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(54) THERMOSTATIC ACTUATOR

(71) We, DANFOSS A/S., a Danish Company, of DK 6430 Nordborg, Denmark, do hereby declare the invention, for which we pray that a patent may be granted to us, and the method by which it is to be performed, to be particularly described in and by the following statement:—

The invention relates to a thermostatic actuator for a heat exchanger temperature regulating valve, and especially a radiator valve.

A thermostatic actuator is known which comprises a room temperature sensor having a liquid-vapour filling, and an operating element of which the effective pressure surface becomes displaced under the action of the vapour pressure against the force of a spring. The actuator is often formed as an attachment for placing on a valve housing. The operating element comprises a pressure chamber formed between a cup-shaped member, carrying an inwardly directed flange at its open end, and a corrugated tubular bellows, arranged in the cup-shaped member, having a movable base and being connected, at its other end, to the flange. The cup-shaped member may consist of thermally conductive metal and serve directly as the room temperature sensor.

Heat exchanger valves regulated by means of such thermostatic actuators should permit just enough heating medium to flow to the heat exchanger that the preset temperature of the room is maintained. However, when a room is aired and the sensor is located in the region of inflowing cold air, which is particularly the case when the sensor is arranged beneath a window or near the floor, the temperature that is determined by the sensor is much too low and the valve is opened completely. The result of this is that the heat exchanger is constantly and unnecessarily replenished with hot water and the room is overheated after the window is closed.

The invention is based on the problem of providing a thermostatic actuator which prevents overheating by the heat-exchanger after temporary airing of a room.

The present invention provides a thermostatic actuator for a heat exchanger temperature regulating valve, the actuator comprising a movable actuating member which is controlled by two thermally responsive systems each having a respective charge which expands when heated and a respective pressure-receiving surface, wherein the movable member is urged in one direction by the pressure of the charge of one of the systems acting against its pressure-receiving surface and the movable member is urged in the opposite direction by the pressure of the charge of the other system acting against its pressure-receiving surface together with the force of a spring, the pressure-receiving surface of the said one system having a greater area than that of the pressure-receiving surface of the said other system, and the said other system having a lower response time constant than the said one system.

With this construction, when there is a sudden temperature change the said other system responds more quickly than the said one system. However, since the effect of the said other system is opposite to that of the said one system, a sudden temperature drop of the kind arising during airing will first cause the valve closure member to move in the closing direction. Contrary to hitherto, therefore, heating medium flowing through the valve is throttled. Only after a certain time will the influence of the said one system predominate; the direction of movement of the closure member then being reversed so that eventually it passes beyond its original position and opens the valve further. The response of the actuator to a sudden temperature drop therefore takes place with a considerable time delay. This

delay can be such that during a conventional airing period, which rarely exceeds 10 minutes, no unduly large quantities of heating medium are passed to the heat exchanger. For slow temperature variations of the kind arising during normal control, the action of the said other system has little influence on the control behaviour (which is governed primarily by the said one system).

The different response time constants of the two systems can be achieved in various ways. In particular, the first system may be associated with a large mass to be heated and the second system with a small mass to be heated. This is achieved in a particularly simple manner if the said one system is constituted by a chamber defined, in part, by the pressure-receiving surface of that system and the said other system is constituted by a chamber defined, in part, by the pressure-receiving surface of that system and a sensor bulb connected to the chamber by a capillary tube. The mass to be heated in the said other system depends effectively on the size of the sensor bulb and is therefore much smaller than the mass to be heated in the said one system.

Another way of influencing the response time constant is to have a different thermal transmission to the two systems. This can be achieved, for example, if the said one system is at least partly thermally insulated.

