

[54] **SHUT OFF DEVICE**

[76] Inventors: **Allan V. Stone**, 33 Summit Rd., Port Washington, N.Y. 11050; **Francis J. Martin**, 5 Skyline Dr., Huntington, N.Y. 11743

[22] Filed: **Oct. 26, 1973**

[21] Appl. No.: **410,088**

Related U.S. Application Data

[62] Division of Ser. No. 205,163, Dec. 6, 1971, Pat. No. 3,779,213.

[52] **U.S. Cl.**..... 137/624.11, 68/12 R, 68/207, 137/460

[51] **Int. Cl.**..... **F16k 17/12**

[58] **Field of Search**..... 137/624.11, 624.18, 613, 137/487, 460; 251/15, 16, 23; 68/12 R, 207, 208

[56] **References Cited**

UNITED STATES PATENTS

3,241,714 3/1966 Murray 251/23 X

3,417,782 12/1968 Mentneck 137/624.11

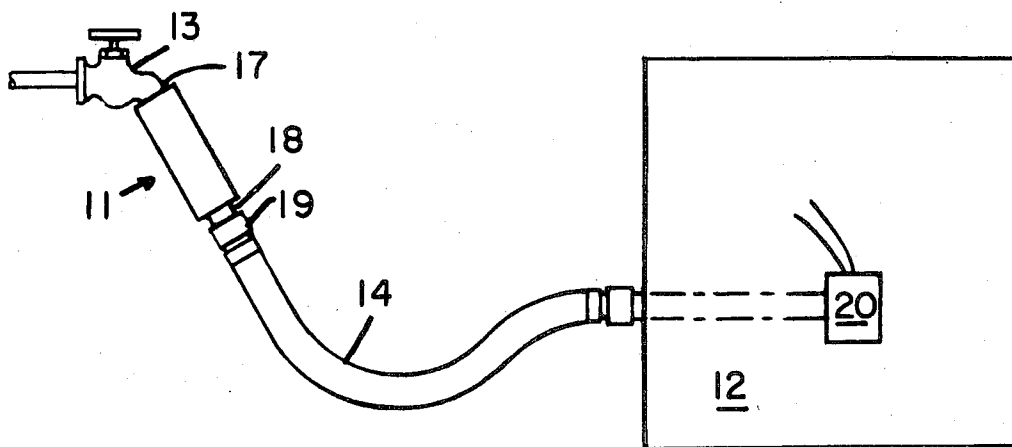
Primary Examiner—Alan Cohan
Attorney, Agent, or Firm—Abner Sheffer

[57]

ABSTRACT

An automatic shut off device particularly designed to be positioned upstream of the flexible hose through which the feed water flows to a household automatic washing machine. The device operates if flow through it continues for longer than the usual water-demand period of the washing machine cycle. It includes means for establishing a pressure differential, whose magnitude is substantially independent of the flow rate over a wide range of flow rates, and shut off means responsive to the continuance of that differential.

