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## Plumbing component


### Abstract

A plumbing component includes a cold water inlet; a hot water inlet; an outlet configured to output cold water, hot water, or a mixture thereof; a flow shut-off mechanism for restricting the flow of water out of the outlet; a first flow control valve for controlling the flow of cold water; and a second flow control valve for controlling the flow of hot water. Each of the flow control valves comprises a valve member and an associated valve seat, each valve member arranged to engage with the associated valve seat to control the flow of water through the flow control valves to the water outlet. One or both of the valve members includes a graduated flow control bead arranged to seal against the associated valve seat to provide a graduated flow transition between a maximum flow state and a minimum flow state of the, or each, control valve.



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## Background/Summary

CROSS-REFERENCE TO RELATED PATENT APPLICATIONS (1) The present application is a Continuation of U.S. patent application Ser. No. 16/867,232, filed May 5, 2020, which claims priority to International Application No. PCT/GB2018/053122, filed Oct. 29, 2018, which claims the benefit of and priority to United Kingdom Priority Application No. 1718562.0, filed Nov. 9, 2017. The entire disclosures of each of the foregoing applications are incorporated by reference herein.

BACKGROUND
(1) This application relates to a plumbing component. The plumbing component may be for controlling the mixture of two supplies of water having different temperatures. The plumbing component may, for example, be used in plumbing fixtures, fittings and water supply systems and installations for washing, showering, bathing and the like employing such plumbing fixtures and fittings.
(2) An example of a prior art plumbing component that can be used to control the mixture of hot and cold water supplies is disclosed in International Patent Application No. PCT/IB2013/001646 (WO2013/190381).
(3) PCT/IB2013/001646 discloses a mixing valve for use in controlling the mixture of two supplies of water having different temperatures, the mixing valve including a cold water inlet configured to receive a supply of cold water; a hot water inlet configured to receive a supply of hot water; an outlet configured to output cold water or hot water or a mixture thereof from the mixing valve; a first flow control valve for controlling the flow of cold water from the cold water inlet to the water outlet; and a second flow control valve for controlling the flow of hot water from the hot water inlet to the water outlet. Each of the first and second flow control valves include a valve inlet communicating with the associated water inlet, first and second valve outlets communicating with the water outlet, and a valve member assembly to control the flow of water through the first and second valve outlets. Each valve member assembly includes a first valve member configured to engage with a first valve seat associated with the first valve outlet in a closed position of the flow control valve and a second valve member configured to engage with a second, separate, valve seat associated with the second valve outlet in the closed position of the flow control valve. The valve members carry an elastomeric seal that engages with the valve seats to seal the valve outlets

preventing flow of water in the closed position. The elastomeric seal is provided by an O-ring carried by each valve member.

## SUMMARY

(4) In one aspect, the present application provides: a plumbing component for controlling the mixture of two supplies of water having different temperatures, the plumbing component comprising any one or more of: a cold water inlet configured to receive a supply of cold water; a hot water inlet configured to receive a supply of hot water; an outlet configured to output cold water or hot water or a mixture thereof; a flow shut-off mechanism operable to restrict the flow of water out of the outlet; a first flow control valve for controlling the flow of cold water from the cold water inlet to the outlet; and a second flow control valve for controlling the flow of hot water from the hot water inlet to the outlet, each of the flow control valves comprising a valve member and an associated valve seat, each valve member arranged to engage with the associated valve seat to control the flow of water through the flow control valves to the water outlet, and wherein: one or both of the valve members comprises a graduated flow control bead arranged to seal against the associated valve seat to provide a graduated flow transition between a maximum flow state and a minimum flow state of the, or each, control valve.

(5) The plumbing component advantageously provides a combination of a flow shut-off mechanism and a graduated flow control bead. This may provide both a smooth graduated transition of water flow through the flow control valves between a maximum and minimum flow rate and a secure flow shut-off to prevent residual water flow from the outlet. For example, the minimum flow rate may still allow a small amount of water to flow through the flow control valves. This may be prevented from flowing out of the outlet by the shut-off mechanism.

(6) Optionally, the graduated flow control bead or beads may each comprise a sealing surface which is arranged to seal against a corresponding sealing surface of the associated valve seat, wherein the flow rate through the respective flow control valve is determined by the extent of the contact between the sealing surface of the graduated flow control bead and the associated valve seat. This may allow graduated control of the flow during movement of the valve member relative to the valve seat and give finer adjustment resolution of the flow rate.

(7) Optionally, the, or each, graduated flow control bead is arranged to move relative to the associated valve seat, and wherein the movement may be between any of the following positions: i) a minimum seal position in which there is no sealing contact between the, or each, graduated flow control bead and the associated valve seat; ii) a first partial seal position in which part of the sealing surface of the, or each, graduated flow control bead is in sealing contact with the valve seat; iii) a second partial seal position in which part of the sealing surface of the, or each, graduated flow control bead is in sealing contact with the associated valve seat, wherein in the second partial seal position a greater extent of the sealing surface of the graduated flow control bead is in sealing contact with the associated valve seat in comparison to the first partial seal position; and iv) a maximum seal position in which a maximum extent of the sealing surface of the, or each, graduated flow control bead is in sealing contact with the associated valve seat.

(8) This may provide improved control of the flow graduation compared to a valve member which does not provide partial seal positions.

(9) Optionally, one or both of the shape and configuration of the graduated flow control bead compared to the shape and configuration of the associated valve seat may provide the graduated flow transition. This may allow the sealing contact between the valve member and valve seat to provide a graduated flow transition.

(10) Optionally, the valve member has a longitudinal axis, and wherein the longitudinal axis is arranged parallel to a first direction in which the graduated control bead is arranged to move relative to the valve seat.

