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PROPORTIONAL PRESSURE REDUCING VALVE FOR USE IN WATERWORKS

BACKGROUND OF THE INVENTION

1. Field of the Invention

This invention relates to a proportional pressure reducing valve for use in waterworks for which a secondary pressure is kept at a predetermined ratio with respect to a primary pressure.

2. Description of the Related Art

In multistoried buildings, in order to remove differential pressures of tap water on each floor and evenly supply tap water to each household, there has been a need to dispose a pressure reducing valve, in which the ratio of a secondary pressure to a primary pressure is set for each floor, in a branch pipe through which water is supplied to each household from a water main.

However, it has been very difficult to attach a large-sized pressure reducing valve, such as a diaphragm type, to existing pipes.

Therefore, an in-line type proportional pressure reducing valve, which is smaller and can be attached relatively more easily than a large-sized pressure reducing valve, is interposed and connected between a secondary side (exit) of

a water meter and a downstream-side distribution pipe so as to remove the differential pressure of tap water in each floor. However, since an interposing space of the proportional pressure reducing valve that can be set during pipe arrangement is extremely short even if the length of the pipe is adjusted, the proportional pressure reducing valve is disposed using a union nut.

An example of a specific structure of the proportional pressure reducing valve will be described with reference to FIGS. 6 through 8.

In this pressure reducing valve a, a cylindrical valve box d is provided with an inlet b and an outlet c designed to be greater in diameter than the inlet b at ends, respectively, of the valve box; a piston g is slidably fitted in the valve box, the piston having a valve member e used to open and close the inlet b at one end and having a hollow part f opened toward the outlet c at an opposite end; a space h, whose sectional area is greater than an area of the inlet b, is provided between a periphery on a side of the one end of the piston g and an inner wall of the valve box d; a water-flow port i that leads to the hollow part f is formed in the cross direction of the peripheral wall of the piston g facing the inner wall of the valve box d through the space h; a union nut j is slidably

mounted to the end on the inlet side of the valve box d and a taper screw k to be screwed into the end of the downstream pipe is formed in the outer periphery of the outlet-side end of the valve box d.

The ratio of the secondary pressure to the primary pressure is changed by setting the area of the valve member e receiving the primary pressure, i.e., by setting the bore diameter of the inlet b.

In order to interpose the pressure reducing valve a between the water meter and the downstream-side distribution pipe, the outlet-side end of the valve box d is screwed into the downstream-side distribution pipe in a state in which the union nut j is temporarily slid to the side of the outlet c, and thereafter the union nut j is slid to the side of the inlet b and is screwed into the water meter, since an interval therebetween is extremely short and is slightly longer than the entire length of the valve box d. If these steps are not performed, the pressure reducing valve a cannot be arranged relatively easily.

Moreover, since the union nut j is designed to be slid in the lengthwise direction of the valve box d in the thus structured proportional pressure reducing valve a, the valve box d must have an outer diameter corresponding to an insertion

hole m of the union nut j . However, since there are restrictions as to the outer diameter and the entire length of the valve box d as mentioned above, the bore diameter of the inlet b must inevitably have the first diameter, whereby pressure loss becomes great, thus making it difficult to secure a stable flow rate.

SUMMARY OF THE INVENTION

In consideration of the problems, the present invention provides a proportional pressure reducing valve comprising a cylindrical valve box that has an inlet and an outlet designed to be greater in diameter than the inlet at ends, respectively, of the valve box; a piston slidably fitted in the valve box, the piston having a valve member used to open and close the inlet at one end and having a hollow part opened toward the outlet at an opposite end; a space, whose sectional area is greater than an area of the inlet, between a periphery on a side of the one end of the piston and an inner wall of the valve box; an annular caved surface formed in a peripheral wall of the piston facing the inner wall of the valve box through the space; and a plurality of water-flow ports formed in the caved surface, each of the water-flow ports leading to the hollow part and having the same diameter as a width of the caved surface,

the water-flow ports arranged to be at an acute angle with respect to an axial line, to be slantingly toward the outlet, and to be with small intervals therebetween; wherein a total area of the water-flow ports is designed to be greater than the area of the inlet and to be greater than an area of the caved surface excluding the total area of the water-flow ports, whereby a flow path small in pressure loss is constructed. Further, the proportional pressure reducing valve is placed in the interior of the exit of a water meter or is placed in the interior of a water device disposed on the secondary side of the water meter so that the piping work of the proportional pressure reducing valve can be omitted, thus solving the problems.

