United States Patent [19]

Hyde

[11] **3,760,839**

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[54] **FLOAT VALVE**

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[73] Assignee: **Pryde Inc.,** Cincinnati, Ohio

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[21] Appl. No.: **193,372**

[52] **U.S. Cl.** **137/414,** 137/217, 251/45

[51] **Int. Cl.** **F16k 31/18**

[58] **Field of Search** 137/217, 218, 414, 137/434, 441, 442, 443, 444, 451; 251/45, 46

[56] **References Cited**

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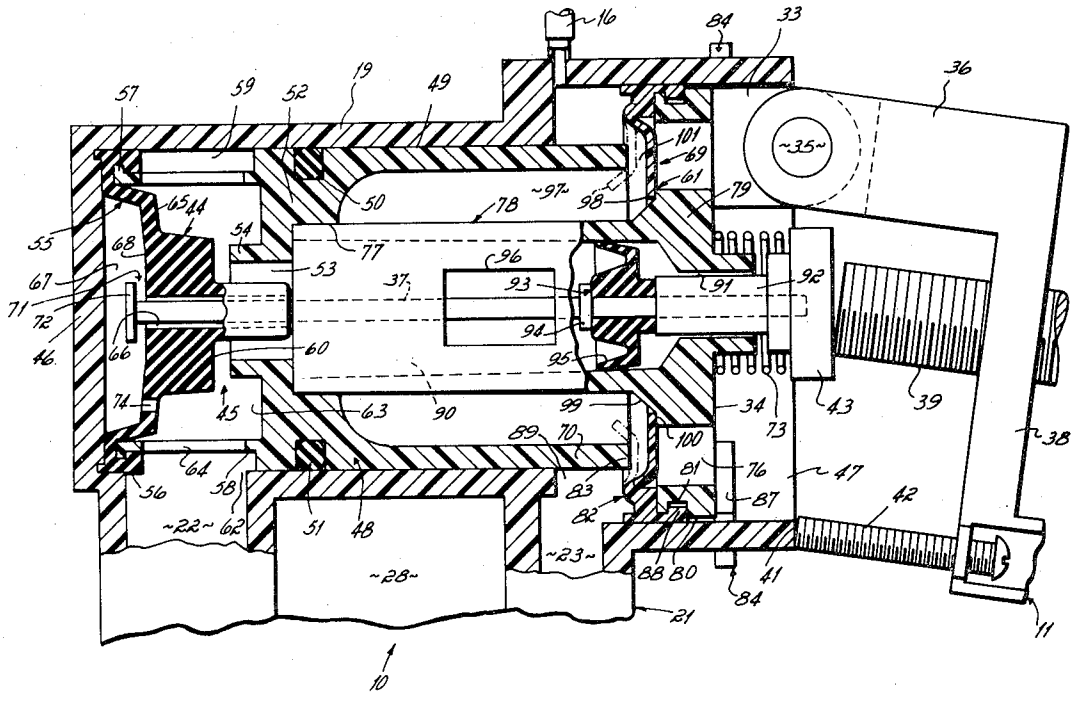
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[57] **ABSTRACT**

A float valve adapted for use in a toilet tank and which, in combination with a float arm and float, serves to control the refill level of water in that tank after the toilet has been flushed. The float valve is structured so that water flow therethrough is essentially noiseless from opening to closing of the valve; the valve's structure is such that more than one pressure drop is created within the valve housing to prevent any one pressure drop from inlet line pressure to tank pressure from being of a sufficient size to create water noise, and is such that chatter or fluttering of the valve is essentially eliminated as water flow through the valve is terminated. Further, the float valve is structured so that overflow of the toilet tank as a result of a leaky float ball is not possible; the valve closes due to water pressure in the inlet line when the tank has been refilled and the valve opens due to the float's weight as the tank is drained when the toilet is flushed.