21 Claims, 5 Drawing Figures



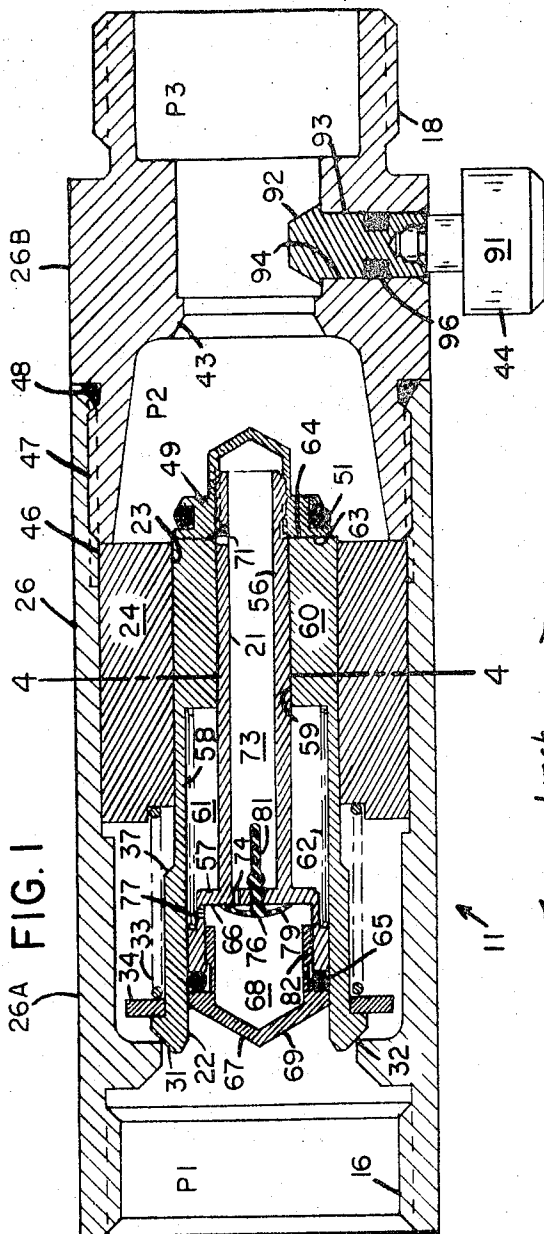
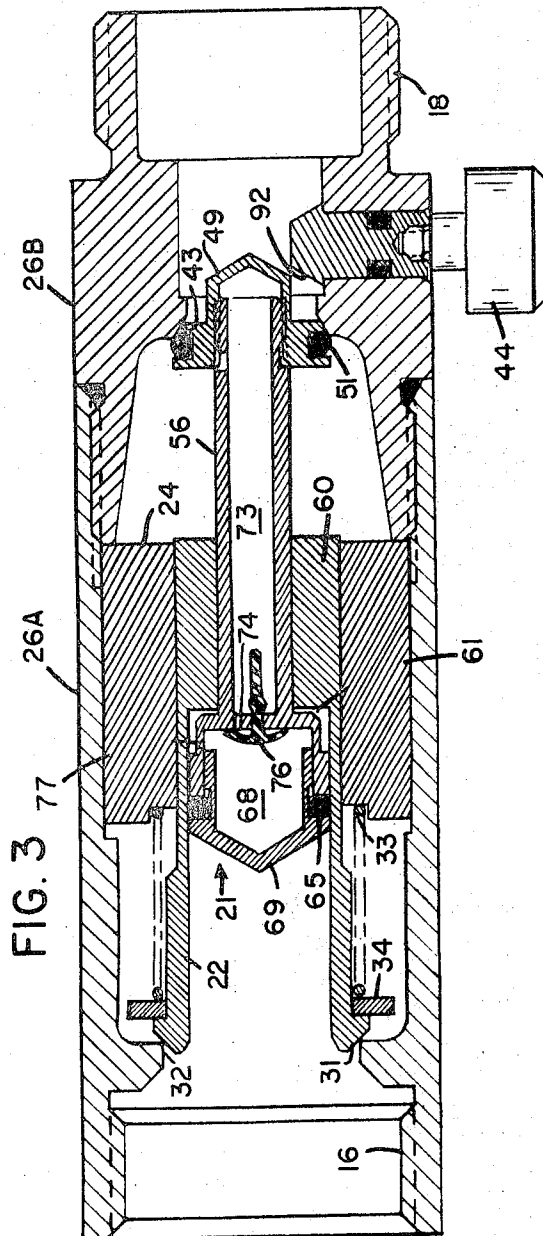


FIG. 2

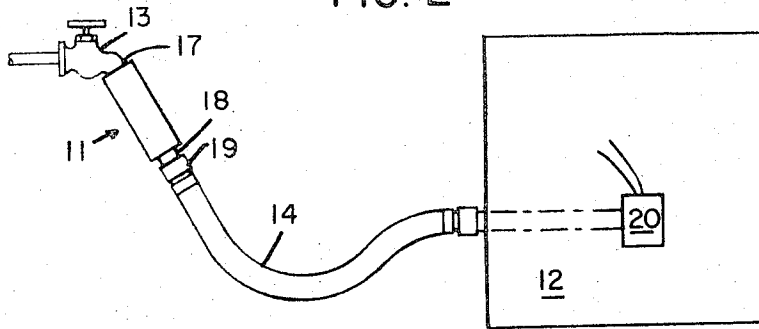


FIG. 4

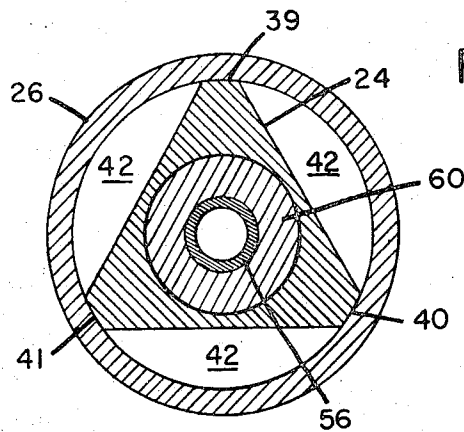
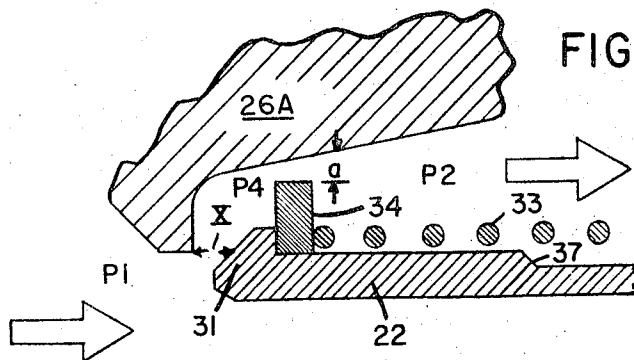


FIG. 5



SHUT OFF DEVICE

This is a divisional of application Ser. No. 205,163 filed Dec. 6, 1971 now U.S. Pat. No. 3,779,273, granted Dec. 18, 1972.

