

LIQUID PRESSURE REDUCING VALVE

The present invention relates to a liquid pressure reducing valve, particularly though not exclusively for water mains.

Loss of water from mains is a problem due to the age of mains pipework and damage to mains and associated equipment. Many mains are old and have multiple leaks. Even newer mains can suffer leaks. Leak flow is greatest when the water pressure is highest, unsurprisingly. However I have noted a simple correlation between on the one hand pressure required downstream of a regulator to maintain a given minimum pressure at a remote point of a local network, the regulator being between a high pressure regional supply and the local network, and on the other hand flow in the local network. Both the required regulated pressure and the flow on the downstream side of the regulator appear to be normally linearly related. Despite this I am aware of no pressure regulators controlled in accordance with flow through them, except for the following.

In the prior proposal of GB 2,176,316, there was disclosed, in terms of its abstract:

Apparatus for controlling the flow of water through a pipe (26) including a valve (29) and an orifice plate (37) and supplying a water distribution system comprises a governor (1) actuating a pilot valve (14) in a servo system controlling the valve (29). The governor (1) has two diaphragms (5) and (6) linked by a tension spring (7) the extension of which is determined by the rate of flow through the orifice plate (37). The first diaphragm (5) operates a valve member (13) of the pilot valve (14) and is subjected to the differential pressure caused by flow through the orifice plate (37). The second diaphragm (6) is loaded by a compression spring (8) and its displacement is dependent upon the control pressure at a tapping (38) in the pipe (26).; The movement of the valve member (14) is the combination of the displacements of the two diaphragms (5 and 6), and raises the control pressure at tapping (38) when demand for water increases.

The object of the present invention is to provide an improved liquid pressure reducing valve

According to the invention there is provided a fluid pressure reducing valve apparatus comprising:

- a spring loaded regulator having:
 - a body containing a chamber,
 - a liquid supply orifice into the chamber and a liquid outlet from the chamber,
 - a regulation plate opposed to the orifice and subject in use to supply liquid acting on it,
 - a spring acting to urge the plate towards to the orifice and
 - a diaphragm between the regulation plate and the body to close the chamber between them and subject in use to regulated pressure in the chamber
- a controllable motor drive acting between the body and an end of the spring remote from the regulation plate,
- a flow meter downstream of the outlet and
- a controller arranged to receive flow data from the flow meter and to control the servo motor for withdrawal of the remote end of the spring in accordance with flow rate measured by the flow meter;

the arrangement being such that in use for increase in demand flow, the regulator plate is partially withdrawn to maintain downstream pressure on such increase and vice versa.

Preferably the controllable motor drive is a servo motor drive.

The invention is particularly applicable to water mains, where the fluid is liquid, in particular water. I envisage that the invention to be applicable to hydrocarbons fluids both liquid and gaseous.

The controller can be adapted for calculation of the servo motor action in spring positioning in accordance with a substantially linear downstream pressure and flow rate relationship. The calculation can be based on pressure to be achieved in terms of servo positioning of the spring; or on servo positioning of the spring alone. Alternatively it can be adapted for servo motor action in accordance with a lookup table of downstream pressure and flow rate. Again the lookup table can include values of pressure to be achieved, but is preferably includes spring positions in terms of servo revolutions.

To help understanding of the invention, a specific embodiment thereof will now be described by way of example and with reference to the accompanying drawings, in which:

Figure 1 is Figure 2 of prior proposal GB 2,176,316,

Figure 2 a diagrammatic, cross-sectional, side view of a pressure regulator of the invention,

Figure 3 is a similar on a smaller scale and including a controller and a line from a remote pressure sensor,

Figure 4 is a typical plot of pressure required to be applied in a network for constant remote pressure with varying demand flow and

Figure 5 is a diagram of a water main having a regulator of the invention and many customer supply taps and leaks.