Preferably, the said one system comprises a chamber defined by a cup-shaped member, the rim of which has an inwardly directed flange, and a corrugated tubular bellows which has a movable base at one end and adjoins the flange at the other end, the internal surface of the movable base constituting the pressure-receiving surface of the said one system, and in which the said other system comprises a chamber which is defined between the said bellows and another corrugated tubular bellows, the other bellows being of smaller diameter than the first mentioned bellows and extending between the flange and the movable base, the pressure-receiving surface of the said other system being constituted by the annular surface of the movable base between the two bellows. This results in a particularly compact construction.

It is not necessary for the said other corrugated tubular bellows to be soldered to the base of the first mentioned corrugated tubular bellows. Instead, the said other corrugated tubular bellows may likewise comprise a movable base and the pressure of the charge in the said other system may be kept lower than in the said one system under normal conditions. This pressure requirement results in the two bases making contact with one another during normal conditions and during sudden cooling. They

need only be separated during sudden heating of the room—a very rare occurrence—with the result that the valve will then for only a short time be regulated in response to the said other sensor.

Advantageously, the charge of both systems consists of the same material (preferably liquid vapour), the said one system being connected to the valve by a thermal conductor bridge having a thermal resistance such that it normally has a somewhat higher temperature than the said other system. As a result of this temperature difference of, say 1°C, it is ensured that the pressure in the said one system element during normal conditions will always be somewhat higher than the pressure in the said other system.

It has proved advantageous for the response time constant of the said other system to be substantially 10% to 30% of that of the said one system. In particular, the response time constant of the said one system may be about 15 minutes and that of the said other system about 3 minutes. As a result, it will be about 10 minutes after a sudden temperature drop before the valve is opened beyond its original position.

A thermostatic actuator and a valve incorporating the actuator both constructed in accordance with the invention will now be described, by way of example only, with reference to the accompanying drawings, wherein:—

Fig. 1 is a longitudinal section of the actuator mounted on a valve housing, and Fig. 2 is a time-displacement graph.

Referring to the accompanying drawings, Fig. 1 shows a regulating valve having a valve housing 1 having an inlet connection 2 and an outlet connection 3.

A pin 4 so engages—it is not secured to—a valve closure member (not shown) which is subjected to an opening spring (not shown) that the spring tends to push the pin 4 to the left as seen in Fig. 1.

Clamped to the valve housing 1 is a thermostatic actuator in the form of an attachment 5. For this purpose the attachment is provided with a carrier 6 having feet 7 that can be clamped about an annular surface 9 of the valve housing by means of a clamping band 8. Supported by the carrier 6 which is of plastics material there is a cup-shaped member 10 carrying an inwardly directed flange 11 at its open end. Two concentric corrugated tubular bellows 12 and 13 are soldered to the flange 11. The corrugated tubular bellows 12 is a one piece member having a movable base 14 and the corrugated tubular bellows 13 is a one piece member with a movable base 15. The base 15 acts on the pin 4 by way of an actuating member in the form of a rod 16. In addition, it supports one end of an

adjustable spring 17, the other end of which is held on a plate 18 having an external screwthread 19. The latter co-operates with the internal screwthread 20 of a sleeve-like knob 21 which is covered at the top by an apertured plate 22. The member 10 together with the outer corrugated tubular bellows 12 bounds a chamber 23 which serves as a first operating element A1 and, since it contains a liquid 24 that can be vaporized, it also serves as a first sensor F1. The element A1 and sensor F1 constitute a first thermally responsive system having a pressure receiving surface formed by the inner surface of the movable base 14. Formed between the corrugated tubular bellows 12 and 13 there is a chamber 25 which serves as a second operating element A2 and is connected by a capillary tube 26 to a second sensor F2 which likewise contains a liquid 27 that can be vaporized. The element A2 and sensor F2 constitute a second thermally responsive system having a pressure receiving surface, as long as the bases 14 and 15 lie on one another, formed by the annular area of the base 14 that is not in contact with the base 15.