12 Claims, 5 Drawing Figures



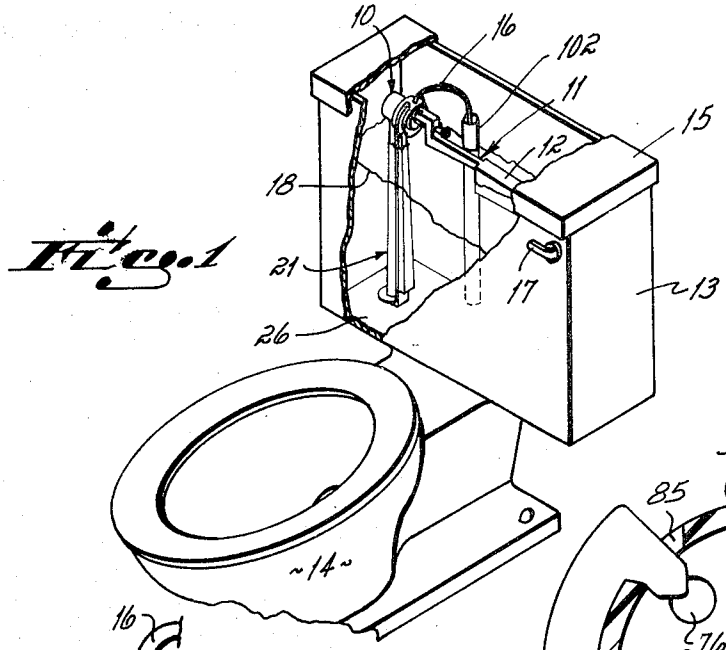


Fig. 1

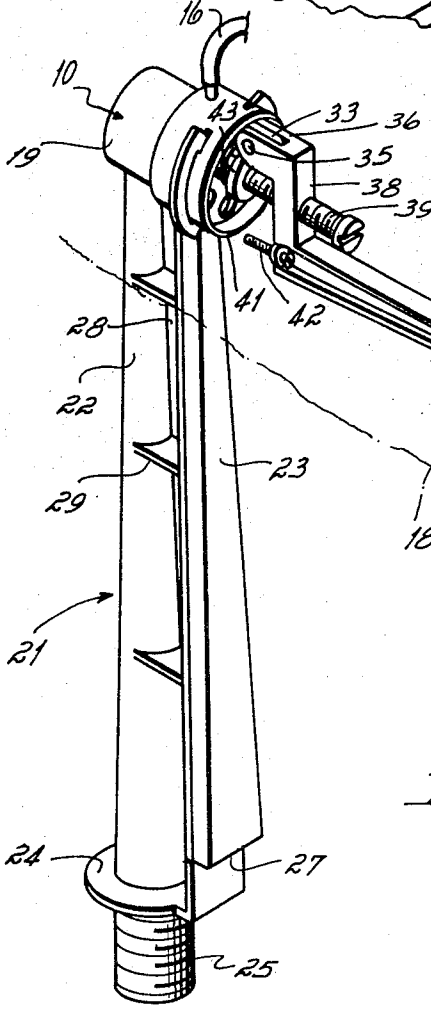


Fig. 2

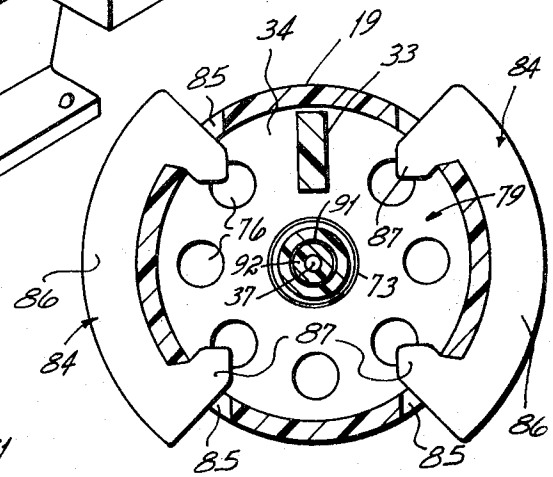


Fig. 5

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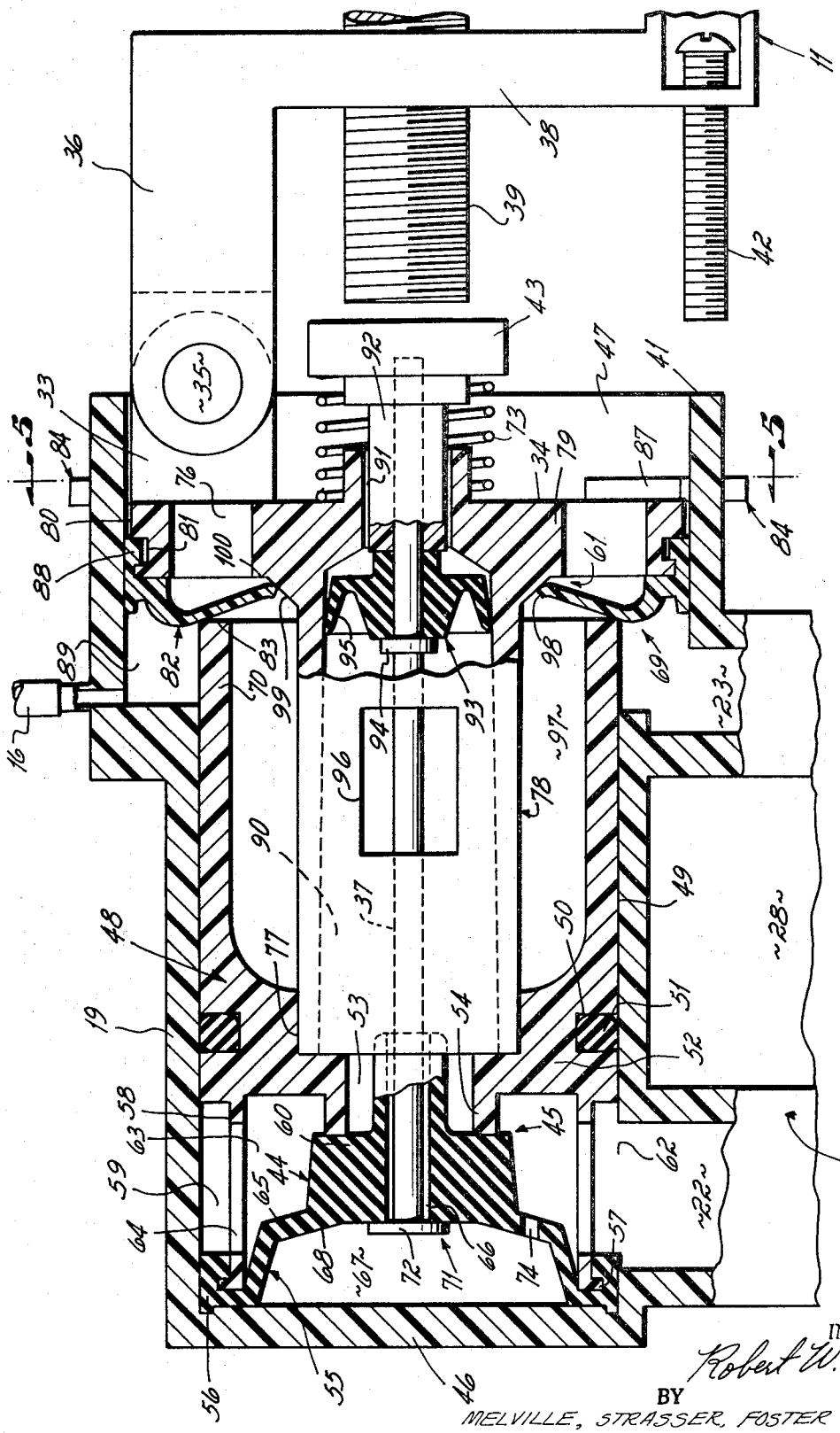


Fig. 3

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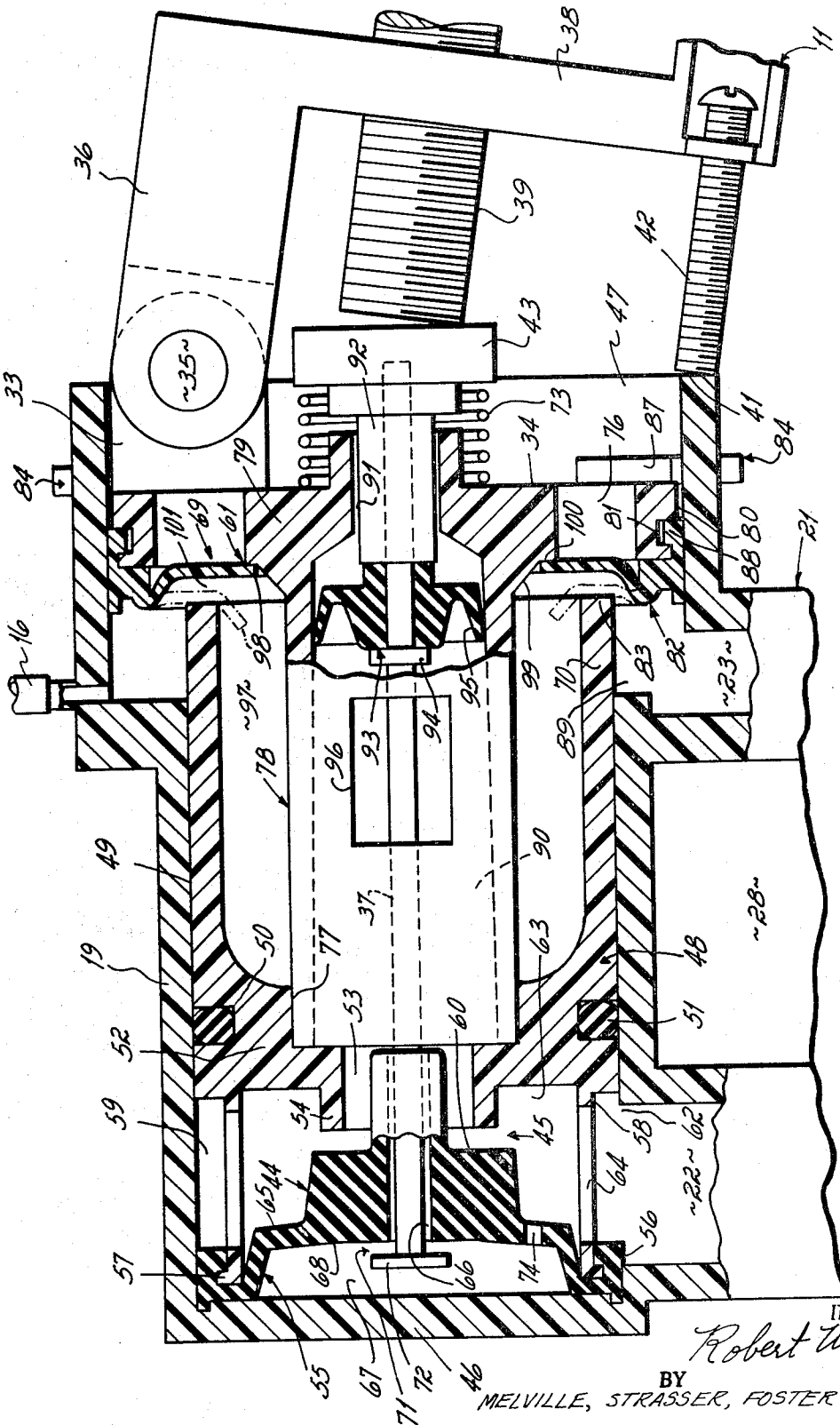


Fig. 4

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FLOAT VALVE

This invention relates to valves. More particularly, this invention relates to a float valve adapted for use in a toilet tank and which, in combination with a float arm and float, serves to control the refill level of water in that tank after the toilet has been flushed.