This invention relates to an automatic shut off device for the control of fluid flow. It is particularly useful as a protective device in the water feed line of a household automatic washing machine. It acts to prevent the extensive flooding which could result from an unintended break in, say, the rubber feed hoses leading to the automatic washing machine.

One preferred embodiment of the invention is shown in the accompanying drawings in which:

FIG. 1 is a view of the device in cross section with the parts in their initial position;

FIG. 2 is a schematic view showing the positioning of the device in relation to the feed line of an automatic washing machine;

FIG. 3 is a view in cross section, like FIG. 1, but with the parts in their shut off position;

FIG. 4 is a cross sectional view taken along the plane 4—4 of FIG. 1; and

FIG. 5 is a cross sectional view (on a larger scale) of a portion of the device in cross section, with certain clearances ("X" and "a") and certain pressures (P1, P4, P2) indicated thereon.

The device 11 shown in FIG. 1 is designed to be positioned in a feed water line leading (FIG. 2) to a household clothes washing machine 12 or automatic dishwasher or other machine. It is located downstream of the usual faucet 13 and upstream of the conventional feed hose 14. Specifically it has a threaded inlet end 16 (adapted to be screwed to, say, the corresponding male threaded outlet 17 of faucet 13), and a threaded outlet end 18 (adapted to be connected to the corresponding threaded inlet fitting 19 of the hose 14).

The household washing machine is not generally used continuously day and night. For most of the time it is not in use. In this condition the built-in feed valve 20 of the washing machine is closed (it is conventionally a solenoid-operated valve), but the faucet 13 may be left open by the householder so that the device 11 and the hose 14 are filled with water. In this condition there is no flow through the device 11, and its parts are in the position shown in FIG. 1.

When fluid flows through feed hose, the parts of the device move to a position like that partly illustrated in FIG. 5. If the flow persists for an extended period of time, a time span substantially longer than the normal designed flow time for the operation of the washing machine, the parts move to the position shown in FIG. 3, thus shutting off the flow. In the preferred embodiment the time span for this movement to shut off position is essentially independent of the flow rate through the device over the operating flow range. If flow through the device ceases before that this predetermined time span the parts return automatically to the position shown in FIG. 1. This happens in the usual cycle of the washing machine (or other type machine) when the built-in valve 20 of the machine shuts off. If the flow rate through the device rises to a level above the upper flow limit as established by the requirements of the washing machine (or other machine to which the device is connected) the parts of the device move to shut off the flow much more quickly, that is, in a much shorter time span than that mentioned above. When the parts are in

the shut off position shown in FIG. 3 they may be returned, by manual control of the device, to their original position, shown in FIG. 1.

In the device 11 there is a timing piston 21. The piston moves to a shut off position in response to a pressure differential generated in the device by the action of a poppet 22. The design of the poppet and associated parts is preferably such that the pressure differential is substantially constant and independent of the flow rate over a wide range of flow rates.

Poppet 22 is slidably mounted in the bore 23 of a support guide 24 (see FIG. 4) which is retained in the body 26 of the device. At one end the poppet is formed into a valve head 31, which is adapted to be forced against a valve seat 32 formed in the body 26. The poppet is spring biased towards its seated position, as by means of a helical spring 33 which surrounds the poppet; one end of the spring is pressed against the guide 24 while the other end is preferably pressed against a compensator ring 34 which is mounted on the poppet (and is preferably pressed by spring 33 against an extension of the valve head 31).

When the household washing machine is not in use and its built-in feed valve 20 is closed while the faucet 13 is open, so that the device 11 and the hose 14 are filled with water, there is no flow through the device, and the pressure (P1) upstream of the poppet 22 and the pressure (P2) downstream of that poppet are the same. Under these conditions the spring 33 forces the sleeve to its extreme upstream position shown in FIG. 1 with its head 31 pressed against the valve seat 32.