(11) Optionally, the, or each, graduated flow control bead may not be a planar bead that extends only in a plane normal to the longitudinal axis. By forming the graduated flow control bead from a

shape which is not a planar bead a more graduated flow transition may be provided.
(12) Optionally, at least part of a sealing surface of the, or each, graduated flow control bead may be shaped so that it is inclined relative to a plane normal to the longitudinal axis. This means that an increasing or decreasing sealing area between the graduated flow control bead and the valve seat may be provided as they move towards or away from each other.
(13) Optionally, the, or each, graduated flow control bead may have a shape that extends between a first extent and a second extent along the length of the valve member, the distance between the first and second extent being greater than a thickness of the graduated flow control bead, and optionally wherein the distance is 2 to 6 times greater. This means that the graduated flow control bead may have an elongate shape which at least partly extends in a direction along the length of the valve member. This may allow a suitable sealing contact between them to provide a graduated flow transition.
(14) Optionally, the, or each, graduated flow control bead may be shaped to follow a path having three or more turning points around the valve member. This may provide a varying sealing contact with the associated valve seat to provide an improved graduated flow transition.
(15) Optionally, the, or each, graduated flow control bead follows an undulating or zigzag path extending along a surface of the respective valve member, and preferably wherein the path is a sinusoidal path.
(16) Optionally, a movement of between 0 mm and 9 mm of the, or each, graduated flow control bead relative to the associated valve seat may cause a change in flow rate between the minimum flow state and the maximum flow state. This may provide an improved resolution of flow rate change for a corresponding distance moved by the valve member. In other words, a larger movement of the valve member may provide the same change in flow rate compared to a non-graduated flow control bead.
(17) Optionally, the thickness of the, or each, graduated flow control bead is between 0.5 mm and 1.5 mm. This may provide a suitable graduated flow transition.
(18) Optionally, the flow shut-off mechanism may be formed by a flow shut-off bead forming part of each valve member, wherein each flow shut-off bead may be arranged to contact the valve seat to provide a transition between an open and a closed state of each control valve. This may allow each valve member to provide both a graduated flow transition and a final flow shut-off transition to stop any residual flow.
(19) Optionally, each flow shut-off bead may be a planar bead that extends only in a plane normal to the longitudinal axis. This may provide a secure final flow shut-off, compared to the graduated flow transition provided by the graduated flow control bead.
(20) Optionally, the flow shut-off mechanism may comprise an electronic shut-off mechanism, such as a solenoid, that is movable between a shut-off position in which the flow of water out of the outlet is restricted and an open position in which flow of water out of the outlet is unrestricted. This may provide a suitable secure flow final shut-off to remove any residual flow remaining when the graduated flow control bead(s) are in a maximum seal position.
(21) Optionally, the water flows through the plumbing component along a water flow path, and wherein the electronic shut-off mechanism may be provided at a point along the water flow path between each of the control valves and an aperture forming the outlet. This may allow the flow shut-off mechanism to stop any residual flow allowed by the flow control valves.
(22) Optionally, the outlet is one of a plurality of outlets, each outlet being arranged to receive water from the first and/or second control valves, and wherein the flow shut-off mechanism may comprise a plurality of solenoids arranged to independently control the flow of water through each of the plurality of outlets. This may allow the plumbing component to supply water to a number of different outlets of a plumbing assembly or system. It may, for example, supply more than one shower head of a shower system.
(23) Optionally, the plumbing component may further comprise a controller configured to control

any one or more of the first control valve, the second control valve or the flow shut-off mechanism in response to at least one of the water temperature or flow rate. This may allow the temperature and/or the flow rate of water exiting the outlet to be adjusted.
(24) Optionally, the controller may be configured to receive temperature or flow rate information from a sensor or sensors, the sensor being arranged to monitor at least one of the temperature or the flow rate of water flowing from the outlet. This may allow the temperature and flow rate to be adjusted to reach target valves which may, for example, be set by the user.
(25) Optionally, the sensor may be arranged to monitor the temperature and/or the flow rate of water flowing along a flow path through the plumbing component between each of the control valves and the outlet. This may allow the temperature and/or flow rate to be monitored once the water has left the flow control valves.
(26) Optionally, the plumbing component may comprise a housing that houses the flow shut-off mechanism and the first and second control valves and includes apertures that form the cold water inlet, the hot water inlet and the outlet or outlets.
(27) Optionally, the housing may be formed from a polymer material. This may make the plumbing component suitable for domestic use as it may be more efficiently produced.
(28) Optionally, each valve member may be mounted on a shaft and the, or each, graduated flow control bead may comprise a sleeve around an outer surface of the valve member. Optionally the sleeve may comprise an elastomeric material. This may provide an efficient way of coupling the valve member and graduated flow control bead and provide a suitable seal with the valve seat.
(29) Optionally, the plumbing component may further comprise a cold water outlet and a hot water outlet, wherein: the cold water inlet is fluidly coupled to both an inlet of the first flow control valve and the cold water outlet; and the hot water inlet is fluidly coupled to both an inlet of the second flow control valve and the hot water outlet, wherein the hot and cold water outlets are adapted to be connectable to the hot and cold water inlets of another plumbing component. This may allow a number of plumbing components to be connected in series with one another. This may reduce the amount of water pipes required to connect the plumbing components to a supply of hot and cold water compared to if they were connected in parallel.
(30) In an second aspect, the present application provides a plumbing assembly comprising a first plumbing component according to the first aspect (or the third aspect below) and a second plumbing component according to first aspect (or the third aspect below), wherein: the cold water outlet of the first plumbing component is fluidly coupled to the cold water inlet of the second plumbing component; and the hot water outlet of the first plumbing component is fluidly coupled to the hot water inlet of the second plumbing component. This may allow the plumbing components to be connected in series or stacked together.
(31) Optionally, the plumbing assembly may further comprise a controller arranged to control the flow control valves of the first and second plumbing components such that the temperature of water flowing from the outlet of the first plumbing component is different from that of the second plumbing component. This may allow the temperature and/or flow rate of water provided by the first plumbing component and the second plumbing component to be independently controlled.
(32) In a third aspect, the present application provides a plumbing component for controlling the mixture of two supplies of water having different temperatures, the plumbing component comprising: a cold water inlet configured to receive a supply of cold water; a hot water inlet configured to receive a supply of hot water; an outlet configured to output cold water or hot water or a mixture thereof; a flow shut-off mechanism operable to restrict the flow of water out of the outlet; a first flow control valve for controlling the flow of cold water from the cold water inlet to the outlet; and a second flow control valve for controlling the flow of hot water from the hot water inlet to the outlet, each of the flow control valves comprising a valve member and an associated valve seat, each valve member arranged to engage with the associated valve seat to control the flow of water through the flow control valves to the water outlet, and wherein: the plumbing component