Float valves of one type or another have, of course, been used for many years in conjunction with the refilling of toilet tanks. Basically, a float valve functions to check the inlet flow of water from a water source into the toilet tank until the toilet has been flushed, to allow water flow into the tank after flushing the toilet, and to close off that water flow after the refill level of the toilet tank has been reached. The refill level of water in the toilet tank is regulated by the vertical position of a sealed float ball connected through a float arm to the float valve's servo-mechanism. The float ball, being hollow and sealed to the atmosphere, rides on the water surface within the toilet tank. In operation, and upon flushing of the toilet, water held in the tank rushes out into the toilet bowl and this causes the float ball to fall. As the water level reaches the bottom of the tank a flush valve closes the tank and, thereby, reseals it from the toilet bowl. As the sealed float ball achieves its lower attitude on flushing of the toilet the float valve is opened to permit refilling of the toilet tank, and as the sealed float ball achieves its upper attitude after refilling the toilet tank the float valve is closed to check further inlet flow of water. Thus, the toilet tank is refilled after flushing of the toilet.

A float valve is not a simple valve. A float valve must, of course, be able to control the flow of water to the toilet tank from a water source as the position of the sealed float ball dictates. But a float valve must also be able to prevent water in the toilet tank from being drawn or siphoned back through the valve into the water supply if a vacuum is established on the valve's inlet line.

One typical float valve on the market today has a housing which defines a single valve chamber. The housing is connected to a water inlet pipe that opens into the chamber's at an inlet port, and receives a valve stem that extends vertically into the chamber from the outside thereof. A water outlet pipe also opens into the chamber. The valve stem is provided with a head adapted to move vertically, as the stem moves axially, into and out of sealing engagement with the chamber's inlet port. The valve stem is connected at one end to a lever arm, a float ball being connected to the lever arm's other end. The lever arm is mechanically linked to the valve housing and to the valve stem. In operation, as the float ball falls to its lowermost position in the toilet tank upon flushing of the toilet, the valve stem is moved axially upward by the mechanical linkage and/or water pressure on the valve head to open the inlet port to the chamber and, thereby, supply water to the outlet pipe to refill the tank. As the float ball reaches its uppermost position in the tank after refilling, the mechanical linkage depresses the valve stem axially downward toward the inlet port to close the inlet port and, thereby, shut off the flow of water to the toilet tank. To provide an anti-siphon characteristic in this float valve, the float valve must be mounted in the toilet tank above the top water level in the tank. The ceiling of the valve housing is provided with a series of holes surrounding the valve stem, thereby essentially

opening the chamber to the atmosphere. A deformable washer is also mounted to the valve stem, the washer being positioned between the valve head and the ceiling of the chamber when the float valve is closed. In operation, as the valve stem moves up when the float ball has fallen due to flushing of the toilet, the deformable washer is pushed into sealing engagement with the holes in the chamber ceiling to prevent substantial loss of water through those holes while refilling the toilet tank. When the toilet tank is refilled and the float valve is closed, the chamber is open to the atmosphere through the ceiling holes. In this attitude, and when water inlet line conditions are such that a vacuum is established in the inlet line, air is sucked into the valve chamber and into the inlet line instead of water in the toilet tank being siphoned back from the tank into the water supply. Prior art float valves which disclose these characteristics are set out in U.S. Pat. No. 2,635,622 and U.S. Pat. No. 3,070,118.

Typically, and as is the case with the float valve structure described in the paragraph above, the prior art float valve adapted for use in a toilet tank is opened either (1) by mechanically raising or moving the valve head off its seat to open the valve as the sealed float ball falls or (2) by eliminating an abutment from the valve stem which keeps the valve head seated on the inlet port so that the inlet line water pressure raises the head off its seat to open the valve as the sealed float ball falls, thereby allowing the inlet flow of water into the toilet tank for refilling the tank. Further, and typically, and as is the case with the prior art float valve structure described above, closing of the float valve depends on the buoyancy of the sealed float ball to pivot the lever arm so that a mechanical linkage can depress the valve stem to force the valve head to seat on the inlet port against the inlet pressure of the water supply, thereby checking the inlet flow of water to the toilet tank after the tank has been refilled.

The prior art float valves of the general type described above have a couple of drawbacks from the standpoint of practical operation in toilet tanks. In the first instance such float valves are noisy. Noise in a float valve occurs generally from at least one of two sources. The first source of float valve noise may arise because of partial vaporization of the water during refilling of the toilet tank, i.e., the forming of bubbles in the water as the water passes through the valve seat's orifice and, thereafter, the recapturing or dissolving of those bubbles back into the water as the pressure on the outlet side of the orifice more or less equalizes. Such partial vaporization of water particularly occurs when the water pressure differential or drop between the water inlet line pressure and the toilet tank pressure is greater than about 40 psi and when that pressure drop occurs across a single orifice of a size typically found in float valves. The inlet water pressure to residential homes is anywhere from about 40 psi (in rural areas) to about 90 psi (in metropolitan areas); thus, the water noise problem is quite prevalent in metrpolitan areas since prior art float valves provide only a single pressure drop (from water inlet line pressure to toilet tank pressure) and since that drop is usually greater than 40 psi. The second source of float valve noise may arise through chattering or fluttering of the valve's head when it closely approaches the final closed attitude with the valve's seat as the toilet tank approaches the final water refill level. In prior art float valves, as the float ball and

lever arm move up due to increasing refill depth of water in the toilet tank, the valve's head is brought in increasingly close proximity with the valve's seat. But this movement is relatively slow, i.e., the valve's head does not move instantaneously between a totally open position and a totally closed position; as the orifice defined between the valve's head and the valve's seat becomes of diminishing area, the water passing therethrough at water inlet line pressure tends to cause a high pitched or screeching sound, and/or tends to rattle or shake the valve's servo-mechanism, all of which results in a chattering or fluttering noise until the valve is totally closed. Thus, in float valves of the prior art it is usually the case that the water pressure provided by the source to the average home in most areas of this country is sufficiently great, if not substantially greater than, that pressure which will cause noise to occur from either one or both of the above sources as the water flows through the float valve into the toilet tank for refilling same.

In the second instance, the float valves of the prior art are not failsafe as to closing in the sense that they usually depend on a float ball which is evacuated of atmosphere and is completely sealed to the atmosphere, i.e., the closing of a typical float valve depends on the buoyancy of the float. This for the reason that the valve's head is mechanically depressed by the pivoting lever arm as the float valve rides up the water level during refilling of the toilet tank. When the water level reaches the final refill level in the tank, the lever arm has mechanically depressed the valve's head into sealing engagement with the valve's seat or inlet line port. If the float ball springs a leak such that it partially or completely fills with water, the float ball will not ride up all the way with the water level as it rises in the toilet tank, i.e., the float valve then will remain open even though the toilet tank is refilled. Of course, such will result in an overflow of the toilet tank with its accompanying damage to the surrounding bathroom environment.

In the third instance, the float valve of that type described above provides substantial maintenance problems over periods of prolonged use. When maintenance problems arise with prior art float valve structures, generally speaking the practical solution of the plumber is to completely replace the entire float valve, instead of repairing it, because of the complexity of the valve structure. Thus, problems in maintenance of the valve are generally solved at the expense of the owner simply by installing a new valve instead of repairing the old one.