In brief, the present invention includes a cylindrical valve box 2 that has an inlet 4 and an outlet 5 designed to be greater in diameter than the inlet 4 at ends, respectively, of the valve box 2; a piston 3 slidably fitted in the valve box 2, the piston 3 having a valve member 11 used to open and close the inlet 4 at one end and having a hollow part 12 opened toward the outlet 5 at an opposite end; a space 15, whose sectional area is greater than an area S_1 of the inlet 4, between a periphery on a side of the one end of the piston 3 and an inner wall of the valve box 2; and a plurality of water-flow

ports 19 formed, each of the water-flow ports leading to the hollow part 12. Accordingly, the secondary pressure P_2 can be reduced to a predetermined ratio with respect to the primary pressure P_1 , and therefore the secondary pressure in each floor of a high-rise building can be set to be the same by changing the area (bore diameter) S_1 of the inlet 4 without changing the bore diameter of the valve box 2. Therefore, the valve box 2 that is substantially equal in outer diameter to a water pipe and that is short in length in the axial direction can be used, and the proportional pressure reducing valve 1 can be easily mounted also in a part where an installation space is small.

Further, since the water-flow ports 19 are formed in the annular caved surface 18 that has a width equal to the diameter of the water-flow port 19 formed in the peripheral wall of the piston 3, the flow of a pressure fluid from the inlet 4 to the space 15 along the generating line of the piston 3 can be smoothly guided to the caved surface 18 where the water-flow ports 19 are formed when the valve is opened, and a pressure loss in the fluid until it reaches the water-flow ports 19 can be reduced. Furthermore, since the water-flow ports 19 formed in the caved surface 18 are not perpendicular to the axial line unlike a conventional one and are led to the hollow part 12 at an acute angle with respect to the axial line and obliquely

toward the outlet 5, a flow according to a flowing direction from the primary side to the secondary side can be secured, and a pressure loss in the fluid until it reaches the hollow part 12 from the water-flow port 19 can be reduced, thereby making it possible to maintain a flow small in pressure loss as a whole.

Furthermore, since the sectional area of the space 15 and the total area S_a of the water-flow ports 19 are set to be greater than the area S_1 of the inlet 4, an area where the pressure fluid can flow smoothly can be secured, and the opening degree of the water-flow ports 19 with respect to the caved surface 18 can be enlarged by making the total area S_a of the water-flow ports 19 greater than the area $(S_b - S_a)$ of the caved surface 18 excluding the area S_a . Furthermore, since the water-flow ports 19 are arranged to be adjacent to each other with small intervals L therebetween over the entire periphery of the caved surface 18, a flow rate that flows in the water-flow ports 19 can be made greater than the one stopped by the intervals L , and a pressure loss in the flow of the pressure fluid that flows in the water-flow ports 19 can be reduced as a whole, thereby making it possible to obtain a high flow rate that passes through the water-flow ports 19.

As described above, according to the present invention,

since flowpaths (inlet 4, space 15, water-flow port 19, hollow part 12, and outlet 5) small in pressure loss as a whole can be structured, a desired flow rate can be secured, and, merely by setting the area S_1 of the inlet 4, the secondary pressure in each floor of a high-rise building can be set to be the same, and a stable flow rate can be supplied.

Therefore, the proportional pressure reducing valve 1 capable of securing a stable flow rate, which could not be expected by the conventional valve a, can be easily mounted by sliding the union nut 7 back and forth on the valve box 2 even if the valve box 2 is formed to have an outer diameter slidable in the insertion hole 7a of the union nut 7 and even if an interval between the water meter and the downstream-side distribution pipe is short.