further comprises a graduated flow control mechanism arranged to provide a graduated flow transition between a maximum flow state and a minimum flow state of the, or each, control valve.
(33) Optionally, the graduated flow control mechanism may comprise one or more sealing surfaces which are arranged to seal against a corresponding sealing surface of the associated valve seat or valve member, wherein the flow rate through the respective flow control valve is determined by the extent of the contact between the sealing surface or surfaces and the associated valve seat or valve member.
(34) Optionally, the, or each, valve member is arranged to move relative to the associated valve seat, and wherein the movement is between any of the following positions: i) a minimum seal position in which there is no sealing contact between the, or each, sealing surface and the associated valve seat or valve member; ii) a first partial seal position in which part of the or each sealing surface is in sealing contact with the associated valve seat or valve member; iii) a second partial seal position in which part of the or each sealing surface is in sealing contact with the associated valve seat or valve member, wherein in the second partial seal position a greater extent of the sealing surface is in sealing contact with the associated valve seat or valve member in comparison to the first partial seal position; and iv) a maximum seal position in which a maximum extent of the or each sealing surface is in sealing contact with the associated valve seat or valve member.
(35) Optionally, one or both of the shape and configuration of the sealing surface formed by the graduated flow control mechanism compared to the shape and configuration of the associated valve seat or valve member provides the graduated flow transition.
(36) Optionally, the graduated flow control mechanism may be formed by one or both of the valve members comprising a graduated flow control bead arranged to seal against the associated valve seat to provide a graduated flow transition between a maximum flow state and a minimum flow state of the, or each, control valve.
(37) Optionally, the graduated flow control mechanism may be additionally or alternatively formed by a graduated flow control portion of the valve seat, the graduated flow control portion being shaped to provide a graduated flow transition between the maximum flow state and the minimum flow state of the, or each, control valve.
(38) Optionally, the graduated flow control portion of the valve seat may comprise a tapered portion of a bore forming the valve seat.
(39) Any of the features described in relation to the first or second aspect may be used in combination with the third aspect.

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## Description

BRIEF DESCRIPTION OF THE DRAWINGS
(1) Embodiments of the invention will now be described, by way of example only, with reference to the accompanying drawings, in which:
(2) FIG. **1** shows a perspective view of a mixer valve used in a plumbing component according to an embodiment;
(3) FIG. **2** shows a cross section through the mixer valve shown in FIG. **1**;
(4) FIGS. **3***a* to **3***d* show a schematic view of a valve member and valve seat of the plumbing component according to an embodiment;
(5) FIG. **4** shows a close up view of a graduated flow control bead of the plumbing component according to an embodiment;
(6) FIG. **5***a* shows a side view of part of a plumbing component according to an embodiment comprising two graduated flow control beads;
(7) FIG. **5***b* shows a cross section view corresponding to FIG. **5***a;*

(8) FIG. **6** shows a side view of a plumbing component according to an embodiment;
(9) FIG. **7***a* shows a perspective view of a mixer valve used in a plumbing component according to an embodiment;
(10) FIG. **7***b* shows a side view of the mixer valve shown in FIG. **7***a;*
(11) FIG. **7***c* shows a cross section through the mixer valve shown in FIG. **7***b;*
(12) FIGS. **8***a* to **8***d* show a schematic view of a valve member and valve seat having a flow shut-off bead according to an embodiment;
(13) FIG. **9***a* shows a side view of part of a plumbing component according to an embodiment showing two graduated flow control beads and two flow shut-off beads;
(14) FIG. **9***b* shows a cross section view corresponding to FIG. **9***a;*
(15) FIG. **10***a* shows a plot of the flow rate against relative valve member position for a plumbing component according to an embodiment; and
(16) FIG. **10***b* shows a plot of the flow rate against relative valve member position for a plumbing component according to another embodiment.