Referring to the drawings, a spring loaded regulator 1 has a body 2 containing a chamber 3. An inlet 4 opens into the chamber via an inlet orifice 5. The inlet is connected to an elevated pressure water main 6. An outlet 7 from the chamber is connected to a network 8 of pipes for local distribution of water to individual consumers. The regulator has a flow pressure regulation plate 9 arranged opposite the inlet orifice 5. A diaphragm 10 is fastened to the plate 9 and radiates from it to the body, forming a seal with upper and lower parts 11,12 of the body 2. Thus the chamber 3 is sealed between the upper and lower parts.

The regulation plate has a guide rod 14 extending down from it into a guide 16 in the inlet orifice 5. The rod extends through both the regulation plate and the diaphragm. At its top end it carries a nut 17 bearing on a spring centring washer 18 and a diaphragm sealing and clamping plate 19. The arrangement keeps the regulation plate centred over the inlet orifice 5.

In a variant, a separate regulation plate 109 opposite the orifice is provided on the lower rod 14. The diaphragm keeps the plate 9 / 109 centred over the orifice 5.

A compression spring 21 acts at its lower end 22 on the top of the clamping plate 19. The spring is kept compressed to a greater or lesser extent as explained below. Thus it stays located around the centring washer 18. Its upper end 23 abuts a spring drive member 24 at the end of a drive tube 25 of a servo device 26. The drive tube is housed in a fixed tube 27 of the servo device, fast with the upper part 11 of the regulator body 2. Remote from the spring a lead screw 28 is journaled for axial alignment in the drive tube within the fixed tube. A motor 29 and gearbox 30 is arranged to drive the lead screw. A nut 31, preferably a

recirculating ball nut, is fast with the remote end of the drive tube 25, with the latter keyed to the fixed tube against rotation. Thus the spring drive member can be advanced to further compress the spring or retracted to relieve compression, by respective rotation of the motor and the lead screw.

Downstream from the outlet 7, the pipework 8 of the local distribution network extends. In it adjacent the outlet is a flow meter 32 and a pressure sensor 33. These are electronically connected to a controller 34. Also connected to the controller is a remote pressure sensor 35 at the furthest point 36 of the pipework 8.

Along the pipework, there are various leaks 37, which increase in their flow rate with pressure and a number of user taps 38 etc. It is these which are the primary determinant of the flow at the pressure regulator 1. If it were of the type permanently set to a pressure maintaining sufficient pressure at the furthest point 36 in the network, the pressure would be such as to aggravate the leaks 37 regardless of the user flow at the taps 38.

In this embodiment of the invention, the entire pressure reducing valve apparatus includes not only the regulator 1 and the flow meter 32, but also the controller 38 for controlling the regulator, via the servo motor, in accordance with flow measured by the flow regulator and indeed the remote pressure sensor 35, which is not strictly necessary for the invention.

Many local distribution networks such as the network 8 have been previously measured and exhibit a pressure / flow characteristic as shown in Figure 4 when the regulator is set to provide the required furthest point pressure for varying flows. The ideal low pressure point 41 for zero flow seldom exists due to leaks. The practical low pressure point 42 can be measured at night when user demand is negligible. Other flow and pressure readings 43 can be made during periods of more and less usage by adjusting the regulator to provide the sufficient furthest point pressure.

In practice, the pressure flow plot is a substantially straight line with a slope or gradient and an offset equivalent to the zero flow offset. The plot can be represented by the equation:

Pressure required at regulator = Zero flow pressure + measured flow x plot gradient
(in terms of pressure per unit flow).

This is surprising, because it might be expected that adjustment of the regulator would alter the measured flow. However, this is a second order effect because the primary determinant of flow is user usage. The leak flow is small by comparison and kept lower than it might be, by keeping the pressure in the network lower than it would be, if were set to its value to ensure that its furthest point sufficiency at maximum flow. This value results in too much flow and too much leakage at all other flows.

The spring 21 in the regulator acts against the force exerted by the diaphragm 10, which is subject to the pressure to be regulated, the upstream pressure force exerted against the regulation plate 9 being substantially constant and being small in comparison with the diaphragm force. Thus shortening of the spring by an amount proportional to the change in pressure required can provide this change, bearing in mind that only a small movement of the regulation plate is required for a significant change in pressure drop at the orifice of the outlet. Thus for practical purposes, linear movement of the end of the spring acted on by the servo motor causes a linear change in regulated pressure. Accordingly the controller can be set up to move the spring end linearly in accordance with the flow.