In the piston 3, the substantially funnel-shaped concave part 20 that is inclined facing the center of the piston 3 is formed in the back of the valve member 11 contiguously to the exit 19a of the water-flow port 19. Accordingly, the pressure fluids that flow in the hollow part 12 from the water-flow ports 19 create a flow without being separated from the slope of the concave part 20 inclined facing the center of the piston 3 at an acute angle with respect to the axial line and continuously from the exit 19a of the water-flow port 19 that is inclined

toward the outlet 5, and the fluids join together and flow to the downstream side. Therefore, unlike the conventional valve a, a negative pressure is not easily generated, and a flow small in pressure loss is created. Therefore, the flow can be made smaller in the pressure loss as a whole together with the aforementioned effects, and a more stable flow rate can be obtained.

Since the valve box 2 in which the inlet 4 and the outlet 5 are caused to correspond to the primary side and the secondary side, respectively, is housed in the interior of the exit M1 of the water meter M, or the valve box 2 is housed in the interior of the water device N disposed at the secondary side of the water meter, the water meter M or the water device N can be provided with the aforementioned performance, and, since there is no need to jointly interpose the proportional pressure reducing valve 1 between the water meter and the downstream-side distribution pipe, working efficiency can be improved while saving time for piping work with a very advantageous practical effect.

BRIEF DESCRIPTION OF THE DRAWINGS

Fig. 1 is a sectional view showing a state where the proportional pressure reducing valve for waterworks is closed.

Fig. 2 is a sectional view showing a state where the valve is opened.

Fig. 3 is a sectional view along line A-A of FIG. 1.

Fig. 4 is a sectional view showing a state where the proportional pressure reducing valve for waterworks is housed in the interior of the exit of the water meter.

Fig. 5 is a sectional view showing a state where the proportional pressure reducing valve for waterworks is housed in the interior of the entrance of the water device.

Fig. 6 is a sectional view showing a state where a conventional proportional pressure reducing valve for waterworks is closed.

Fig. 7 is a sectional view showing a state where the conventional one is opened.

Fig. 8 is a sectional view along line B-B of FIG. 6.

DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENT

An embodiment of the present invention will hereinafter be described with reference to the drawings.

Reference character 1 designates an in-line type proportional pressure reducing valve for use in waterworks, which is interposed between a secondary side (exit) of a water meter (not shown) to be equipped in each household of, for

example, a high-rise apartment and a downstream-side distribution pipe (not shown). The proportional pressure reducing valve 1 is primarily composed of a valve box 2 thereof and a piston 3 mounted in the valve box 2.

The valve box 2 is shaped like a cylinder. An inlet 4 and an outlet 5 designed to be greater in diameter than the inlet 4 are provided at ends, respectively, of the valve box 2. A valve seat 6 is projected from the rim of a secondary-side opening of the inlet 4.

The valve box 2 further has an outer diameter slidable in an insertion hole 7a of a union nut 7 to be fitted to a union screw provided with the inlet 4 at the outer periphery of the exit of the water meter. A union collar 8 for anti-detaching and hooking the union nut 7 is projected from the outer periphery of the end 4a of the inlet 4 of the valve box 2. A taper screw 9 to be screwed into a downstream tube is engraved on the outer periphery of the end 5a of the outlet 5.

An annular packing 10 formed to come in contact with the end face of the exit of the water meter is bonded to the end face of the union collar 8.

The piston 3 is shaped like a cylinder and has a valve member 11 used to open and close the inlet 4 by reaching and leaving the valve seat 6 at one end thereof and a hollow part

12 caved toward the outlet 5 at the other end. The piston 3 is slidably fitted in a diameter-narrowed portion 13 formed in a substantially central part in the valve box 2 while being in an airtight state by means of a U-ring packing 14.

A space 15 is formed between the periphery of the end (where the valve member 11 is provided) of the piston 3 and the inner wall of the valve box 2 that communicates with the inlet 4 and that serves as a part of a flow path for a pressure fluid when the valve is opened. The sectional area of the space 15 (corresponding to a ring-shaped area between the valve box 2 and the piston 3) is set to be greater than an area S_1 of the inlet 4. A flange 17 around which the U-ring packing 16 is provided is projected from the rim of the other end (open end) of the piston 3. The flange 17 is slidably in contact with the inner wall of the valve box 2.