The float valve of this invention is adapted for use with a toilet tank to control the refill level of water in that tank after the toilet has been flushed. The valve is connected to a float through a float arm, the float being adapted to ride on top the water surface in the tank. The float valve is structured so that water flow therethrough is essentially noiseless from opening to closing of the valve; the valve's structure is such that at least one pressure drop is created within the valve housing to prevent any one pressure drop from inlet line pressure to tank pressure from being of a sufficient size to create water noise, and is such that chatter or fluttering of the valve is essentially eliminated as water flow through the valve is terminated. Further, the float valve is structured so that overflow of the toilet tank as a result of a leaky float ball is not possible since the float used need not be sealed in the first instance but may be merely of an inverted cup-shaped configuration; the valve closes due to water pressure in the inlet line when the tank has been refilled and the valve opens due to the float's weight as the tank is drained when the toilet is flushed.

The noiseless operation of the float valve is accomplished by more than one pressure drop orifice in the valve's housing through which the water must flow from the water inlet line to the toilet tank so as to reduce the pressure of the inlet water in more than one step from the inlet pressure level to the outlet pressure level. Two of these orifices may be established by an open-close valve and a back pressure valve carried in the valve's housing. The increment of the pressure drops created at each of the orifices is less than that which creates noise, i.e., less than 40 psi, thereby allowing the water flow through the valve to be essentially noiseless.

The float valve is designed to close due to water pressure, and open due to the weight of the float, by providing an open-close valve that includes a flexible diaphragm (the valve head) which separates a section of the valve's housing into a pilot chamber and a feed chamber; the pilot and feed chambers are related through a bleed port in the diaphragm, and the water inlet line opens into the feed chamber. The diaphragm functions to close (when the valve is closed) and to open (when the valve is open) a main port (the valve seat) by which water is allowed to pass through the valve as the toilet tank is being refilled. An auxiliary valve head is continually biased against a relief port in the flexible diaphragm and, in the float valve closed attitude, such causes the diaphragm to seal off the main port. In operation, as the water level in the toilet tank falls the float arm depresses the auxiliary valve head's stem, and this opens the relief port in the diaphragm to allow water in the pilot chamber to pass therefrom. Water in the feed chamber then is at a greater pressure than water in the pilot chamber, and this causes the flexible diaphragm to move to the open position (against the diaphragm's normal closure bias) so that water can pass through the main port to refill the toilet tank. As the tank refills the float arm is moved out of abutting engagement with the auxiliary valve head's stem because of the float riding up on the water surface, thereby allowing the relief port in the diaphragm to close in accord with its usual closure bias and permitting inlet water pressure to be reestablished in the pilot chamber through the bleed port. The pressure area of the diaphragm in the pilot chamber is preferably substantially greater than the pressure area of the diaphragm in the feed chamber; this insures that the diaphragm will seal off the main port after the toilet tank is refilled since the water pressure in the pilot and feed chambers are equal as long as the relief port is closed by the auxiliary valve head.

Therefore, it has been one objective of this invention to provide a float valve adapted for use in toilet tanks that is substantially noiseless in operation from opening to closing of the valve.

It has been another objective of this invention to provide a float valve adapted for use in toilet tanks which is constructed to a self-close due to the inlet pressure of water to the valve when the tank is refilled and which is constructed to open due to the float's weight as the tank is drained when the toilet is flushed.

It has been a further objective of this invention to provide a float valve adapted for use in toilet tanks which incorporates a novel servo-mechanism that co-operates with the float arm.

It has been yet a further objective of this invention to provide a float valve adapted for use in toilet tanks which is of modular construction, the main functioning parts of the valve being easily removable from the valve housing, inlet piping and outlet piping, thereby allowing simple replacement of a worn part within the valve housing to provide easy and inexpensive maintenance thereof.

Other objectives and advantages of the invention will be more apparent from the following detailed description taken in conjunction with the drawings in which:

FIG. 1 illustrates the float valve of this invention in its operating environment, namely, with a toilet tank and toilet bowl;

FIG. 2 is a perspective view illustrating the float valve with the float arm, inlet piping, and outlet piping;

FIG. 3 is a partial cross-sectional view taken along lines 3—3 of FIG. 2 illustrating the float valve in the closed attitude after the toilet tank has been refilled;

FIG. 4 is a partial cross-sectional view similar to FIG. 3 illustrating the float valve in the open attitude during refilling of the toilet tank; and

FIG. 5 is a cross-sectional view taken along lines 5—5 of FIG. 3.

The float valve **10** of this invention is adapted for use with a float arm **11** and float **12**, see FIG. **2**. The environment within which the float valve **10**, float arm **11** and float **12** operate includes, of course, a toilet tank **13** and a toilet bowl **14**, see FIG. **1**. Access to the inside of the toilet tank **13** is provided through a toilet tank cover **15** that is removable. The float valve **10**, float arm **11**, and float **12** are adapted to cooperate with flush valve structure, not illustrated, of any type well known to the art, and the float valve is also adapted to cooperate with an afterfill tube **16** of that type well known to the art. In use, the toilet **13, 14** is flushed in the usual manner, i.e., by turning handle **17**; this causes the flush valve to open (which allows the water in the toilet tank **13** to drain rapidly into the bowl **14**) and then close, and causes the float **12** to fall as the water level in the tank **13** recedes. As the float **12** falls to a lower position from an upper position the float valve **10** is opened (as will be subsequently explained in detail) to allow the tank **13** to be refilled. As the water level in the tank achieves the maximum refill depth **18** the float **12** rides thereon back to its upper position at which the float valve is closed (as will be subsequently explained in detail) to close off or check the refill flow of water into the toilet tank, thereby controlling the flow and refill level of water in the toilet tank.

General Structure

The float valve **10** is mounted on, and the float valve's casing or housing **19** is molded integral with, a pipe structure **21** that defines a water inlet pipe **22** and a water outlet pipe **23**, see FIG. **2**. A web **28** with reinforcing steps **29** is provided between the outlet pipe **23** and the inlet pipe **22** so as to maintain the rigidity of the pipe structure **21** which, along with valve housing **19** is a one-piece molding.

The inlet pipe **22** has a flared collar **24**, the pipe being threaded (as at **25**) below that collar. The pipe structure **21** is fixed in operating relation with a water source line (not shown) feeding the toilet tank **13** by screwing the threaded section **25** of the inlet pipe **22** into the floor **26** of the tank until collar **24** rests on the floor **26**; thus, the collar serves to provide vertical stability to the float valve **10**-pipe **21** structure. It will be noted that the outlet **27** of the outlet pipe **23** is positioned just above the collar **24.** This allows water to be exhausted from the outlet pipe **23** into the toilet tank **13** very close to the tank's floor **26.** Therefore, during most, if not all, of the refilling of the toilet tank **13** the refill water is discharged into the tank below the water's surface; such tends to muffle the noise during refill. Also, note that the inlet pipe **22,** which basically supports the float valve **10,** is of sufficient height to position the float valve **10** above the refill level **18** of water in the toilet tank; such is important (as will be subsequently described in detail) in providing anti-siphon characteristics for the float valve.

The float **12** is molded integral with the front end of the float arm **11,** and is simply an inverted cup-shaped chamber open at the bottom **32.** When the water level rises to meet the float **12** as the toilet tank **13** is being refilled, the water itself entraps or seals air inside the float's open chamber **31.** This provides the float **12** with the buoyancy required to permit it to ride up with the water level as the water level continues to rise in the toilet tank **13** until the water level achieves the refill depth **18.**

The float arm **11** is pivotally mounted to an ear **33** extending from and fixed to the front face **34** of the float valve **10.** The ear **33** presents a pin **35** adapted to fit in holes defined by tongues **36** molded integral with the rear end of the float arm **11.** Thus, the float arm **11** is connected to the float valve **10** for pivotal movement in a vertical plane.