DETAILED DESCRIPTION

(17) According to one embodiment, a plumbing component for controlling the mixture of two supplies of water having different temperatures (e.g. hot and cold water supplies) is disclosed. The plumbing component may output water having a desired temperature for use and may also control the output flow rate.
(18) The plumbing component may be incorporated into a plumbing fixture or fitting for washing, showering, bathing or the like and water supply systems and installations employing such plumbing fixtures and fittings. For example, the plumbing component may be incorporated in a tap (or faucet) for a basin, sink, shower bath or the like. The plumbing component may be incorporated in a water supply system or installation having one or more outlets for washing, showering, bathing or the like. Each outlet may include a tap (or faucet) incorporating the plumbing component. Alternatively, the plumbing component may be incorporated in a fitting supplying more than one outlet. For example, multiple shower heads may be supplied with water from one plumbing component as will be described in further detail later.
(19) The plumbing component according to one embodiment generally comprises a cold water inlet configured to receive a supply of cold water; a hot water inlet configured to receive a supply of hot water; and an outlet configured to output cold water or hot water or a mixture thereof.
(20) The plumbing component comprises a first flow control valve for controlling the flow of cold water from the cold water inlet to the outlet and a second flow control valve for controlling the flow of hot water from the hot water inlet to the outlet. The first and second control valves may therefore form a mixer (or mixing) valve to control the temperature and rate of flow of water flowing from the outlet.
(21) Each of the flow control valves may comprise a valve member and an associated valve seat. Each valve member may be arranged to engage with the associated valve seat to control the flow of water through the flow control valves to the water outlet.
(22) The plumbing component further comprises a flow shut-off mechanism operable to restrict the flow of water out of the outlet. The flow shut-off mechanism may provide a transition between an open and closed state. In the closed state the flow of water through the flow shut-off mechanism may be zero or approximately zero. It may therefore provide a secure shut-off of the water supply from the outlet to prevent undesired residual water flow (e.g. it may reduce dripping of a shower or tap being supplied by the plumbing component).
(23) One or both of the valve members comprises a graduated flow control bead arranged to seal against the associated valve seat to provide a graduated flow transition between a maximum flow state and a minimum flow state of the, or each, control valve. By a graduated flow transition we may mean a smooth or gradual transition from there being a maximum level of flow to minimum level of flow. In some embodiments, the minimum level of flow may be a small or residual flow of

water e.g. a drip. In yet other embodiments, the minimum level of flow may be zero or approximately zero. In some embodiments, the maximum flow level may correspond to the valve being open with no restriction of the water flow. The graduated flow transition is in contrast to a sharp or immediate transition between the valve allowing a maximum level of flow and a minimum level of flow.

(24) The plumbing component may advantageously provide both a graduated flow transition and a separate flow shut-off. The graduated control of the rate of flow of hot and cold water out of the outlet allows the temperature and flow rate of output water to be accurately and smoothly controlled between maximum and minimum flow rates. The flow shut-off mechanism provides a separate secure shut-off that may not otherwise be provided by the graduated flow control bead(s) even when the flow rate is at the minimum. This may reduce any residual flow that may be allowed by the graduated flow control bead(s) and may reduce undesired dripping of a tap or shower being supplied by the plumbing component.

(25) A mixer valve suitable for use in the plumbing component is shown in more detail in FIGS. **1** and **2**. In some embodiments, the mixer valve may be as described in International patent application no PCT/IB2013/001646 (which is hereby incorporated by reference), but adapted to include a graduated flow control bead. FIG. **1** shows a mixer valve **1** enclosed within a valve housing **2**. An aperture **3** in the housing **2** forms a first fluid inlet **4** for receiving a first fluid (cold water in this embodiment). Similarly, as shown in the cross section view of FIG. **2**, the housing **2** includes a further aperture **5** that forms a second fluid inlet **6** for receiving a second fluid (hot water in this embodiment) and a still further aperture **7** that forms a fluid outlet **8** for outputting the first fluid or the second fluid or a mixture thereof.

(26) In the described embodiment, the mixer valve **1** comprises a first flow control valve **9** and a second flow control valve **10** located within a mixing chamber **11**. The first flow control valve **9** controls the flow of fluid from the first fluid inlet **4** to the mixing chamber **11**. The second flow control valve **10** controls the flow of fluid from the second fluid inlet **6** to the mixing chamber **11**. The mixing chamber **11** provides a volume in which the first and second fluids can mix and directs the mixed fluid to the fluid outlet **8**.

(27) The first and second flow control valves **9**, **10** may be similar and are arranged side by side in parallel and on opposite sides of the mixing chamber **11**. There follows a description of the construction and operation of the first flow control valve **9** and the same reference numerals have been used but with an additional apostrophe to identify similar features of the second flow control valve **10** such that the construction and operation of the second flow control valve **10** will be apparent and understood from the description of the first flow control valve **9**.

(28) The first flow control valve **9** comprises a valve member assembly **12**, a valve inlet chamber **13** and first and second valve outlets **14***a* and **14***b*. The inlet chamber **13** is substantially cylindrical in the described embodiment, but may be other suitable shape in other embodiments, and may be square or oval for example. The first fluid inlet **4** opens into the inlet chamber **13** through the side wall of the inlet chamber **13** (the second inlet **6** opens into the valve inlet chamber **13′** of the second flow control valve **10** through the side wall of the inlet chamber **13′**).

(29) The first valve outlet **14***a* is arranged at one end of the inlet chamber **13** and the second valve outlet **14***b* is arranged at an opposed end of the inlet chamber **13**. Each of the valve outlets **14***a* and **14***b* comprises a through bore with a cylindrical centre section **15** of reduced diameter relative to the end sections **16**, **17**. The bore is tapered between the centre section **15** and the end sections **16**, **17**. The valve outlets **14***a* and **14***b* are axially aligned and in this embodiment the centre sections **15** of the outlets **14***a* and **14***b* are coaxial and have the same diameter. The valve member assembly **12** controls the flow of water through the first flow control valve **9** from the inlet chamber **13** to the mixing chamber **11**. In the described embodiment, the centre section **15** and end sections **16**, **17** are circular in cross section. This is however only one such example, in other embodiments these components may have any other suitable cross section and may be square or oval, for example.

(30) The valve member assembly **12** comprises a first valve member **18***a* adapted to cooperate with the first valve outlet **14***a* and a second valve member **18***b* adapted to cooperate with the second valve outlet **14***b* to control flow of water from the inlet chamber **13** to the mixing chamber **11**. The first and second valve members **18***a*, **18***b* are fixedly mounted on a shaft **19** such that they are held a predetermined distance apart. The predetermined distance corresponds to the distance between the first and second valve outlets **14***a*, **14***b*.

(31) A first end of the shaft **19** is received within a blind guide bore **21** formed in the housing **2**. A second, opposed end of the shaft **19** extends through an opening in the housing **2** and is connected to an actuator **22**. The actuator **22** is connected to the housing **2**. The actuator **22** is adapted to control the linear position of the shaft **19** and thus the position of the first and second valve members **18***a*, **18***b* with respect to the valve outlets **14***a*, **14***b*.