An annular caved surface 18 is formed in the peripheral wall of the piston 3 that always faces the inner wall of the valve box 2 through the space 15. In the caved surface 18, a plurality of water-flow ports 19 (six ports in the figures), each of which leads to the hollow part 12 of the piston 3 and has the same diameter as the width of the caved surface 18, are formed to be at an acute angle (approx. 60 degrees in the figures) with respect to an axial line of the valve box 2, to

be oblique toward the outlet 5, and to be with narrow intervals L therebetween. The total area S_a of the water-flow ports 19 is set to be greater ($S_a > S_1$) than the area S_1 of the inlet 4, and to be greater ($S_a > S_b - S_a$) than the area ($S_b - S_a$) of the caved surface 18 obtained by subtracting the total area S_a of the water-flow ports 19 from the total area S_b of the caved surface 18 (including the total area S_a of the water-flow ports 19) (see FIGS. 1 and 3).

In the piston 3, a substantially funnel-shaped concave part 20 that is connected to the exit 19a of the water-flow port 19 and that is inclined toward the center of the piston 3 is formed in the back of the valve member 11.

A retaining ring 21 for preventing the piston 3 (flange 17) from falling off is projected from the inner periphery of the outlet 5 of the valve box 2. The stroke of the piston 3 corresponds to a distance where the flange 17 comes in contact with the retaining ring 21. The diameter-narrowed portion 13 is set not to close the water-flow port 19 in this state (see FIG. 2).

In the valve box 2, an airtight space between the diameter-narrowed portion 13 and the flange 17 leads to the outside through a vent hole 22 formed in the valve box 2, so that the piston 3 can move smoothly.

The aforementioned embodiment has shown a structure in which the proportional pressure reducing valve 1 is interposed between the exit of the water meter and the downstream-side distribution pipe. However, another structure may be formed such that the inlet 4 and the outlet 5 of the valve box 2 are caused to correspond to the primary side and the secondary side, respectively, and the proportional pressure reducing valve 1 is placed in the interior of the exit M1 of the water meter M as shown in FIG. 4 or is placed in the interior of the water device N arranged at the downstream side of the water meter as shown in FIG. 5.

In this case, the valve box 2 excludes the union collar 8 and the taper screw 9, and is shaped like a right circular cylinder in which the end 4a of the inlet 4 and the end 5a of the outlet 5 are equal in outer diameter to each other.

The exit M1 of the water meter M that houses the proportional pressure reducing valve 1 is shaped like a straight pipe slightly longer than the entire length of the valve box 2. In the interior of the exit M1, an annular stepped part M2 slightly smaller than the end 4a of the inlet 4 of the valve box 2 is formed at an inner part thereof, and the end 4a of the inlet 4 of the valve box 2 is in contact with the annular stepped part M2, and the retaining ring 21 for

preventing the valve box 2 and the piston 3 from falling off while being in contact with the end 5a of the outlet 5 is projected from the inner periphery of the end on the side of the exit M1 corresponding to the end 5a of the outlet 5.

A vent path M3 by which the vent hole 22 is led to the outside is provided at the side part of the exit M1, and, in the interior of the exit M1, a sealing member (O ring) G that maintains airtightness between the vent path M3 and the vent hole 22 is fitted before and behind a vent-path hole M4.

The water device N disposed at the downstream side of the water meter is a valve of a distribution pipe or of a stop cock. The proportional pressure reducing valve 1 is housed in the interior of the exit or entrance of the straight distribution pipe or is housed in the interior of a straight-pipe-like entrance provided in the valve.

Since the structure housing the pressure reducing valve 1 in the interior of the exit of the distribution pipe is the same as the structure housing it in the exit M1 of the water meter M, a drawing thereof is omitted. A structure housing the pressure reducing valve 1 in the interior of the entrance of the distribution pipe or the valve is shown in FIG. 5, and, basically, is formed in the same manner as above.

