its closing movement.

The quiet close-off

Because the rate of flow during the final movement of the flush valve toward its seat is reduced to a very small value by the small clearance of two or three thousandths of an inch between the parts **23** and **48**, the velocity of flow in the supply line is reduced to such a small value that there is no objectionable tendency toward a water-hammer when the flush valve closes off. Moreover, because of the small rate of flow passing through the flush valve, the actual seating itself is silently accomplished.

Quantity regulation

The quantity of water delivered by the flush valve in its main flushing operation may be readily regulated by turning the regulating screw **71**. Turning the regulating screw **71** in a direction to raise it, raises the seat carried on the lower end thereof for limit valve **36**. With this adjustment made, the piston of the flush valve rises further before the limit valve **36** comes to a seat to terminate the outflow of water from upper chamber **42**. As a result, the piston of the flush valve has a longer distance to travel in its downward return movement. A correspondingly larger quantity of water is delivered.

When the quantity of water delivered during the main flushing operation is higher than desired, the regulating screw **71** may be turned so as to bodily lower it and thereby lower the limit-valve seat which it carries. With this adjustment, the limit valve **36** comes to a seat on the bottom end of regulating screw **71** before the piston of the flush valve has travelled so far. Under this condition, the piston of the flush valve has a lesser distance to travel in its return movement, and accordingly a correspondingly lesser quantity of water is delivered during the main flushing operation.

The adjustment movement of the regulating screw **71** is preferably limited in both directions to insure that this screw cannot be so set inadvertently as to interfere with the proper and intended functioning of the limit valve **36**. In its uppermost position of adjustment, the enlarged threaded portion of the stem **71** contacts the cupped metal washer **79** placed at the bottom of stem packing **73**. This washer **79** and the stem packing **73** are held firmly in place by the pressure applied by packing nut **74**, when it is tightened sufficiently to prevent leakage around stem **71**.

With the stem **71** in its uppermost position of adjustment, the seat carried thereby for limit

valve 36 is raised somewhat from the illustrated position, and the limit valve is held higher during the return movement of the flush valve piston than it is with the illustrated position of adjustment. Therefore, the head 41 of stem 40 is engaged by the bottom of retaining nut 33 while the flush valve is still further from its final seating position. The dimensions of the parts concerned are preferably so chosen that, in the assumed position of adjustment of stem 71, the forward or bottom portion of refill head 23 will have at least reached or entered the straight portion of the throttle throat, whereby the rate of flow through the flush valve is reduced to substantially its minimum value, whereby only a small flow can be continuously derived from the flush valve if the push button 59 is held indefinitely.

The lower limit of adjustment of stem 71 is reached when the shoulder portion thereof, immediately below the cross holes 75, is turned down against the accurately machined floor of relief-intake chamber 54. In this position of adjustment, the seat cooperating with limit valve 36 is so lowered that the limit valve hangs lower during the descent of the flush valve piston. Under this condition, the head 41 of stem 40 is not engaged by the bottom portion of gland 33 until the piston has more nearly reached its final closed position. The dimensions of the parts concerned are preferably so chosen that the head 41 is engaged substantially before the piston of the flush valve reaches its final seated position, whereby the limit valve 36 is reliably restored and not allowed to remain in seated position to prevent the exercise of further control of the flush valve through the push button 59.

With further reference to the provisions for preventing water-hammer and similar noises and disturbances upon the unseating and seating of the flush valve B, it should be noted that the velocity-retarding effect produced by the described and illustrated scoring of the cylindrical surface of refill head 23, when it is within the straight portion of throat 48, permits greater manufacturing tolerance. Without roughening to retard the velocity when the valve is in the vicinity of its seat, the diameter of refill head 23 must be made so near that of the throat 48, to secure smooth opening and closing on long runs of supply pipe, that almost no diametrical tolerance can be permitted. With such scoring to retard the velocity, the described diametrical difference of about five-thousandths inch is satisfactory, and may vary a thousandth or more each way without causing difficulty.

As has been previously pointed out, the guide stem 24 and refill head 23 are accurately held to a common centre by the upper end portion of part 24, which enters and fits closely within part 23. With this accurate centering arrangement, a small amount of looseness or play between the guide wings and cooperating guide wall may be permitted without danger of actual scraping contact between head piece 23 and the throat wall 48.

What we claim is:

1. In a flush valve, a valve casing including an inlet opening and an outlet opening interconnected by a central chamber, a main valve reciprocable in said central chamber to open and close communication between said openings, a control passageway, a primary control valve for opening and closing said passageway, means responsive to an opening of said passageway for moving said main valve from closed position to open position, and responsive to a closure of said passageway for returning said main valve to closed position, a secondary control valve for closing and opening said passageway, means responsive to the opening movement of said main valve when the primary control valve is opened for closing said secondary control valve to effect a reclosing movement of the main valve, and means controlled by the movement of the main valve toward its closed position for reopening said secondary control valve.

2. In a hydraulically-actuated flush valve including a valve operable between a closed position and an open position, a control device having a normal position and an actuated position, means responsive to the bringing of said control device into actuated position to move said valve to its open position, and responsive to a restoration of said control device to its normal position for returning said valve to its closed position, and means controlled by the movement of said valve to its open position for temporarily removing said valve from under the control of said control device and for initiating the return of said valve to its closed position independent of whether or not said control device remains in its actuated position or is restored to its normal position, and means responsive to the arrival of said valve in a position intermediate its open and closed positions for again placing the valve under the control of said control device.