When the washing machine is in use and its built-in feed valve 20 is open, the pressure of the water upstream of the poppet 22 forces the poppet in a downstream direction and water flows past the valve seat 32 and around the valve head 31 and compensator ring 34. This movement is limited by a shoulder 37, formed on the poppet, which shoulder is adapted to come into contact with the guide 24 and act as a stop. The size and shape of the poppet 22 and compensator ring 34 and of the passageways around them are such that over a wide range of rates of flow of the fluid there is a substantially constant pressure differential (ΔP) between the pressure (P1) just upstream of the poppet and the pressure (P2) downstream of the poppet. In response to this substantially constant pressure differential the timing piston 21, previously mentioned, moves at a correspondingly constant rate towards a position shutting off the flow. This shut off occurs after a predetermined time span.

The design of the parts to attain the substantially constant pressure differential will be explained in detail at a later point in this application. Generally speaking this constant pressure differential results (in the preferred embodiment illustrated in the drawings) from the fact that as the poppet travels in downstream direction (to the right in the drawings) the annular flow area increases according to a quadratic equation (given later herein) such that the flow rate is not material factor in determining the pressure drop.

The guide 24 is so shaped and situated as to offer minimum resistance to the flow of water; in the illustrated embodiment this guide is a block of generally triangular construction (see FIG. 4) supported in the body 26 at three spaced areas 39, 40, 41 and there is ample space 42 around it for the flow of water through the device. As shown the body 26 is in two parts. The

forward part 26 A has the female threaded portion 16 and the valve seat 32 and the rear part 26 B has the male threaded portion 18 and a shut off valve seat 43 as well as a release button 44 to be described later. These two parts of the body are suitably threaded at 46 and 47 and thereby screwed securely together and sealed by packing 48.

The shut-off means includes the previously mentioned timing piston 21 which has tapered valve head 49 carrying a packing (preferably an O-ring) 51 adapted to engage, and seal against, the valve seat 43 formed in the body portion 26 B. The head 49 is fixed (as by threading, welding or cementing) to the downstream end of the tubular stem 56 of the axially, movable timing piston 21. At the other end the stem 56 carries a piston head 57 which is fitted to be slidably supported in a wide bore 58 of poppet 22, the stem 56 being movable through a narrow bore 59 in a collar portion 60 of the same poppet. It will be seen that between the piston head 57 and the collar 60 there is an annular cavity or chamber 61. The timing piston 21 is biased (as by a helical spring 62 mounted between the piston head 57 and the collar portion 60 of poppet 22) in a direction to increase the volume of the chamber 61; the retraction movement of the timing piston is, however, limited by the engagement of the upstream face 63 of the tapered head 49 with the downstream face 64 of the collar portion 60 of poppet 22. There is a controlled small clearance between the stem 56 and the bore 59 for movement of fluid out of cavity 61, for a purpose to be described below. Escape of fluid from cavity 61 past head 57 may be prevented by the provision of packing 65.

The piston head 57 is made in two parts 66, 67 with a cavity 68 between them for reasons which will be explained later. The upstream piston head part 67 has a tapered face 69.

It will be seen that when water flows through the device the upstream face 69 of the timing piston head is exposed to the pressure P1 while, because of the pressure differential (ΔP) previously mentioned, the effective downstream face of the piston 21 such as tapered head 49, is exposed to the lower pressure P2. This tends to force the piston in a downstream direction, the force being resisted by the action of the spring 62 and the incompressibility of the water in the chamber 61. That water *ca*, however, leak slowly at a controlled rate through the small clearance between the bore 59 and the tubular stem 56, escaping downstream at the edge of the face 64.

The time span for shutoff is controlled by the clearance between bore 59 and tubular stem 56, as the rate is proportioned to the cube of the clearance, all other factors remaining constant.

As the piston moves slowly downstream relative to the poppet 22, the chamber 61 corresponding becomes smaller. If the flow of water continues long enough (owing, say, to a break in the hose 14) the tapered head 49 reaches the seat 43 thus shutting off the flow of water by the seal 51 (see FIG. 3).

The tapered head 49 now acts a check valve. The pressure on its upstream face 63 is P2 which, because of the shutoff, rises again to approach or equal the line pressure P1. The pressure P3 just downstream of the seat 52 falls to substantially zero, owing to the break downstream of the device. This pressure difference is

enough to overcome the opposing force exerted by springs 33 and 62.

The biasing spring 33 does however gradually force the poppet 22 back to its extreme upstream position. It pushes against the poppet so as to generate, in cavity 61, a pressure which is greater than P1 or P2, forcing the fluid (water) in cavity 61 to flow out by way of the controlled orifice between 56 and 59 over a period of time until the poppet head 31 seats against the valve seat 32. All movement then stops until action is taken to mechanically recycle the device.