It will be noted that the float arm **11** is pivotally connected to the float valve **10** above the valve's stem **37,** and that the float arm is provided with a foot **38** that traces a diameter across the valve's front face **34** adjacent the point **35** of pivotal connection. The upper end of the foot **38,** of course, mounts the tongues **36** and the lower end of the foot **38** is molded integral with the float arm **11.** A control screw **39** is threaded through the foot **39** intermediate its length, the head of the control screw being accessible for adjustment by a screwdriver and the base of the control screw being engageable with a push button **43** fixed to the exposed end of the valve stem **37**; that is, the control screw **39** is fixed to the foot **39** so that it is substantially axially aligned with, but not in contact with, the valve stem **37** when the water level is at refill level **18.** The function of the control screw **39** is to open the float valve **10** by depressing the valve stem **37** as the water level in the toilet tank **13** recedes upon flushing the toilet **13, 14**; once the float valve is opened water flows therethrough for refilling of the toilet tank.

A limit screw **42** is threaded into the float arm **11** at a point on the foot where the limit screw's head can abut the rim **41** of the valve's housing **19** when the toilet tank **13** is substantially empty of water. The limit screw **42** is accessible for adjustment simply by pivoting the float arm **11** vertically upward. The function of the limit screw **42** is to limit clockwise (as viewed in the drawings) pivotal motion of the float arm **11** as the water level in the toilet tank recedes upon flushing the toilet **13, 14,** thereby preventing undue damage to the valve's servo-mechanism from the weight of the float

12 and the float arm 11 once the servo-mechanism has been moved to the open attitude.

Valve Structure

The float valve 10 is provided with a cylindrical housing or casing 19 with the inlet pipe 22 and outlet pipe 23 radially intersecting same in approximately the same plane, see FIGS. 3 and 4. The housing 19, in cross-section, is provided with a closed end 46 and an open end 47, i.e., the housing is hollow when no component parts are located inside.

An outer tubular insert 48 is the first component located within the valve housing during assembly, see FIG. 3. The outer surface 49 of the outer tubular insert 48 is provided with a groove 50, the groove being located between the inlet pipe 22 and the outlet pipe 23 when the insert 48 is in place within the housing 19. The groove 50 receives an O-ring 51, thereby closing off the inlet pipe 22 from the outlet pipe 23 except through the porting or orifices provided and described in detail below.

The outer tubular insert 48 includes a port wall 52 located between the inlet pipe 22 and outlet pipe 23 when the insert 48 is in place within the housing 19, the port wall 52 defining a first pressure drop orifice 53 located axially of the housing. The first pressure drop orifice 53 is provided with an annular boss 54 which defines a valve seat for open-close valve 45. That portion of the housing 19 interior between closed end wall 46 and port wall 52 is divided by a diaphragm or valve head 44 for open-close valve 45. The diaphragm 44 is flexible and is hat-shaped in configuration, the outer periphery of the hat's brim 55 being fixed or held against the closed end wall 46 of the housing 19; the brim 55 of the hat-shaped diaphragm 44 is provided with feet 56 adapted to conform around an annular ledge 57 integral with tubular wall section 58 of the outer tubular insert 48, thereby allowing the diaphragm 44 to be held against the closed end wall 46 of the housing 19. Thus the hat-shaped diaphragm 44 and the first pressure drop orifice 53 cooperate as the open-close valve 45, and the chamber 67 between the underside 68 of the diaphragm 44 and the housing's closed end wall 46 is essentially a pilot chamber.

The wall section 58 is cylindrical in configuration and is offset inwardly from the outer surface 49 of the tubular insert so as to define an annular feed chamber 59 in combination with the valve's housing 19. The feed chamber 59 surrounds the tubular insert 48 and is connected with a water supply source through inlet pipe 22 which intersects chamber 59 at 62. The feed chamber 59 is interconnected with a baffle chamber 63, which essentially is part of the feed chamber 59, by two ports 64 located at 180° relative one to the other about the periphery of wall section 58. The baffle chamber 63 functions mainly to assure even pressure distribution of water flowing into the valve 10 from inlet pipe 22 about the top side 65 of the hat-shaped diaphragm 44. The pilot chamber 67 communicates with the baffle chamber 63 through at least one small bleed port 74 located in the brim 55 of the hat-shaped diaphragm 44.

Preferably the outside diameter of the first pressure drop orifice 53 and boss 54 relative to the brim 55 diameter of the hat-shaped diaphragm 44 is such that only a minor surface 65 of the diaphragm 44 is presented to water pressure in the baffle chamber 63, i.e., the pressure or force area on the baffle chamber side of the diaphragm 44 (for opposing the pressure area on the pilot chamber 67 side of the diaphragm 44) is only equal to brim area 65. On the other hand, a major surface area 68 of the diaphragm 44 is presented to water under pressure in the pilot chamber 67, i.e., the pressure or force area on the pilot chamber side of the diaphragm 44 (for opposing the pressure area on the baffle chamber 63 side of the diaphragm 44) is equal to the brim area 65 and the crown area 60.

The top side 65 of the hat-shaped diaphragm 44 is provided with a nose-shaped relief port 66 located axially of the housing 19, the relief port being axially aligned with first pressure drop orifice 53 defined in the port wall 52. The valve stem 37 is of a length such that it extends from the pilot chamber 67 to the front face 34 of the float valve 10 where it terminates in push button 43 that can be contacted by control screw 39. The valve stem 37 is integral with a pilot head 72 located within the pilot chamber 67, that pilot head being adapted to close the relief port 66 in the hat-shaped diaphragm 44. Thus, the pilot head 72 (as the valve head) and relief port 66 (as the valve seat) define an auxiliary valve 71. The valve stem 37, through use of compression spring 73, is continually urged to the right as shown in the Figures (and, thereby, pilot head 72 is continually urged toward a closure attitude with the relief port 66) to close the auxiliary valve 71 unless float arm 11 has pivoted down so that control screw 39 depresses the valve stem to the left (and, thereby, moves pilot head 72 to an open attitude with the relief port 66) to open the auxiliary valve 71 which occurs when the toilet is flushed.

In the float valve 10 closed attitude where water flow is checked or stopped, therefore, and as water is directed into the feed chamber 59, 63 through inlet pipe 22, some of the water bleeds into the pilot chamber 67 through the bleed port 74. The pressure created on the major force area 68 of the diaphragm 44 from the pilot chamber 67, however, is substantially greater than the pressure created on minor force area 65 of the diaphragm from the feed chamber 59, 63 because of the difference in surface areas on which the water pressure acts; such a pressure differential, under equilibrium conditions and when the pilot head 72 is closed against relief port 66, keeps the diaphragm 44 in the closed attitude relative to the valve seat 54 in main port wall 52. This, of course, prevents water flow through the float valve 10 since the first orifice 53 at valve seat 54 is closed. Thus, the open-close valve 45 portion of the float valve 10 and, hence, the float valve itself, is closed by water pressure of the inlet water, and not by mechanical linkages actuated by the float arm 11.

The outer tubular insert 48 is adapted to cooperate with an inner tubular insert 78, the inner tubular insert being coaxially positioned therein during assembly and being seated at its inner end in recess 77 of port wall 52. The inner tubular insert 78 is provided with a plate 79 molded integral therewith that defines the valve's front face 34 and that serves to locate the inner insert in the outer insert 48 at plate 79 end. The plate 79 also defines a series of air ports 76 which function in a manner to be subsequently explained. The outer periphery 80 of plate 79 defines a groove 81 adapted to receive foot 88 of an annular donut-shaped diaphragm 82, the donut-shaped diaphragm being fixed in place when the inner tubular insert 78 is assembled with the valve's housing 19 by locating foot 88 between the plate's outer periphery 80 and the inside surface of housing

19. The donut-shaped diaphragm 82 is flexible and is adapted to flex into and out of engagement (compare FIGS. 3 and 4) with rim 83 presented by the forward tubular wall 70 of the outer tubular insert 48, the normal flexure attitude being a closed attitude as illustrated in FIG. 3. Thus, the donut-shaped diaphragm 82 serves as a valve head, and the tubular wall's rim 83 serves as a valve seat, to establish a back pressure valve 69 inside the float valve 10 that is directly connected with the outlet pipe 23. Further, the back pressure valve 69 allows discharged water flow into the outlet pipe 23 through an annular or third pressure drop orifice 101, see solid line position of donut-shaped diaphragm in FIG. 4.