Known actuators do not have the system consisting of the second operating element A2 and the second sensor F2 and in their absence the final position of the valve closure member would be reached when equilibrium is obtained between the force of the spring 17 and the vapour pressure in the chamber 23 times the area of the base 14. By turning the sleeve 21, the stress of the spring 17 and thus the desired temperature can be altered. When such a valve (that is to say without elements A2 and sensor F2) has a position x_0 in order to maintain a certain temperature in the room and the sensor is suddenly swept by cold air as a result of airing the room thereby leading to a new position x_1 at which the valve is opened further, one obtains the chain-dotted curve I in Fig. 2 from which it will be evident that at a time t_1 of for example 10 minutes after the time t_0 when the window was opened the valve will already have moved more than 50% of the distance to the new position. By reason of this, the connected heater (for example a radiator) will have been filled with hot water and stored an excessive amount of heat when the window is closed.

In the new construction (that is to say with element A2 and sensor F2 present) an additional force acts in the direction of the spring equal to the vapour pressure in the sensor F2 times the annular area of the second operating element A2. The second sensor F2 has a much smaller mass than the first sensor F1. Consequently it has a correspondingly lower response time constant. During a sudden temperature drop,

its vapour pressure is rapidly reduced. This relief results in a closure movement of the valve. The movement will be reversed only when the first sensor is cooled further. Only at the time t_1 will the original position x_0 of the of the closure member be reached again. Only thereafter will there be further opening corresponding to the curve II shown in full lines in Fig. 2. This shows that on airing the room there will be no increase in the opening cross-section of the valve at all up to a time t_1 , i.e. the heater cannot be filled with hot water in an uncontrolled manner. On the contrary, the flow of heating medium is more intensively throttled. Only when the cold spell lasts for a longer period and is obviously not accounted for by airing of the room will the valve be set to the appropriate slow cross-section.

The vaporizable liquids in both sensors consist of the same medium. The carrier 6 forms a thermal bridge between the valve housing 1 and the first sensor F1. By means of an appropriate construction and choice of material, it should have a thermal resistance such that the temperature of the sensor F1 is slightly higher than that of the sensor F2 during normal conditions. A temperature difference of about 1°C is sufficient to keep the vapour pressure in the operating element A1 larger than in the operating element A2 with the result that the two bases 14 and 15 lie on top of one another. This abutting relationship is maintained even when the pressure in the operating element A2 drops further during cooling.

To obtain the desired different response time constants it is not only material that considerably larger masses have to be heated for the first sensor F1 than for the second sensor F2 but also the fact that the first sensor is partially surrounded by thermal insulation that is here formed by parts of the sleeve 21. It is only through the hole 28 in the aperture plate 22 and through slots 29 in the sleeve that convection flow can pass unhindered to the surface of the member 10.

In one example, the base 14 had an area of 10 cm^2 and the base 15 an area of 6 cm^2 . The position x_0 corresponds to a pressure of 2.1 kg/cm^2 in the operating element A1 and a pressure of 2.0 kg/cm^2 in the operating element A2 as well as a load of 13 kg by the desired value spring. Upon a temperature drop, the pressure in the second sensor is reduced to 1.8 kg/cm^2 to give rise to further compression of the spring to 13.8 kg and thus further closure of the valve. Only after the pressure in the first operating element A1 has also dropped to 1.9 kg/cm^2 will the final condition x_1 be obtained at which the spring was able to expand to 11.8 kg.

In this case the first sensor had a response time constant of 15 minutes and the second sensor a response time constant of 3 minutes. This results in a time lag ($t_1 - t_0$) of about 10 minutes.

WHAT WE CLAIM IS:

1. A thermostatic actuator for a heat exchanger temperature regulating valve, the actuator comprising a movable actuating member which is controlled by two thermally responsive systems each having a respective charge which expands when heated and a respective pressure-receiving surface, wherein the movable member is urged in one direction by the pressure of the charge of one of the systems acting against its pressure-receiving surface and the movable member is urged in the opposite direction by the pressure of the charge of the other system acting against its pressure-receiving surface together with the force of a spring, the pressure-receiving surface of the said one system having a greater area than that of the pressure-receiving surface of the said other system, and the said other system having a lower response time constant than the said one system.