Once the break in the hose 14 has been repaired (as by replacing the hose) the device can be quickly reset to its original position (of FIG. 1) by pressing the reset button 44 which forces the tapered head 49 away from the valve seat 43, thus permitting the water to flow past that seat into the hose. This temporarily lowers the pressure P2 within the device so that the poppet is forced downstream by the line pressure. Water thus flows past seat 32, until the hose becomes filled with water and the water pressure downstream of the tapered head 49 rises to substantially the same level as the water pressure in the rest of the device. At the same time the spring 62 forces the timing piston upstream, enlarging the chamber 61. Water, to fill the chamber 61 quickly during this operation, flows through hole 71 at the downstream end of the hollow tubular stem 56 into the interior 73 of that stem, then through a hole 74 (located in piston head portion 66) past a check valve 76, into the open space 68 between the two parts 66, 67 of the piston head 57 and then through another hole 77 (also located in piston head portion 66) leading from the space 68 into the chamber 61.

The check valve 76 may comprise a flexible cap 79 situated on a stem 81 anchored in the piston head, the whole check valve being suitably integrally molded of material such as rubber. The cap 79 prevents water from flowing out of the space 68 (which communicates, through hole 77, with the chamber 61) into the hole 74. But when the chamber 61 and space 68 are at a lower pressure (due to the previously described expansion of the chamber by the action of spring 62) the cap flexes to permit flow in the opposite direction.

The reset button is constructed and arranged to move the tapered head 49 (and its attached piston assembly) only a short distance upstream. Thus if the reset button is pressed before the break in the hose is repaired, the device will not reset to its original position shown in FIG. 1. Instead it will quickly return, under the influence of the water pressure differential ΔP , to its shut off position.

In the normal operation of the device the fluid flow is ended (as by the action of the built-in washing machine valve 20) when the timing piston 21 has traversed only part way to the shut off position. Then the pressures P1, P2, and P3 become essentially equal and the poppet 22 returns under the influence of spring 32 to seat the poppet head 31 against the valve seat 32. The timing spring 62 pushes the timing piston 21 in an upstream direction, reducing the pressure in cavity 61 to a level lower than P2 and allowing the timing piston 21 to return to the position shown in FIG. 1.

In the preferred embodiment the seal formed between poppet head 31 and seat 32 when the parts are in the position shown in FIG. 1 is not tight. There is a very slight leakage past the seat 32. This is a source of makeup fluid for the expansion of cavity 61.

It is often desirable that the substantially constant pressure differential (P1 minus P2) resulting from flow past the poppet 22 be relatively low so as to keep the inlet pressure of the washing machine high. This can be accomplished by appropriate design, as explained below. To insure proper operation of the timing piston, particularly when this pressure differential is low, the friction of the packing 65 against bore 58 should be kept at a low value. To this end, during manufacture, the spacing provided for the packing 65 (between the piston head parts 66, 67) is set so that the outer periphery of the packing 65 just makes contact with the bore 58 of poppet 22. This then compensates for variations, due to manufacturing tolerances, in the bore diameter 58, the size of packing 65 and the size of the packing cavity. For this purpose the piston head part 67 may have a skirt 82 which makes an adjustable press fit in the other head part 66, or the parts 66, 67 may be adjustably threaded together.

In a modification of the invention the packing 65 is omitted and the components are designed so that the pressure (P5) in chamber 61 is equal to P1. For instance the areas and spring force may be chosen in the following relationship (involving F_s , the spring force exerted by spring 62; A_p , the projected area of the upstream face of the timing piston head; A_R , the projected area of the piston stem 56; A_C , the projected area of the upstream face of chamber 61): $P1 \times A_p$ should be greater than the sum of $P2 \times A_R$ plus $P5 \times A_C$ plus F_s , and F_s should be greater than $P1 \times A_p$ minus $P2 \times A_R$ minus $P5 \times A_C$.

Returning to the design considerations for maintaining a substantially constant pressure differential ΔP (i.e., P1 minus P2), flow does not occur through the device until ΔP equals the installed spring force exerted by spring 33. This is defined as the cracking pressure of the device, which for our purposes is preferably about 4 pounds per square inch; this pressure differential can occur with even a small, but continuous loss of fluid downstream of the device in excess of the very small amount of fluid which can leak past the seat 32 when the parts are in the position shown in FIG. 1. Referring to the arrangement which is shown schematically in FIG. 5, it will be seen that there are two annular orifices involved in this particular design: the primary orifice between valve seat 32 and poppet head 31, and the secondary orifice between the outer upstream edge of compensator ring 34 and the inner wall of body 21a. Up to the cracking pressure of the device the following forces act on the poppet 22:

$$(P1 - P2) A1 = F_{s0}$$

(1)

where A1 is the projected upstream area of the poppet head 31 and F_{s0} is the installed spring force of spring 33. Once flow starts, the forces on poppet 22 will be:

$$(P1 - P2) \bar{A}1 + (P4 - P2) \bar{A}2 = \bar{F}_{s0} + F_{f1} + F_{f2} + K_1 X$$

(2)

where A_2 is the projected upstream area of compensator ring 34; F_{f1} and F_{f2} are the flow forces at the primary and secondary orifices, respectively; K_1 is the spring rate and X is the poppet travel.