In detail, in the interior of the entrance N1 of the water

device (distribution pipe or valve) N, an annular stepped part N2, which comes in contact with the outlet end 5a of the valve box 2 and which is used as a substitution of the retaining ring 21 provided at the stroke end of the piston 3, is formed at an inner part thereof in a diameter-narrowed manner, and a retaining ring R for preventing the valve box 2 from falling off while being in contact with the inlet end 4a is projected from the inner periphery of the end on the side of the entrance N1 corresponding to the inlet end 4a. Further, in the same manner as mentioned above, a vent path N3 by which the vent hole 22 is led to the outside is provided at the side part of the entrance N1, and a sealing member G is fitted before and behind the vent-path hole N4 in the interior of the entrance N1.

Next, a description will be given of the operation of the proportional pressure reducing valve 1 according to the present invention.

In the proportional pressure reducing valve 1, the piston 3 is shaped so that an acting force in the primary-side direction acting on the valve member 11 of the piston 3 can balance with a fluid acting force (i.e., the product of a pressure-receiving area, which corresponds to the area S_2 of the outlet 5, of the secondary pressure P_2 on the side of the

hollow part 12 and the secondary pressure P_2) in the secondary-side direction acting on the side of the hollow part 12 of the piston 3 by use of a bore difference between the inlet 4 and the outlet 5.

The acting force in the primary-side direction is the sum of the product of the pressure receiving area (corresponding to the area S_1 of the inlet 4) of the primary pressure of the valve member 11 and the primary pressure P_1 , the product of the pressure receiving area (corresponding to the area (S_3-S_1) of the annular surface obtained by subtracting the pressure receiving area S_1 of the primary pressure from the whole area S_3 of the valve member 11) of the secondary pressure of the valve member 11 and the secondary pressure P_2 , and a frictional resistance force α of the piston 3 based on the U-ring packings 14 and 16, etc.

That is, $S_1P_1 + (S_3-S_1)P_2 + \alpha = S_2P_2$, and thereby $P_2 = (S_1P_1 + \alpha) / (S_2 - (S_3-S_1))$

Therefore, the secondary pressure P_2 is the one in which the primary pressure P_1 is reduced to a value determined by the pressure receiving area $(S_2 - (S_3-S_1))$, the pressure receiving area S_1 , and the frictional resistance α .

Since the inlet 4 is set to be smaller in diameter than the outlet 5 as mentioned above, the area S_1 of the inlet 4

is smaller than the area S_2 of the outlet 5 ($S_1 < S_2$), and, since the area $(S_3 - S_1)$ of the annular surface in the valve member 11 is set ($S_3 \leq S_2$) depending on the area S_1 of the inlet 4, the secondary pressure can be set by changing the area S_1 (bore diameter) of the inlet 4.

Therefore, when the secondary pressure is a predetermined one, the valve member 11 reaches the valve seat 6, and the proportional pressure reducing valve 1 is in a closed state, and, when the secondary pressure falls from the predetermined pressure by opening a hydrant cock and using water, the valve member 11 leaves the valve seat 6 and is opened by the primary pressure, and a primary-side fluid flows to the secondary side through the inlet 4, the space 15, the water-flow port 19, and the hollow part 12.

A detailed description will be given of the flow of a pressure fluid (tap water) in the valve-opened state mentioned above. The pressure fluid that has flowed from the inlet 4 to the space 15 creates a flow along the generating line of the piston 3, and the pressure fluid flowing along the generating line of piston 3 flows into the water-flow port 19 along the annular hollow since the water-flow port 19 is situated at the position (on the caved surface 18) below the outer periphery of the piston 3.

Since the sectional area of the space 15 and the total area S_a of the water-flow ports 19 are greater than the area S_1 of the inlet 4, an area where the pressure fluid passes smoothly can be secured. In addition, since the total area S_a of the water-flow ports 19 is greater than the area $(S_b - S_a)$ of the caved surface 18 that excludes the total area S_a , and since the opening degree of the water-flow port 19 with respect to the caved surface 18 is large, and since the water-flow ports 19 are arranged to be adjacent to each other with narrow intervals L therebetween over the entire periphery of the caved surface 18, a flow that flows in the water-flow ports 19 is greater than a flow stopped by the intervals L , and, as a whole, the flow of the pressure fluid that flows in the water-flow ports 19 is small in pressure loss, thus securing a large flow rate that can pass through the water-flow ports 19.