This back pressure valve 69 is, in a sense, a dual action valve in that it also includes an annular nose portion 98 that cooperates with the inside surface 99 of face plate 79. This establishes an anti-siphon valve 61 inside the float valve 10, the anti-siphon valve's head being the donut-shaped diaphragm's nose portion 98 and the anti-siphon valve's seat being rim area 99 on the inner face 100 of the tubular insert 78. When a suction is established on inlet pipe 22, this anti-siphon valve 61 allows only air from above the water refill level 18 in the toilet tank 13 to be sucked back through the float valve, thereby insuring that water in the toilet tank 13 will not be sucked back through the outlet pipe 23 and the float valve 10 into the water supply. If a vacuum or suction is established on inlet pipe 22, nose portion 98 is deflected away from, i.e., sucked away from, contact with valve seat 99 so that air can be drawn into the float valve 1 through air ports 76 in the float valve's front face plate 79. Further, when the nose portion 98 of the diaphragm 82 is so deflected the outlet pipe 23 is sealed from the float valve's interior by the back pressure valve 69 portion of the diaphragm. The anti-siphon attitude of the diaphragm 82 is illustrated in phantom lines in FIG. 4.

The inner tubular insert 78 defines a first intermediate chamber 90 that is cylindrical in configuration, and that is coaxial with the first pressure drop orifice 53 in port wall 52 and with feed chamber 59, 63. This first intermediate chamber 90 is provided with a passage 91 at its other end that is coaxial with main port 53. A second pressure drop orifice in the form of two rectangular orifices 96 are provided in the first intermediate chamber 90 in the middle thereof, i.e., in the side walls of that chamber, opposite one from the other. These ports or orifices 96 provide passageways between the first intermediate chamber 90 and a second intermediate chamber 97 in the float valve 10. The second intermediate chamber 97 is a concentric, annular chamber that is defined along its side walls by the outer tubular insert 48 and the inner tubular insert 78, is closed at one end by the port wall 52, and cooperates with the back pressure valve 69 at the other end. Thus, the main water flow through the float valve 10 proceeds from inlet pipe 22 into feed chamber 59, 63, through first pressure drop orifice 53, into first intermediate chamber 90, through second pressure drop orifices 96, into second intermediate chamber 97, through third pressure drop orifice 101, through annular exhaust chamber 89, and into outlet pipe 23.

The valve stem 37 passes through passage 91 and terminates in push button 43 located outside the valve's housing 19. The push button 43 is T-shaped in cross-section, and includes a sleeve 92 by which the button is fixed to the valve stem 37. The passage 91 in the plate 79 is configurated to cooperate with the sleeve 92 to aid in guiding the valve stem 37 in its reciprocal motion back and forth between the open attitude and closed attitude as will be subsequently explained. The compression spring 73 is positioned to bear between the underside of the push button 43 and the valve's front face 34, thereby continuously urging the valve stem 37 toward the right as illustrated in the figures (thereby, continuously urging the pilot head 72 toward the major surface area 68 of the hat-shaped diaphragm 44). A packing ring 93 is fixed on the valve stem 37 between a stop 94 mounted to the valve stem and the bottom of the push button's sleeve 92. The packing ring 93 is provided with flexible annular walls 95, the packing ring functioning to prevent spitting of water through the passage 91 in the plate 79 as water flows through the first intermediate chamber 90. Note particularly that valve stem 37 is carried by, and located within the float valve 10 by virture of, packing ring 93 and hat-sahped diaphragm 44. Since both the packing ring 93 and hat-shaped diaphragm 44 are flexible they are conveniently made of a relatively high energy absorbing material, e.g., rubber; this tends to damp out vibrations of the valve stem 37 as water flows through the valve (and particularly is this so as the hat-sahped diaphragm 44 moves toward closure attitude shown in FIG. 3 from the open attitude shown in FIG. 4 as the maximum refill depth is approached during filling of the toilet tank) and, thereby, tends to reduce noise during refilling of the toilet tank.

The inner tubular insert 78 and the outer tubular insert 48 are held in coaxial assembly within the valve housing 19 by means of finger locks 84 inserted through notches 85 in the housing, see FIG. 5. The finger locks 84 are in the nature of arcuate bars 86 each of which partly circumscribes the outer periphery of the housing, the bars 86 each presenting two locking fingers 87 fixed thereto and adapted to be inserted into the interior of the housing through the notches 85. When the finger locks are in position they press the tubular inserts 48, 78 toward the closed rear wall 46 of the housing 19, thereby maintaining the float valve 10 in operating assembly.

The after-fill tube 16 is tapped into water exhaust chamber 89 as at 102. The after-fill tube 16 is of a small diameter relative to the diameter of water outlet pipe 23 and it feeds overflow tube 102 that is fixed to the floor 26 of the toilet tank 13. The after-fill tube 16 functions as is well known to the art, to tap off a small quantity of water flowing through the float valve 10 as the toilet tank 13 is being refilled, that water being directed through overflow tube 102 into the bowl 14 of the toilet to refill the bowl at the same time the tank is being refilled.

In operation, and under those conditions which obtain when the toilet tank 13 is full of water to refill level 18, the attitude of the float valve 10 is closed as is illustrated in FIG. 3; in this attitude no water flows through the float valve. In the closed attitude, and at refill level 18 in the tank 13, float 12 has caused float arm 11 to pivot counterclockwise (as viewed in the Figures) until control screw 39 is removed from contact with push button 43; this allows valve stem's pilot head to maintain closure or sealing contact with relief port 66 in the diaphragm 44 due to compression spring 73. Further, in the closed attitude water from inlet line 22 is in the

feed chamber **59, 63** and the pilot chamber **67** (having entered through bleed port **74**) with the water pressure in those chambers being substantially equal because the water cannot escape from the pilot chamber as relief port **66** is sealed. But the total force exerted on the pilot chamber **67** side of the hat-shaped diaphragm **44** by the water present in the pilot chamber **67** is substantially greater than the total force exerted on the feed chamber **59, 63** side of the diaphragm **44** by the water present in the feed chamber because only a minor surface area **65** is exposed to the water pressure in the feed chamber and a major surface area **68** is exposed to the water pressure in the pilot chamber; this causes the diaphragm **44** to seat against the boss **54** on the main port wall **52**, thereby closing off first pressure drop orifice **53** and outlet pipe **23** from the water source and inlet pipe **22**. It is emphasized that float valve **10** is maintained in the closed attitude, and is in fact closed, by virtue of the water pressure in the inlet pipe **22** acting on the major surface **68** of the diaphragm **44** in the pilot chamber **67** when the control screw **39** is moved out of contact with the valve stem's push button **43**. Further, it is emphasized that the float arm **11** itself does not close the float valve **10**, i.e., there is no mechanical linkage between the float arm **10** and the open-close valve **45** which causes the diaphragm **44** to seat against the boss **54** in the port wall **52**.