(32) The actuator **22** may comprise a stepper motor arranged to move the shaft **19** linearly in an axial direction. Any suitable actuator for controlling linear motion of the shaft may be employed in place of the stepper motor including, but not limited to, linear actuators. The actuator **22** is connected to the shaft **19** by a shaft connector portion **23** coupled to the second end of the shaft **19** that extends through an opening in the housing **2**. An elastomeric seal **24** engages the second end of the shaft **19** within the opening to prevent leakage of water from the mixing chamber **11**. The seal **24** could be an O-ring located in a groove in the housing **2**.

(33) The first fluid inlet **4** opens to the inlet chamber **13** between the first and second valve outlets **14***a*, **14***b*. When opening the first flow control valve from a closed position, the force exerted by the water acts to resist opening movement of the first valve member **18***a* and to assist opening movement of the second valve member **18***b*. When closing the first flow control valve from an open position, the force exerted by the water acts to resist closing movement of the second valve member **18***b* and to assist closing movement of the first valve member **18***a*.

(34) In the described embodiment, the valve outlets **14***a*, **14***b* are arranged to present substantially the same area to the water flow and arranging the valve members **18***a*, **18***b* so that water acts on the valve members **18***a*, **18***b* in opposite directions and with substantially the same force, the valve member assembly **12** of the first flow control valve **9** is essentially balanced. As a result, there is substantially no net force on the valve member assembly **12** due to force exerted by the water pressure when opening and closing the first flow control valve **9**. In other embodiments, the valve outlets **14***a*, **14***b* may be of different cross sectional shapes or have different cross sectional areas to each other. In such embodiments, the forces may not therefore be balanced.

(35) Each of the valve members **18***a*, **18***b* comprises a graduated flow control bead **20***a*, **20***b* arranged to seal against the associated valve seat formed by the centre section **15** of the first and second valve outlets **14***a*, **14***b* to seal the valve outlets **14***a*, **14***b* controlling flow of water from the inlet chamber **13** to the mixing chamber **11**. Each of the valve members **18***a*, **18***b* is movable relative to the associated valve seat to provide a transition between a maximum flow state and a minimum flow state of the respective flow control valve.

(36) The engagement between one of the graduated flow control beads and the valve seat is shown in FIGS. **3***a* to **3***d*. In this embodiment, a flow control valve **200** is shown schematically, with some components shown in FIG. **2** omitted for ease of explanation. The flow control valve **200** comprises a valve member **202** that engages with a corresponding valve seat **204**. The valve member **202** comprises a graduated flow control bead **206** which is arranged to sealably couple to the valve seat **204**.

(37) The graduated flow control bead **206** comprises a sealing surface which is arranged to seal against a corresponding sealing surface of the valve seat **204**. The flow rate of fluid through the flow control valve may be determined by the extent of the contact between the sealing surface of the graduated flow control bead **206** and the valve seat **204**. For example, an increase in the extent of the sealing surface in sealing contact with the valve seat **204** may cause a corresponding reduction in the flow of water through the flow control valve **200**. A decrease in the extent of the

sealing surface in sealing contact with the valve seat **204** may cause a corresponding increase in the flow of water through the flow control valve **200**.

(38) The flow control bead **206** is shown in a minimum seal position in FIG. **3***a*, a first partial seal position in FIG. **3***b*, a second partial seal position in FIG. **3***c* and a maximum seal position in FIG. **3***d*.

(39) In the minimum seal position of FIG. **3***a*, there is no sealing contact between the graduated flow control bead **206** and the valve seat **204** (i.e. the minimum seal position is therefore an unsealed position). The flow of fluid through the valve **200** is therefore not restricted and the flow control valve **200** is in a maximum flow state. In the case of the embodiment shown in FIG. **2**, the maximum flow state of the first flow control valve **9** is provided when the first valve member **18***a* is located within the inlet chamber **13** upstream of the associated valve outlet **14***a* and the second valve member **18***b* is located outside the inlet chamber **13** downstream of the associated valve seat **18***b* in the mixing chamber waterway.

(40) In the first partial seal position of FIG. **3***b* part of (but not a maximum amount, or all of) the sealing surface of the graduated flow control bead **206** is in sealing contact with the valve seat **204**. The flow of fluid through the valve is therefore partly restricted as not all of the extent of the sealing surface engagement required to provide the maximum seal position is present. The rate of flow is therefore reduced compared to the minimum seal position, but not reduced to the level of the maximum seal position. In the case of the embodiment shown in FIG. **2**, the first (and second) partial seal positions correspond to where the first valve member **18***a* is partially received within the associated valve outlet **14***a* (e.g. as shown in FIG. **2**) and the second valve member **18***b* is partially received within the associated valve seat **18***b* in the mixing chamber waterway.

(41) In the second partial seal position of FIG. **3***c* part (but not a maximum amount or all of) of the sealing surface of the graduated flow control bead **206** is again in contact with the valve seat **204**. In the second partial seal position, a greater extent or amount of the sealing surface of the graduated flow control bead **206** is in sealing contact with the valve seat **204** in comparison to the first partial seal position. This results in a reduced flow of fluid through the flow control valve **200** compared to the first partial seal position. The flow of fluid is however not reduced to the flow rate of the minimum flow rate of the maximum seal position.