Combining equations (1) and (2) one obtains:

$$(P4 - P2) \bar{A}2 = F_{f1} + F_{f2} + K_1 X$$

(3)

At constant values of P1 minus P2 the following relationship holds:

$$(P1 - P2) = (P1 - P4) + (P4 - P2)$$

(4)

In the following equations $k_1, k_2, k_3, k_4, k_5, k_6, k_7$ and k_8 are constants. Using the well known orifice equation across the primary orifice the pressure drop of P1 minus P4 gives a flow (Q) of

$$Q = k_1 X \sqrt{(P1 - P4)}$$

(5)

across the secondary orifice, the pressure drop of P4 minus P2 gives a flow (in terms of the radial clearance "a" between ring 34 and body 26.) of:

$$Q = k_2 a \sqrt{(P4 - P2)}$$

(6)

Using the steady state flow force equations developed by Lee and Beachburn at M.I.T., the flow force F_f at the primary orifice is:

$$F_{f1} = k_3 X (P1 - P4)$$

(7)

and the flow force at the secondary orifice is (in terms of the radial clearance "a" between ring 34 and body 26.):

$$F_{f2} = k_4 a (P4 - P2)$$

(8)

Substituting (5), (6), (7), and (8) into (3) and simplifying we obtain:

$$k_5 (\bar{A}_2 / a^2) = (k_6 / X) + (k_7 / a) + (K_1 X / Q^2)$$

(9)

Substituting (5) and (6) into (4) and simplifying we obtain:

$$Q^2 = \frac{k_8 (P1 - P2)}{\left(\frac{1}{X^2} + \frac{1}{a^2}\right)}$$

(10)

Substituting (10) into (9) we obtain:

$$\left[k_6 + \frac{K_1}{(P1 - P2)} \right] a^2 + k_7 X a + \frac{k_8 K_1}{(P1 - P2)} X^2 - k_5 \bar{A}_2 X = 0$$

(11)

Upon examination of equation (11) it is seen that for a constant pressure drop (P1 minus P2) the radial clearance "a" must change via the poppet travel X as a quadric equation, and that the flow through the device has been eliminated as a variable. Therefore it is possible to select the physical parameters so that the pressure drop (P1 minus P2) will remain constant vs. the flow through the device. The upper flow limit will occur when the poppet shoulder 37 engages the guide

24. At this flow the travel of poppet 22 stops and the pressure drop (P1 minus P2) will increase vs. flow, following approximately the familiar equation:

$$(P1 - P2) = kQ^2$$

(12)

This feature is desirable for, if the hose 14 should develop a large break so that the flow greatly exceeds the normal demand (e.g. a flow of above 10 gallons per minute as compared to a normal demand of the automatic washing machine of say 5 to 6 gallons per minute), the device shuts off as soon as possible. At this large flow rate, the pressure differential (P1 minus P2) will increase as the flow Q^2 . Therefore the pressure across the controlled orifice 59 will increase and the leakage from cavity 61 will increase allowing the timing piston to traverse to its shutoff position in less time than for the normal flow condition. Consequently, less fluid will be spilled than if this feature were not included in the design.

The release button 44 has a head 91 and a tapered end 92 which serves as a cam adapted to engage the tapered valve head 49 of the timing piston when the latter is in shut off position. Head 91 and tapered end 92 are connected by a stem 93 fitted in a bore 94 of the body 26B. A packing 96 prevents leakage through that bore.

As can be seen from FIG. 4 the body 26, poppet 22 and timing piston 21 are preferably radially symmetrical, except as indicated on other FIGS.

FIGS. 1, 3 and 4 are drawn to scale; the scale of one preferred embodiment particularly designed for use with household automatic washing machines is indicated on FIG. 3.