2. An actuator as claimed in claim 1, in which the said one system is constituted by a chamber defined, in part, by the pressure-receiving surface of that system and the said other system is constituted by a chamber defined, in part, by the pressure-receiving surface of that system and a sensor bulb connected to the chamber by a capillary tube.

3. An actuator as claimed in claim 1 or claim 2, in which the said one system is at least partly thermally insulated.

4. An actuator as claimed in any one of claims 1 to 3, in which the said one system comprises a chamber defined by a cup-shaped member, the rim of which has an inwardly directed flange, and a corrugated tubular bellows which has a movable base at one end and adjoins the flange at the other end, the internal surface of the movable base constituting the pressure-receiving surface of the said one system, and in which the said other system comprises a chamber which is defined between the said bellows and another corrugated tubular bellows, the

other bellows being of smaller diameter than the first mentioned bellows and extending between the flange and the movable base, the pressure-receiving surface of the said other system being constituted by the annular surface of the movable base between the two bellows.

5. An actuator as claimed in claim 4, in which the said other corrugated tubular bellows comprises a movable base and the pressure of the charge in the said other system is kept lower than that in the said one system under normal conditions.

6. An actuator as claimed in claim 5, in which the charge of both systems consists of the same material and in which the said one system is connected to the valve by a thermal conductor bridge having a thermal resistance such that it normally has a somewhat higher temperature than the said other system.

7. An actuator as claimed in any one of claims 1 to 6, in which the response time constant of the said other system is substantially 10% to 30% of that of the said one system.

8. An actuator as claimed in claim 7, in which the response time constant of the said one system is substantially 15 minutes and that of the said other system substantially 3 minutes.

9. An actuator as claimed in any one of claims 1 to 8, in which the said one system has a liquid-vapour charge.

10. An actuator as claimed in any one of claims 1 to 9, in which the said other system has a liquid-vapour charge.

11. A thermostatic actuator substantially as hereinbefore described with reference to and as illustrated by the accompanying drawings.

12. A valve incorporating an actuator as claimed in any one of claims 1 to 11.

13. A valve substantially as hereinbefore described with reference to and as illustrated by the accompanying drawings.

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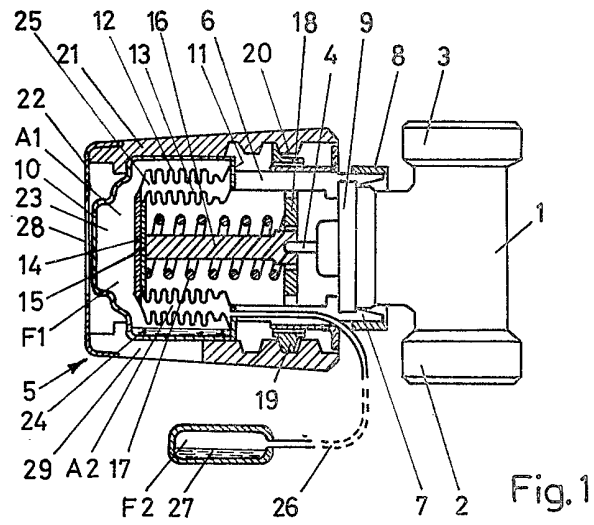


Fig. 1

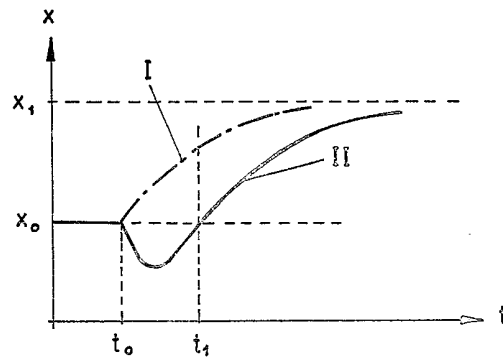


Fig. 2