(42) In the maximum seal position of FIG. **3***d*, a maximum extent of the sealing surface of the graduated flow control bead **206** is in sealing contact with the valve seat **204**. This may be the extent of the sealing surface required to reduce the flow through the flow control valve to a minimum. In this position, flow of fluid through the flow control valve may be restricted so that there is a minimum flow (or no flow of fluid and the valve is in a closed state). In the embodiment of FIG. **2**, the maximum seal position corresponds to a position where the first and second valve members **18***a*, **18***b* are completely received in the centre sections **15** of the first and second valve outlets **14***a*, **14***b* and the graduated flow control bead **20***a*, **20***b* engages the valve seats provided by the centre section **15** of the first and second valve outlets **14***a*, **14***b* to seal the valve outlets **14***a*, **14***b* preventing flow of water from the inlet chamber **13** to the mixing chamber **11**.

(43) Movement from the maximum seal position to the minimum seal position via the first and second partial seal positions therefore provides a graduated transition between a maximum and minimum flow state of the flow control valve **200**. The reverse movement also provides a graduated transition between a minimum and a maximum flow state.

(44) As can be seen in FIGS. **3***a*-**3***d*, the relative shape and/or configuration between the flow control bead **206** and the associated valve seat **204** provides the graduated flow transition. The relative shape and/or configuration allows for varying amounts of the flow control bead **206** to come into sealing contact during its motion relative to (and in contact with) the valve seat **204**. This allows a varying sized aperture to be formed between the valve member **202** and valve seat **204** as they move relative to each other that allows a smoothly varying or graduated flow transition.

(45) FIGS. **3***a*-**3***d* show one embodiment of a graduated flow control bead **206** that provides a

graduated flow transition. In this embodiment, the valve member **202** has a longitudinal axis (labelled A in the Figures). The longitudinal axis is arranged parallel to a first direction in which the valve member **202** (and so also the graduated control bead **206**) is arranged to move relative to the valve seat **204**. In the described embodiment, the longitudinal axis A corresponds to a central axis of the valve seat **204**. In this embodiment, the valve seat **204**, the valve member **202** and the graduated flow control bead **206** are therefore all arranged concentrically to each other. This is however only one such example, and other configurations of the valve seat **204** and valve member **202** may be provided where only some of these components are concentrically aligned.

(46) In the described embodiment, the valve member **202** is received within the valve seat **204** to provide a sealing contact between them. The valve seat **204** is therefore formed by a sealing surface on the internal wall of a hole or aperture in the body of the plumbing component. The valve member **202** may have a corresponding outer surface along the length of the valve member **202** (the length being along an axis corresponding to the direction of movement of the valve member **202** relative to the valve seat **204**). The outer surface of the valve member **202** may have a corresponding shape such that it can be received in the aperture forming the valve seat **204**. In the described embodiment, both of the aperture forming the valve seat **204** and the valve member **202** are circular in cross section. In other embodiments, they may have any other cross section such as square or oval. The graduated flow control bead **206** is provided on the outside surface of the valve member **202** such that it may sealably couple to the inside surface of the valve seat **204**. As can be seen in the Figures, the flow control bead **206** may protrude radially from a sidewall of the valve member **202** and so may contact the inside sealing surface of the valve seat **204** when they move relative to each other. In the minimum seal position, the valve member is not received within the aperture formed by the sealing surface of the valve seat, in the partial seal positions the valve member is partly received within the aperture formed by the sealing surface of the valve seat and in the maximum seal position the valve member is completely received within the aperture formed by the sealing surface of the valve member.

(47) Further detail of the graduated flow control bead **206** is shown in the close up view of FIG. **4**. In the described embodiment, at least part of a sealing surface of the graduated flow control bead **206** is shaped so that it is inclined relative to a plane normal to the longitudinal axis A. This means that an increasing amount of the graduated flow control bead **206** will come into sealing contact with the valve seat **204** as they move relative to each other along the first direction.

(48) The graduated flow control bead **206** may be shaped such that it extends between a first extent (labelled “X” in FIG. **4**) and a second extent (labelled “Y” in FIG. **4**) along the length of the valve member **202** (the length being parallel to the axis A). In such an embodiment, the distance between the first extent X and second extent Y is greater than the thickness (labelled “t” in FIG. **4**) of the graduated flow control bead **206** itself. This means that the graduated flow control bead **206** has a generally elongate shape and is configured such that it extends in a direction having a component along the length of the valve member **202**. The distance between the first extent X and the second extent Y may determine the inclination of the sealing surface relative to the valve seat **204**. In some embodiments, the distance between the first extent X and the second extent Y may be multiple times greater than the thickness, e.g. may be 2 to 6 times greater that the thickness of the flow control bead **206**, and preferably may be approximately 3 times greater.

(49) In the described embodiment, the graduated flow control bead **206** is shaped to follow a path on the outer surface of the valve member, wherein the path may have three or more turning points around the valve member **202**. Four such turning points can be seen in the view shown in FIG. **4**. In one embodiment, the graduated flow control bead **206** may have only two turning points along the length of the valve member **202**. In such an embodiment, the flow control bead **206** forms an elliptical shape around the valve member **202**.

(50) In the described embodiment, the graduated flow control bead **206** follows an undulating or zigzag path along the surface of the respective valve member. The shape of the graduated flow