The household water supply pressures (e.g. those prevailing just upstream of valve 13 in FIG. 2) are normally in the range of about 20 to 70 psig and the normal rate of flow of water to a household automatic washing machine is a plurality of gallons per minute, (e.g. in the range of about 3 to 6 g.p.m.) with the time period for such flow being normally well below 10 minutes. The device of the present invention is preferably constructed so as to shut off such flow if it continues for more than 20 or 30 minutes. It also shuts off flow in a similar period of time when the flow rate is much lower, such as a flow rate of less than 0.1 gallon per minute, e.g. 0.03 gallon per minute, which could occur as a result of a small leak (e.g. a small break in the rubber hose). Thus it acts to stop the flow through a leak in a relatively short time, before the leak has a chance to expand. The design is preferably such that the pressure differential (ΔP) at such low rates of flow is an appreciable fraction, e.g. over one fourth, of the ΔP at the normal rates of flow mentioned above. As previously explained, at rates of flow much higher than normal ΔP goes up sharply and the device acts much more quickly.

In the illustrated embodiment, measurements of ΔP at different flow rates gave the following values: about 3 psi when flow begins, about 4 psi at 0.2 gpm and 5 gpm, about 4.5 psi at 3 gpm and about 6 psi at 10 gpm. It will be seen when a curve is made by a plotting these figures of ΔP (as ordinate) vs. flow rate (as abscissa) the slope of the curve for a relatively short initial region (at low flow rates) is higher than the overall slope at for a longer region (at moderate flow rates) the overall

slope for the latter region being within the range less than about 0.5 psi per gpm (e.g. about 0.2 psi per gpm); after this longer region of low slope, the slope of the curve increases sharply. Thus the curve rises for a short initial region, substantially levels off over a longer intermediate region and then rises again rapidly.

It is understood that the foregoing detailed description is given merely by way of illustration and that variations may be made therein without departing from the spirit of the invention. The "Abstract" given above is merely for the convenience of technical searchers and is not to be given any weight with respect to the scope of the invention.

I claim:

1. In combination, a household automatic washing machine connected to a water feed line by a flexible hose, said washing machine having automatically and cyclically operated valve means to permit the water to flow into said machine from said hose for a period of time and then to stop said flow of water, and a device through which the water passes on its way to the hose, said device comprising means controlled by the flow through the device for shutting off the flow to said hose after a predetermined time period of flow which is longer than the longest time period of flow permitted by said automatically operated valve means in the washing machine cycle.

2. A combination as in claim 1 in which said shutting off means includes movable means moving from an initial position to a shut off position during said predetermined time period, said device including means for automatically returning said movable means to its initial position if flow through the device ceases before said movable means reaches said shut off position.

3. A combination as in claim 1 in which said device includes means for shortening said time period when the rate of flow to said hose attains a predetermined value, which value is greater than the operating rates of flow for said washing machine.

4. A combination as in claim 2 including manually operable means for returning said movable means to a position intermediate its initial and shut off positions, whereby said movable means will automatically return from said intermediate position to its initial position if the demand for water from said device has ended prior to said return.

5. A combination as in claim 1 in which said device includes means for establishing a substantially constant pressure drop over a wide range of rates of flow through said device, and means movable in response to said pressure drop from a position permitting said flow to a position shutting off the flow through said device whereby the time elapsing between the start of flow through the device and said shutting off of the flow is substantially constant over said range of flow rates.

6. A combination as in claim 1,

said device comprising means for establishing a substantially constant pressure drop over a wide range of rates of flow through said device, and means, including timing means, movable in response to said pressure drop from position permitting said flow to a position shutting off the flow through said device so that the time elapsing between the start of flow through the device and said shutting off of the flow is substantially constant over said range of flow rates.

7. A combination as in claim 6 in which said device

comprises orifice means through which the water flows in passing through said device and means for increasing the cross-sectional area of said orifice means in response to increase in the rate of flow through said device whereby to maintain a substantially constant pressure drop across said orifice means despite the increase in said rate of flow.

8. A combination as in claim 7

in which the movement of said movable means is resisted by dash pot means including a water-containing chamber having a restricted opening through which the water of said chamber is forced out into the stream of water flowing through said device.

9. A combination as in claim 6

in which said range of rates extends upward from (a) a rate corresponding to a slow leak in said hose to (b) a rate corresponding to the normal demand of said machine, said range being wide enough to include an at least fifteenfold change in rate, said movable means moving to said shut off position in response to the continuation of said pressure drop for an extended period of time which is more than sufficient to fill said machine at said rate b.

10. A combination as in claim 6

adapted for use with a feedline having a water supply pressure of about 20 to 70 psig, said wide range of rates extending over at least the range from 0.2 gallon per minute to 3 gallons per minute, the construction and arrangement being such that when the rate of flow through the device increases beyond a given rate the magnitude of said pressure drop does increase substantially on further increase in flow rate, thus decreasing said elapsed time for said movement to said shut off position, said shutting off means having an original position, said device including means for returning said shutting off means to said original position if said flow ceases before said shutting off means reaches said shutting off position.