If the zero flow pressure and the gradient of the measured flow plot are not known, the controller can be set up to adjust the regulated pressure periodically for different flows to establish the pressures required to achieve the sufficient furthest away point pressure. For this connection is made with the remote pressure sensor 35 and the near pressure sensor 33, suitably wirelessly in the former case.

The controller can be provided with a memory adapted to record a map of pressure and flow as opposed to memorising merely the offset and gradient and use this as a look-up table for the pressure to which it should regulate the downstream pressure as a function of measured flow.

The sensor 33 can be used to fine tune the servo motor control to achieve the desired pressure in accordance with measured flow.

CLAIMS:

1. A fluid pressure reducing valve apparatus comprising:
 - a spring loaded pressure reducing valve having:
 - a body containing a chamber,
 - a liquid supply orifice into the chamber and a liquid outlet from the chamber,
 - a regulation plate opposed to the orifice and subject in use to supply liquid acting on it,
 - a spring acting to urge the plate towards to the orifice and
 - a diaphragm between the regulation plate and the body to close the chamber between them and subject in use to regulated pressure in the chamber
 - a flow meter downstream of the outlet for measuring the flow rate through the liquid outlet

wherein the apparatus further comprises:

- a controllable motor drive acting between the body and an end of the spring remote from the regulation plate, and
- a controller arranged to receive flow data from the flow meter and to control the controllable motor drive for withdrawal of the remote end of the spring in accordance with flow rate measured by the flow meter;

the arrangement being such that in use for increase in demand flow, the regulation plate is partially withdrawn to maintain downstream pressure on such increase and vice versa.

2. A fluid pressure reducing valve apparatus as claimed in claim 1, wherein the apparatus is adapted for reducing the pressure of water.
3. A fluid pressure reducing valve apparatus as claimed in claim 1, wherein the apparatus is adapted for reducing the pressure of hydrocarbons fluids both liquid and gaseous.
4. A fluid pressure reducing valve apparatus as claimed in claim 1, claim 2 or claim 3, wherein the controllable motor drive is a servo motor drive.

5. A fluid pressure reducing valve apparatus as claimed in claim 4, wherein the controller is adapted for calculation of the servo motor action in spring positioning in accordance with a substantially linear downstream pressure and flow rate relationship.
6. A fluid pressure reducing valve apparatus as claimed in claim 5, wherein the calculation is based on pressure to be achieved in terms of servo positioning of the spring.
7. A fluid pressure reducing valve apparatus as claimed in claim 5, wherein the calculation is based on servo positioning of the spring alone.
8. A fluid pressure reducing valve apparatus as claimed in claim 5, wherein the calculation is based on a lookup table of downstream pressure and flow rate.
9. A fluid pressure reducing valve apparatus as claimed in claim 8, wherein the lookup table includes (a) values of pressure to be achieved; or (b) spring positions in terms of servo revolutions.
10. A fluid pressure reducing valve apparatus as claimed in any preceding claim, wherein the regulation plate is provided in abutment with a central region of the diaphragm, with a guide rod extending into a centring guide in the orifice.
11. A fluid pressure reducing valve apparatus as claimed in any one of claims 1 to 9, wherein the regulation plate is provided spaced from the diaphragm, on a guide rod extending from the diaphragm into a centring guide in the orifice.
12. A fluid pressure reducing valve apparatus as claimed in any preceding claim, wherein the spring is a compression spring acting on the side of the diaphragm remote from the orifice.
13. A fluid pressure reducing valve apparatus as claimed in any one of claims 1 to 11, wherein the spring is a tension spring acting on the side of the diaphragm near to the orifice.
14. A fluid pressure reducing valve apparatus as claimed in any preceding claim, wherein the controllable motor drive includes a nut and lead screw device arranged to act on the spring at an end remote from the diaphragm and actuatable by a motor of the drive.

15. A fluid pressure reducing valve apparatus as claimed in any preceding claim in combination with a remote pressure sensor for measuring downstream pressure to be maintained.