control bead is therefore formed by a plurality of periodic oscillations. The amplitude of the oscillations may determine the inclination of the sealing surface relative to the valve seat **204** and thus determine the graduation of the flow transition. In some embodiments, the graduated flow control bead may follow a sinusoidal path along the surface of the valve member.
(51) In some embodiments, the graduated flow control bead **206** is provided as a separate component which is attached to the surface of the valve member **204**. In other embodiments, the graduated flow control bead **206** may be formed by a resilient portion over molded onto an outwardly facing surface of the valve member **202**. For example, the graduated flow control bead **206** may be formed as part of a sleeve extending around the valve member **204**. In yet other embodiments, the graduated flow control bead **206** may be formed integrally with the valve member **202**. The graduated flow control bead **206** may be formed from any suitable material that will provide a sealing engagement with the valve seat **204**. The graduated flow control bead **206** may, for example, be formed from an elastomer material such as EPDM, TPE, LSR etc.
(52) The embodiment shown in FIG. **4** is only one example of a graduated flow control bead **206** that provides a graduated flow transition. In other embodiments, there may be other suitable shapes and configurations of graduated flow control bead **206** and valve seat **204** that may also provide a graduated flow transition.
(53) For example, in some embodiments, the graduated flow control bead **206** may be a shape and/or configuration such that is it not a planar bead that extends only in a plane normal to the longitudinal axis A. This means that the graduated flow control bead **206** is arranged such that all of its sealing surface required to achieve the minimum flow state (or to close the valve) does not come into simultaneous contact with the valve seat **204**. E.g., the graduated flow control bead is not provided by a perpendicularly configured O-ring as shown in FIGS. 2 to 4 of International application PCT/IB2013/001646 (WO2013/190381).
(54) The degree of graduated flow transition may be quantified by the change in flow rate caused by a corresponding distance of movement of the graduated flow control bead **206** relative to the valve seat **204**. In some embodiments, a movement of between 0 mm and 9 mm of the graduated flow control bead **206** relative to the associated valve seat **204** causes a change in flow rate between the minimum flow state of the valve and the maximum flow state of the valve. This is in comparison to a non-graduated flow transition (e.g. that provided by a planar bead that extends only in a plane normal to the longitudinal axis A) where a smaller movement of graduated flow control bead **206** relative to the associated valve seat **204** causes a similar change in flow rate e.g. a smaller relative movement may change the flow rate from the minimum flow state of the valve and the maximum flow state of the valve.
(55) In the described embodiment, the graduated flow control bead **206** may extend along the length of the valve member (e.g. between X and Y in FIG. **4**) a distance between 1 mm and 3 mm. This may provide a suitable graduated flow transition. In other embodiments this distance may be different to provide suitable flow transitions for other implementations of the flow control valve.
(56) One embodiment of a graduated flow control bead is shown in more detail in FIGS. **5***a* and **5***b*. These Figures show a pair of valves members **18***a*, **18***b* integrally formed with a shaft **19** (corresponding reference numerals to those of FIG. **2** have been used). The valve seats and remainder of the plumbing component is not shown.
(57) In this embodiment, the graduated flow control beads **20***a*, **20***b* are formed as part of a sleeve around an outside surface of each of the valves members **18***a*, **18***b* (e.g. an over molded sleeve). This can be seen more clearly in the cross section of FIG. **5***b*. In this embodiment, each of the graduated flow control beads **20***a*, **20***b* have a thickness (corresponding to “t” labelled in FIG. **4**) of approximately 0.8 mm and extend along the length of the respective valve member a distance of approximately 2.8 mm (e.g. the distance between extents X and Y in FIG. **4**). In this embodiment, the size of the aperture forming the valve seat is approximately 6 mm (e.g. the diameter in embodiments where it is circular). These dimensions may be suitable for a domestic

implementation of the plumbing component. In other embodiments, these dimensions may be varied according to the desired flow rate through the plumbing component. These dimensions are therefore only one illustrative example.
(58) The mixer valve **1** shown in FIG. **1** and described above may be included in a plumbing component **300** as shown in the embodiment of FIG. **6**.
(59) The plumbing component **300** comprises a housing **302** that houses the flow shut-off mechanism and the first and second control valves and includes apertures **304** and **306** that form part of the cold water inlet and the hot water inlet. A further aperture is provided to form the outlet. The water inlets and outlet may be formed by channels formed within the housing which provide waterways along which water may flow.
(60) In some embodiments, the housing of the plumbing component may be integral with the housing that forms the mixer valve **1**. In other embodiments, the mixer valve **1** may be provided as a separate component having a separate housing that is housed within the housing **302** of the plumbing component **300**. In such an embodiment, the housing of the mixer valve **1** may be coupled to the housing of the plumbing component so that water may flow between them as required.
(61) In some embodiments, the housing of the plumbing component (and the housing of the mixer valve if separate) may be formed from a polymer material. In some embodiments this may be a filled polymer material, e.g. a glass filled polymer. In some embodiments, the housing may be formed or molded in two or more separate components which when connected together form the waterways through which the water may flow within the plumbing component. In such an embodiment, the surface of the housing may form the walls of the waterways. In yet other embodiments, the waterways formed within the housing may be lined. In other embodiments, the housing may be formed by any other suitable method or material as would be apparent to the skilled person.
(62) By forming the plumbing component predominantly from a polymer material it may be efficiently and cost effectively manufactured. This may make the plumbing component more suitable for domestic use compared to, for example, a machined metal housing.
(63) In some embodiments, each of the shafts on which the valve member(s) are mounted may be formed from a polymer material. Furthermore, the valve members may also be formed from a polymer material. This may further allow the plumbing component to be quickly and efficiently manufactured so domestic use. In other embodiments, these components may be formed from any other suitable material such as a metal.
(64) In some embodiments, the plumbing component may comprise a disinfecting mechanism arranged to kill bacteria or microbes or the like that may be present in the waterways. In some embodiments the disinfecting mechanism may comprise a flush mechanism arranged to flush the waterways of the plumbing component with heated water. This use of such a flush mechanism may be suited to embodiments where the body of the plumbing component is predominantly made from a polymer material and so is not suitable for self-heating disinfectant methods.
(65) In other embodiments, the body of the plumbing component may be formed from the metal material rather than a polymer material. In such an embodiment, the disinfecting mechanism may be formed by a heater arranged to heat the body to kill any bacteria that may be present. This embodiment may be more suited to commercial applications, and may be useful for implementation in hospitals, for example, where efficient disinfection is advantageous.
(66) In the embodiment shown in FIG. **6**, the fluid outlet **8** of the mixer valve **1** is fluidly coupled to a plurality of outlets **308** *a*, **308** *b*, **308** *c*. Three such outlets are shown in FIG. **6**. However, the plurality of outlets may comprise any other suitable number of outlets according to the specific implementation of the plumbing component **300**. In some embodiments, there may be between one and six separate outlets. Each of the plurality of outlets **308** *a*, **308** *b*, **308** *c* is fed by water from the first and second flow control valves and so each provide a supply of water having the same