11. A combination as in claim 1, said device being a

fluid flow control device having an inlet for fluid and an outlet for said fluid and means for shutting off the flow of fluid to said outlet, said flow control device having orifice means through which the fluid flows in passing from said inlet to said outlet whereby there is a pressure drop across said orifice means, said shutting off means including timing means and being responsive to the magnitude of said pressure drop and to the duration of said pressure drop, and means for increasing the cross sectional area of said orifice means in response to increases in the rate at which said fluid flows through said orifice means so as to decrease the differences in the pressure drop across said orifice means resulting from differences in said rate of flow.

12. A combination as in claim 11, said device

comprising housing means through which the fluid passes, valve means in the path of the flow of the fluid and movable in the direction of fluid flow, there being annular orifices for the flow of said fluid past said valve means, and means biasing the valve means in a direction to reduce the size of said

annular orifices and opposite to the direction of fluid flow.

13. A combination as in claim 12

in which said orifices are annular; said valve means comprises a valve seat, a poppet having an orifice-defining head adapted to engage said seat, and an orifice-defining shoulder on said poppet downstream of said head; said shutting off means comprises a timing piston adapted to move from an initial position to a shut off position; said timing piston has an upstream end which is acted upon by the pressure upstream of said orifices and a downstream end which is acted upon by the lower pressure downstream of said orifices; said timing piston has a shut off valve head adapted to engage a second valve seat to shut off said flow when the piston has moved to the shut off position; said device has a fluid-containing chamber connected to a restricted passageway for the flow of fluid from said chamber; the construction and arrangement is such that the movement of said timing piston towards the shut off position exerts pressure on the fluid in said chamber whereby the rate of said movement of said piston is controlled by the rate of fluid flow through said restricted passageway; said device also comprises means for automatically restoring said timing piston to its initial position when the fluid flow through said device is shut off downstream of said device and the pressure downstream of said orifices approaches the pressure upstream of said orifices; and said restoring means comprises a spring acting on said timing piston and acting to expand said chamber, means defining a fluid passage for the return of fluid to said chamber, and a check valve in said fluid passage permitting said return of fluid and preventing flow of fluid through said passage in the opposite direction.

14. A combination as in claim 13, said device

including manually operable means for moving said timing piston, when in shut off position, for a distance equal to a minor portion of the overall travel of said piston, whereby operation of said manually operable means, after any path of fluid flow downstream from said device has been closed subsequent to the shutting off of flow in said device by the action of said piston, brings said piston to a position from which it is then restored to its initial position by the action of said restoring means.

15. A combination as in claim 14

in which said device is of generally cylindrical configuration; the poppet and the timing piston are each tubular and movable rectilinearly in said device along the general direction of fluid flow through the device; the piston has a head movable in a second, narrower, annular bore of said poppet; and said restricted passageway is formed by the clearance between said stem and said second bore.

16. A combination as in claim 13

in which said poppet moves in response to fluid flow through said device, to a position which provides greater orifice sizes when the rate of flow through the device is greater.

17. A combination as in claim 13

in which the construction and arrangement is such that when the rate of flow through the device increases beyond a given level the size of the orifices does not increase substantially whereby the magni-

11

tude of said pressure drop does increase substantially on further increase in flow rate, thus increasing the speed at which the piston travels to said shut off position.

18. A combination as in claim 13

including means for limiting the movement of said poppet whereby the size of the orifices does not increase when the rate of flow through the device increases beyond a given level so that the magnitude of said pressure drop does increase substantially on further increase in flow rate, thus increasing the speed at which the piston travels to said shut off position.

19. A combination as in claim 1, said device being a

fluid flow control device having an inlet for fluid and an outlet for said fluid and means for shutting off the flow of fluid to said outlet, said flow control device having means through which the fluid flows in passing from said inlet to said outlet whereby there is a pressure drop across said means, said shutting off means including timing means and being responsive to the magnitude of said pressure drop and to the duration of said pressure drop, the con-

12

struction and arrangement of said first means being such that the curve made by plotting the magnitude of said pressure drop (as ordinate) against the flow rate rises for a short initial region then substantially levels off over a longer intermediate region and then rises again rapidly.

20. A combination as in claim 9

in which said movable means is constructed and arranged to move toward said shut off position during said extended period and to move in the opposite direction on the cessation of said flow prior to its reaching said shut off position.

21. A combination as in claim 11

in which said shutting off means responds to shut off said flow after said pressure drop has continued for an extended period of time and said means for increasing said area is constructed so that the pressure drop across said orifice means is substantially constant over a range of flow rates in which there is an at least fifteenfold change in flow rate so that said extended period for the flow rate at the low end of said range is similar to said extended period for the flow rate at the high end of said range.

* * * * *

25

30

35

40

45

50

55

60

65