In a conventional proportional pressure reducing valve a (hereinafter referred to conventional valve a), the total area S_x of the water-flow ports i is larger than the area S_z of the inlet 4, but the total area S_x of the water-flow ports i is smaller than the area $(S_y - S_x)$ obtained by subtracting the total area S_x of the water-flow ports i from the area S_y of the annular surface on the circumference of the piston that has the width of the bore diameter of the water-flow port i

(i.e., surface between alternate long and short dash lines corresponding to the caved surface 18 in FIG. 6). In addition, since the interval L_1 between the adjoining water-flow ports i is larger than that in the proportional pressure reducing valve 1 of the present invention, a flow rate of a fluid stopped by the interval L_1 of the water-flow ports i is higher than that of the fluid that flows in the water-flow ports i , and the pressure loss in the flow of the pressure fluid that flows in the water-flow ports i becomes large as a whole. Therefore, a greater flow rate that passes through the water-flow ports i cannot be secured than that in the proportional pressure reducing valve 1 of the present invention.

Unlike the conventional valve a, the pressure fluid that has flowed in the water-flow ports 19 is not perpendicular to the flowing direction (corresponding to the axial direction of the valve box 2), and leads to the hollow part 12 at an acute angle with respect to the axial line. Therefore, the flowing resistance of the pressure fluid becomes smaller than that in the conventional valve a.

Further, the pressure fluids that pass through the water-flow ports 19 and flow into the interior of the hollow part 12 create a flow without being separated therefrom on the slope that inclines toward the center of the piston 3

continuously from the exit of the water-flow port 19, i.e., a flow similar to a fluid smoothly running as if on the surface of a blade, and the pressure fluids join together. Accordingly, the pressure fluids that do not easily generate a negative pressure in joining together and that have a stable stream can flow to the downstream side.

In contrast, in the conventional valve a, the pressure fluids that flow from the water-flow ports i to the hollow part f collide violently with each other and join together because the back of the valve member e is flat along the water-flow ports i. Accordingly, the pressure fluids generate a negative pressure at the center of the back of the valve member e in joining together. Therefore, a pressure loss in the flow of the pressure fluids increases, and the fluids flow to the downstream side.

Thus, the proportional pressure reducing valve 1 of the present invention is, as a whole, smaller in pressure loss of pressure fluids when the valve is opened than that in the conventional valve a, and can secure a stable flow rate.

When the hydrant cock is closed after water is used, the piston 3 is returned to the primary side in response to a rise in the secondary pressure, and the valve is closed when the secondary pressure reaches a predetermined pressure.

WHAT IS CLAIMED IS:

1. A proportional pressure reducing valve for use in waterworks, comprising:

a cylindrical valve box that has an inlet and an outlet designed to be greater in diameter than the inlet at ends, respectively, of the valve box;

a piston slidably fitted in the valve box, the piston having a valve member used to open and close the inlet at one end and having a hollow part opened toward the outlet at an opposite end;

a space, whose sectional area is greater than an area of the inlet, between a periphery on a side of the one end of the piston and an inner wall of the valve box;

an annular caved surface formed in a peripheral wall of the piston facing the inner wall of the valve box through the space; and

a plurality of water-flow ports formed in the caved surface, each of the water-flow ports leading to the hollow part and having the same diameter as a width of the caved surface, the water-flow ports arranged to be at an acute angle with respect to an axial line, to be slantingly toward the outlet, and to be with small intervals therebetween;

wherein a total area of the water-flow ports is designed

to be greater than the area of the inlet and to be greater than an area of the caved surface excluding the total area of the water-flow ports.

2. The proportional pressure reducing valve according to Claim 1, wherein the piston has a substantially funnel-shaped concave part formed at the back of the valve member, the concave part being connected to an exit of the water-flow port and being tapered to the center of the piston.

3. The proportional pressure reducing valve according to Claim 1 or Claim 2, wherein a valve box in which the inlet and the outlet are caused to correspond to a primary side and a secondary side, respectively, is housed in an interior of an exit of a water meter.

4. The proportional pressure reducing valve according to Claim 1 or Claim 2, wherein a valve box in which the inlet and the outlet are caused to correspond to a primary side and a secondary side, respectively, is housed in an interior of a water device disposed at a secondary side of a water meter.