When the handle **17** on the toilet tank **13** is rotated to flush the toilet bowl **14**, water is rapidly drained from the toilet tank **13**. As water drains from the toilet tank **13** the float arm **11** pivots clockwise as illustrated in FIG. **2**, thereby bringing the control screw **39** into contact with the valve stem's push button **43** to open the float valve **10**. As the float arm continues to pivot clockwise due to the falling float **12**, and until the head of limit screw **42** abuts rim **41** of the float valve's housing **19**, the valve stem **37** is moved axially toward the left as illustrated, compare FIGS. **3** and **4**. This opens relief port **66** between the pilot chamber **67** and the first intermediate chamber **90**, thereby permitting high pressure water in the pilot chamber to drain into the first intermediate chamber **90**. This creates a substantial pressure differential between the feed chamber **59, 63** and the pilot chamber **67**, the pressure in the feed chamber being substantially higher because of the high rate water flow thereto at inlet line pressures from the inlet pipe **22**, and the very low rate water flow into the pilot chamber **67** through the bleed port **74**. In turn, this high pressure condition is the feed chamber **59, 63** in combination with the low pressure condition in the pilot chamber **67** causes the diaphragm to collapse toward the closed end **46** of the valve's housing **19**, i.e., move toward the left as illustrated in the Figures. The difference in the diaphragm force area **68** in the pilot chamber **67** and the opposing force areas **60** and **65** is sufficient to permit collapsing of the diaphragm **44** at this point. This, of course, opens first orifice **53** in the port wall **52** and allows water from the feed chamber **59, 63** to pass through the float valve **10**. As long as the valve stem **37** is depressed into that attitude illustrated in FIG. **4** (which will be the case at least until the refill level contacts the bottom of float **12**) an open equilibrium condition is created for water flow through the float valve **10**, the valve being held open in the same manner by which it is opened in the first instance.

After the main valve **45** is opened, water passes from the feed chamber **59, 63** into the first intermediate chamber **90**. It will be particularly noted that a radial water flow to the feed chamber **59, 63** and into the first pressure drop orifice **53** is transposed into a longitudinal water flow within the first intermediate chamber **90** toward the packing ring **93**, thereby aiding in the creation of a pressure drop in the water as it moves between the inlet and outlet of this first intermediate chamber.

From the first intermediate chamber **90** the water flows out through the two side wall orifices **96** (i.e., the second pressure drop orifice) into the second intermediate chamber **97**, see FIG. **4**. It will be recalled that the annular donut-shaped diaphragm **82**, in its closed attitude as illustrated in FIG. **3**, is such that the central portion or web thereof is seated against the rim **83** of the outer tubular insert **48**, thereby closing the outlet pipe **23** to the second intermediate chamber **97**. But as water enters the second intermediate chamber **97** from the first intermediate chamber **90** through ports **96**, the pressure thereof causes the diaphragm **82** to deform into that attitude illustrated in solid lines in FIG. **4**. This, of course, opens the third pressure drop orifice **101** (which is directly connected with outlet pipe **23** through annular exhaust chamber **89**), thereby providing valving by which the water is admitted to the outlet pipe from the second intermediate chamber into the toilet tank **13** for refilling same.

One particular novel characteristic of this float valve **10** is its ability to damp or eliminate the noise usually generated in toilet tank float valves. The chatter or flutter source of water noise is substantially eliminated because valve heads **44, 82** are of a resilient, sound dampening character, e.g., rubber or the like, and because valve stem **37** is essentially encased and carried by rubber sleeves in the form of apertured relief port **66** in the diaphragm **44** and packing ring **93**. The vaporization source of water noise is controlled by providing a series of three controlled pressure drops over the three pressure drop orifices **53, 96,** and **101**, the water pressure in the inlet pipe **22** being reduced to atmospheric pressure in the toilet tank **13** in three stages. The three functional orifices over which the three step pressure drop occurs include, in sequence, (*a*) that orifice **53** defined by hat-shaped diaphragm **44** and valve seat **54** in the main port wall **52** (this orifice being a variable orifice) i.e., the open-close valve's **45** orifice; (*b*) the two fixed dimension orifices **96** in the side wall of the first intermediate chamber **90**; and (*c*) that orifice **101** between valve seat **83** on the outer tubular insert **48** and the flexible donut-sahped diaphragm **82** (this also being a variable valve's **69** orifice), i.e., the back pressure valve's orifice. Generally speaking, the water pressure supplied to the homeowner is in a range anywhere from about 40 psig to about 90 psig; the lower water pressure ranges are usually found in rural areas, and the higher water pressure ranges are generally found in city areas. Further, the flow of water through an orifice at such a rate and pressure which establishes a pressure drop across that orifice of greater than about 40 psi will cause noise. Consequently, and if the pressure drop over each of the three orifices remains less than 40 psi (as is possible where three orifices are provided as disclosed herein), there will be no noise generated in the float valve because the audible and undesirable noise level is generally found where there is a pressure drop of 40 psi or greater.

The pressure drop over the first orifice **53** is controlled to an extent by the inside diameter of the boss **54** which defines the orifice in relation to the back pressure imposed on that orifice by the dimensions of the side wall orifices **96** in the first intermediate chamber **90.** Further, the pressure drop is controlled over the first orifice **53** because radial water flow from the main port **22** is transposed into longitudinal water flow which is braked by the packing ring **93,** the water flow being reversed before it can pass through the side wall orifices **96** of the first intermediate chamber **90.** As a general rule, and for a given orifice **53** size in the port wall **52,** a decrease in the orifice **96** size in the first intermediate chamber **90** will increase the back pressure and, thereby, act to lessen the pressure drop of the water as it flows through the first orifice **53.** Therefore, the orifice **96** size in the first intermediate chamber **90** should be such to assure that the pressure drop through the first pressure drop orifice **53** is not greater than about **40** psi.

Further, the donut-sahped diaphragm **82** cooperates with the second pressure drop orifices **96** of the first intermediate chamber **90** to insure that the pressure drop through the orifices **96** is not greater than **40** psi. As with the function of the orifices **53** in the first pressure drop chamber **90,** the flexible donut-shaped diaphragm **82** creates a back pressure on the water within the second intermediate chamber **97** to control the pressure drop created as the water passes through orifices **96.** The back pressure established by the back pressure valve **69,** i.e., the pressure required to open the third pressure drop orifice **101,** can be varied by varying the thickness of the diaphragm **82,** the cross-sectional shape of the diaphragm **82,** or the durometer of the flexible material used. The higher the durometer or the thicker the donut-shaped diaphragm **82** in that shape shown, the greater will be the pressure required to open the third orifice **101** and the less will be the pressure drop across orifices **96.** Since there is no back pressure on the third orifice **101,** the water pressure must be below about 40 psi when the water starts to pass through that orifice so that no noise is created as it passes therethrough and, of course, such is the case because of the pressure drops created at the first **53** and second **96** orifices. Thus, water passes from the inlet pipe **22** through the float valve **10** and out the outlet pipe **23** into the toilet tank **13** with no pressure drop at any of the three orifices **53, 96,** or **101** greater than about 30 psi if the inlet water pressure is no greater than about 90 psi; 90 psi, it will be recalled, is about the highest water pressure for home use ever observed in the majority of the areas of this country.

Continuing with the operation of the float valve **10,** air is entrapped in the float **12** by the rising water as the toilet tank **13** is refilled with water after flushing the bowl **14,** thereby creating a buoyant float which will ride up on the water. As the float **12** rides up on the water the control screw **39** is moved out of contact with the valve stem's push button **43,** thereby permitting the spring **73** to maintain the valve stem's pilot head **72** into sealing contact with the relief port **66** in the hat-shaped diaphragm **44.** When this occurs water that is bleeding from the feed chamber **59, 63** into the pilot chamber **67** through the bleed port **74** is captured and retained in the pilot chamber. As the pilot chamber **67** fills once again with water, the pressure exerted on the pilot chamber **67** side of the diaphragm **44** becomes substantially greater than the pressure exerted on the feed chamber **59, 63** side of the diaphragm because of the difference in the diaphragm force areas **68, 65** presented in each of those chambers. This causes the diaphragm head **44** to move axially toward the right, as illustrated in FIG. **4,** to close the orifice **53** in the port wall **52** of the float valve, i.e., to cause the valve's servo-mechanism to once again achieve the closed attitude as illustrated in FIG. **3.** This, of course shuts off water flow through the float valve **10.** The bleed port **74** size controls the rate of closing the orifice **53** by diaphragm **44.** Thus, it is particularly noted that the float valve is opened due to the weight of the float **12** which, as it follows the water level down when water is being drained from the toilet tank **13** into the toilet bowl **14** upon flushing the toilet, finally abuts the valve stem's push button **43** and causes the open-close orifice **71** to open. Further, the float valve **10** closes simply by removing the control screw **39** abutment from the valve stem's push button **43** to allow the auxiliary valve **71** to remain closed, and to allow water pressure to force the diaphragm **44** against boss **54,** all in the manner aforedescribed.