3. In combination, a valve casing having an inlet opening and outlet opening, a hydraulically controlled valve in said casing having a throttle position in which only limited communication between said openings is afforded and an open position in which free communication is afforded between said openings, a control device operable between a normal position and an actuated position, means responsive to an operation of said control device from its normal position to its actuated position for moving said valve to its said open position, other control means brought into play responsive to the movement of said valve for starting the return movement of said valve from its open position to the said throttle position while the first-named control device remains in actuated position, and means effective in the event that the first said control device is still in its actuated position when the said valve reaches its throttle position for maintaining said valve in its throttle position so long as the first said control device remains in actuated position, and means responsive to the restoration of the first said control device to its normal position, or responsive to the arrival of said valve in its throttle position, whichever last occurs, for restoring said other control means to again place the said valve under the direct control of the first said control device.

4. In combination, a metering flush valve operable between a closed position and an open position, structure carried by said valve and effective during a substantial portion of the movement of the valve from open position to closed position to throttle the flow through the valve whereby said flush valve, in moving from open position to closed position first delivers a metered quantity before it reaches its throttle position and then delivers a further quantity at a substantially lesser rate of flow while it is passing through its throttle position to its closed position, a control device, means responsive to an actuation of said

control device for bringing said valve into open position, and means effective upon the arrival of said valve in open position for causing the valve to travel toward its throttle and closed positions and to deliver a uniform quantity in traveling from its open position to its throttle position in spite of any further actuation or restoration of the said control device which may occur.

5. In a flush valve, a casing having inlet and outlet openings, a main valve reciprocable in said casing between a closed position and a full open position to control communication between said openings, a control valve, means responsive to an actuation and restoration of said control valve for hydraulically moving said main valve from its closed position to its open position and for returning said main valve to its closed position, a limit valve and means for actuating it responsive to the arrival of said main valve at its full open position to render the said control valve ineffective, whereby the main valve is started on its return movement independent of the further actuated or unactuated condition of the control valve, and means for regulating the distance through which the main valve travels before the limit valve is actuated, and consequently the distance the main valve must travel in returning from full open position to closed position.

6. In a flush valve, a casing having an inlet opening and an outlet opening, a main valve reciprocable in said casing to open and close communication between said openings, a control valve and means associated therewith for hydraulically opening and closing the main valve responsive to an opening and a closing of the control valve, a limit valve loosely carried by the main valve, a seat for said limit valve secured to the casing and serially related to the said control valve, said limit valve being so positioned as to be brought to its seat by the main valve when the latter travels away from its seat, the seating of said limit valve being effective to terminate flow through the control valve and thereby initiate the return movement of the main valve even though the control valve be held open, and means for regulating the length of the stroke of the main valve pursuant to regulation of the quantity of fluid discharged in an operation thereof, said regulating means including means for bringing the said seat of the limit valve closer to and farther from the position occupied by said main valve when seated.

7. A piston unit for a hydraulically-actuated metering flush valve including a structure having a packing member at the upper end thereof, a main seat concentric with the packing member and longitudinally displaced therefrom toward the lower end of the piston, there being a vertically disposed central opening extending through said packing to the upper end of the piston, the upper end of said opening having an internal shoulder around a portion of reduced diameter, a limit valve normally lying on the upper end of said piston when the piston is in upright position and at rest, said limit valve having a stem extending down into said central opening, and means on said stem within said central opening for engaging said internal shoulder to prevent said stem from being detached from the piston, but located sufficiently below said shoulder that the limit valve can be moved upward a substantial distance from its normal position before further movement is stopped by said shoulder.

8. A piston unit for a hydraulically-actuated metering flush valve including a main body structure having a packing member at the upper end thereof and a main seat concentric with the packing member and longitudinally displaced therefrom toward the lower end of the piston unit, a substantially cylindrical throttle portion or refill head, a guide stem, means for assembling said refill head to the piston unit below said main seat and for assembling the guide stem below said refill head, and means including an annular extension portion on one of said refill and guide members cooperating with an annular recess in the other of the said members for accurately holding the two said members concentric with each other.

9. A piston unit for a hydraulically-actuated metering flush valve including a main body structure having a packing member at the upper end thereof and a main seat concentric with the packing member and longitudinally displaced therefrom toward the lower end of the piston unit, a substantially cylindrical throttle portion or refill head, a guide stem, means for assembling said refill head to the piston unit below said main seat and for assembling the guide stem below said refill head, means including an annular extension portion on one of said refill and guide members cooperating with an annular recess in the other of the said members for accurately holding the two said members concentric with each other, and means for holding the said refill member concentric with the main body portion of said piston unit, including an annular extension portion on one of the two last named parts and an annular recess in the other.

10. In a hydraulically actuated flush valve operable to discharge a metered quantity of fluid at a relatively high rate of flow, a device actuatable to control the operation of said flush valve, and means in said flush valve effective upon prolonged actuation of said control device for throttling the rate of flow through said flush valve to a comparatively small value and for maintaining the said throttled rate of flow through said flush valve so long as the said control device is maintained actuated.

11. In a hydraulically actuated flush valve operable to discharge a metered quantity of fluid, means including a limit valve actuated by said flush valve for controlling the flush valve in its metering operation, regulating means for said flush valve for regulating the amount of said metered discharged quantity of fluid, and a valve seat for said limit valve arranged on said regulating means, said limit valve operable into and out of engagement with said valve seat solely by the actuation of said flush valve.

12. In a hydraulically actuated flush valve operable to discharge a metered quantity of fluid, means including a limit valve operated by said flush valve for controlling said flush valve in its metering operation, a regulating member for regulating the amount of said metered discharged quantity of fluid, a valve seat cooperable with said limit valve arranged on said regulating member, said limit valve operable by said flush valve into engagement with said valve seat at the beginning of a metering operation of the flush valve and operable by said flush valve out of engagement with said valve seat as the flush valve approaches the end of its metering operation.

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