It is possible under certain float valve **10** operating conditions for a suction to be established in the water inlet pipe **22.** The problem associated with float valves that do not have an anti-siphon characteristic is that the water in the toilet tank will be sucked back up the outlet pipe, through the float valve, and back into the water supply when a suction is established in the inlet pipe. Such would definitely provide health hazards to the general public in that contamination of the water supply is possible by this route if any contaminants or the like are in the toilet tank when this contingency arises. Hence, it is common for municipal codes to require that float valves have an anti-siphon characteristic. As noted, this particular float valve **10** is mounted above the refill level **18** of the water in the toilet tank **13,** and must be so mounted for the anti-siphon structure to be fully operative. When a suction is established on the inlet pipe, and as illustrated in phantom lines in FIG. **4,** the flexible donut-shaped diaphragm **82** is sucked toward the closed end **46** of the valve's housing **19.** This assures that the outlet pipe **23** is sealed from second intermediate chamber **97** and, hence, from the inlet pipe **22.** Further, this causes the nose **98** of the donut-shaped diaphragm **82** to deflect inwards and open an annular port to the atmosphere through air ports **76** in the face plate **79.** Because air ports **76** in the plate **79** are always open to the atmosphere when the nose **98** of the diaphragm **82** is as illustrated in phantom in FIG. **4** (due to the suction present in the inlet pipe **22**), the atmosphere is open to the inlet pipe and only atmosphere is sucked through the float valve **10.** That is, because the float valve **10** is mounted above the refill level **18** of the water in the toilet tank **13,** when a suction is established on the inlet pipe **22** there is nothing but air sucked through the float valve **10** back to the water supply. Thus, no water from the toilet tank **13** can be siphoned back into the inlet pipe **22,** and back to the supply source.

It will be noted that the structure of this float valve **10** unit is comprised of replaceable cartridge parts within the valve's housing **19,** and that the float valve can be repaired while mounted within the toilet tank. That is, the only thing that need be done to provide maintenance to the float valve **10,** or indeed to provide

an entire new servo-mechanism and valve structure inside the housing **19**, is simply to remove the locking fingers **87** from the housing and slip out the inner **78** and outer **48** tubular inserts. Thereafter, new inserts, diaphragms, spring, packing ring and/or valve stem need merely be installed or assembled with the housing to once again make the float valve **10** operational. This modular construction, of course, reduces maintenance costs to the homeowner.

Having described in detail the preferred embodiment of my invention, which I desire to claim and protect by Letters Patent is:

1. A float valve used in combination with a float arm and float inside a toilet tank, said float valve comprising

a housing interconnected with a water inlet pipe and a water outlet pipe,

a flexible diaphragm having a permanently open bleed port therein and being fixed in said housing so as to divide at least a section thereof into a feed chamber and a pilot chamber, said inlet pipe being interconnected with said feed chamber, and said bleed port allowing water to bleed into said pilot chamber from said feed chamber,

a wall of said feed chamber having structure that defines a main port opening into an intermediate chamber, interconnected with said outlet pipe, said main port being adapted for closure by said diaphragm to close off the flow of water through the float valve, and

a valve stem extending into said pilot chamber, said valve stem mounting a pilot head inside of said pilot chamber and said pilot head being adapted to cooperate with a relief port defined in said diaphragm to open and close same depending on the water level in the toilet tank, said relief port extending between said pilot chamber and said intermediate chamber,

the float arm being associated with said valve stem so as to cause said pilot head to close said relief port when the refill level of the toilet tank has been reached and to open said relief port as the toilet tank is drained, the water pressure in said feed chamber causing said diaphragm to flex away from said main port and open the float valve when said relief port is first opened, and the water pressures in said feed and pilot chambers allowing said diaphragm to seal said main port and close the float valve when said relief port is closed.

2. A float valve as set forth in claim **1** wherein the force area of said diaphragm in said pilot chamber is substantially greater than the force area of said diaphragm in said feed chamber, thereby causing the diaphragm to flex into sealing contact with said main port when said relief port is closed by said pilot head and when the water pressure is substantially equal in the feed and pilot chambers.

3. A float valve as set forth in claim **1** including

an anti-siphon valve between said intermediate chamber and said outer pipe, said anti-siphon valve allowing air to be sucked through said float valve into said inlet pipe when a vacuum is established on said inlet pipe, and said float valve being positioned above the refill water level in said toilet tank.

4. A float valve as set forth in claim **1** wherein said feed chamber is annular in configuration and surrounds a concentric baffle chamber that directly cooperates with said flexible diaphragm, said feed chamber collecting water presented by said inlet pipe and distributing said water evenly on the feed chamber side of said diaphragm by use of said baffle chamber.

5. A float valve as set forth in claim **1** including

a spring loading on said valve stem, said spring loading normally urging said pilot head into sealing contact with said relief port when the toilet tank is refilled, and said valve stem being depressed by a control device fixed to said float arm so as to open said relief port as said float arm falls during draining of said toilet tank.

6. A float valve as set forth in claim **1** wherein said inlet pipe, float valve housing, and outlet pipe are of a one-piece plastic molding, said inlet pipe being of at least sufficient length to locate the float valve above the refill level of said tank, and said outlet pipe extending down from the float valve a sufficient length to allow its termination adjacent the floor of said toilet tank.

7. A float valve as set forth in claim **1** including

a back pressure valve at the outlet of said intermediate chamber, said back pressure valve serving to create a back pressure on the water flow through said main port to control the pressure drop through that main port.

8. A float valve as set forth in claim **7** wherein said back pressure valve is comprised of a flexible diaphragm adapted to flex between a first attitude where said outlet pipe is closed relative to said main port and a second attitude where said outlet pipe is open relative to said main port, said back pressure diaphragm being closed when no water is flowing through the float valve and being open when water is flowing through the float valve.

9. A float valve as set forth in claim **8** wherein said back pressure diaphragm is also adapted to flex into a third attitude where it opens air ports in said housing to said main port, said diaphragm being flexed to this third attitude when a vacuum is established on said inlet pipe so that air can be sucked through said float valve.

10. A float valve as set forth in claim **9** wherein said back pressure diaphragm seals off said outlet pipe as well as opens said air ports when in its third attitude, seals off said air ports and opens said outlet pipe to said main port in its second attitude, and seals both said outlet pipe and said air ports from said main port in its first attitude.

11. A float vavle as set forth in claim **7** including

structure within said housing defining two intermediate chambers into which water flow from said main port is discharged the water flowing from said main port into said first intermediate chamber and then through said second intermediate chamber in sequence, and said back pressure valve being located at the outlet of said second intermediate chamber, and

at least one orifice communicating between said first and second intermediate chambers to allow water flow therebetween, said port providing a third pressure drop orifice in addition to the pressure drop orifices provided at said main port and back pressure valve so that water noise is substantially eliminated as water flows through the float valve.

12. A float vavle as set forth in claim **11** wherein said two tubular intermediate chambers are located axially and concentrically within said housing, the water flow to said main port being in an annular flow which is transformed to a longitudinal flow after it passes through said main port, and the water flow to said back pressure valve being a longitudinal flow which is transformed into an annular flow as it exhausts from said back pressure valve.

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