temperature. The plurality of outlets **308** *a*, **308** *b*, **308** *c* may provide separate water supplies for different parts of a plumbing fixture or assembly such as a tap or shower system. For example, a shower system having a plurality of shower heads may be supplied by the plurality of outlets **308** *a*, **308** *b*, **308** *c*, with each of the plurality of outlets coupled to each of the shower heads.
(67) As previously described, the plumbing component **300** comprises a separate flow shut-off mechanism that is arranged to provide a non-graduated transition or less graduated transition between a closed and an open condition. In one embodiment, the flow shut-off mechanism may comprise an electronic shut-off mechanism. The electronic shut-off mechanism may be formed by a solenoid that is movable between a shut-off position in which the flow of water out of the outlet (or outlets) of the plumbing component **300** is restricted and an open position in which flow of water out of the outlet(s) is unrestricted.
(68) In some embodiments, the flow shut-off mechanism may provide a sharp, non-graduated transition between the open and closed conditions. In other embodiments, a more graduated transition between the open and closed conditions may be provided. In such an embodiment, the graduated flow transition of the flow shut-off mechanism is less graduated than that provided by the graduated flow control bead. In some embodiments, the transition may be determined by the movement of the solenoid. The graduated flow transition may be determined by the armature position of the solenoid in a partially open state. For example, the solenoid may be a proportional solenoid arranged to provide one or more intermediate positions at which flow is limited between a fully open and a fully closed state.
(69) The electronic shut-off mechanism may be provided at a point along a water flow path between each of the first and second flow control valves and an aperture forming the outlet (or outlets). This allows the flow of water to be shut-off downstream of the flow control valves (e.g. downstream of the mixer valve **1**).
(70) In some embodiments, a single flow shut-off mechanism (e.g. a single solenoid) may be provided to restrict flow from the outlet or plurality of outlets **308***a*, **308***b*, **308***c* of the plumbing component **300**. In other embodiments, for example that shown in FIG. **6**, a plurality of flow shut-off mechanisms **310***a*, **310***b*, **310***c* (e.g. a plurality of solenoids) may be provided to independently restrict flow from each, or one or more of, the plurality of outlets **310***a*, **310***b*, **310***c*.
(71) In another embodiment, the flow shut-off mechanism may be formed by a flow shut-off bead forming part of each or some of the valve members of the flow control valves. An example of such an embodiment is shown in FIGS. **7***a* to **7***c*, **8***a* to **8***d* and FIGS. **9***a* and **9***b*.
(72) FIGS. **7***a* to **7***c* show views of a mixer valve **400**, which can be used as part of a plumbing component according to another embodiment or the embodiment described above. Corresponding reference numerals to those of FIGS. **1** and **2** have been used for ease of reference. The mixing valve **400** comprises a housing **401** having an aperture forming the cold water inlet **404** and an aperture forming the hot water inlet **406**. The housing **401** further comprises an aperture to form the outlet **408**.
(73) The housing **401** houses a first flow control valve and a second flow control valve having corresponding features to those shown in FIGS. **1** and **2**. The first flow control valve is arranged to control the flow of cold water from the inlet **404** to the mixing chamber **411**. The second flow control valve is arranged to control the flow of hot water from the inlet **406** to the mixing chamber **411**. From the mixing chamber **411** water flows from the outlet **408** which may be connected to other parts of the plumbing component or may form the outlet of the plumbing component in which the mixer valve **400** is used.
(74) The mixer valve **400** of FIGS. **7***a* to **7***c* differs from that shown in FIG. **1** by the layout of the inlet and outlet. In the embodiment of FIGS. **7***a* to **7***c* the direction of flow of water through the inlets **404**, **406** and outlet **408** is generally parallel. This may allow the inlets and outlets to be provided on the same face of the mixer valve **400** housing **402** as can be seen in FIG. **7***a*. This is different to the embodiment of FIG. **1** where the flow of water through the inlets is in opposite

directions to each other, with flow from the outlet being in a third perpendicular direction. In this embodiment, the inlets and outlet are all provided on different faces of the housing of the mixer valve to each other.
(75) In the embodiment shown in FIG. **7***c*, the first flow control valve comprises a first valve member **418** *a* and a second valve member **418** *b* each mounted to a shaft **419**. The valve members are arranged to seal against associated valve seats as described above. The shaft **419** is movable via an actuator **422**. The second flow control valve corresponding comprises a first valve member **418** *a*′ and second valve member **418** *b*′ mounted to a shaft **419**′ moved by an actuator **422**′.
(76) In the embodiment shown in FIG. **7***c*, the valve members **418***a*, **418***b*, **418***a*′, **418***b*′ each comprise both a graduated flow control bead **420***a*, **420***b*, **420***a*′, **420***b*′ and a flow shut-off bead **420***c*, **420***d*, **420***c*′, **420***d*′. The graduated flow control beads **420***a*, **420***b*, **420***a*′, **420***b*′ may be as described in relation to the embodiment of FIGS. **1** and **2**.
(77) In the embodiment of FIGS. **7***a* to **7***c*, each of the valve members may be provided with a flow shut off bead. In other embodiments, only some of the valve members may be provided with a flow shut of bead. In some embodiments, the flow shut off mechanism may be formed by one or both of an electronic shut of mechanism and one or more flow shut-off beads.
(78) The operation and features of the flow shut off beads are shown in more detail in the sequence of FIGS. **8***a*-**8***d*. These Figures show examples of the valve member **202** in the minimum seal, first partial seal, second partial seal and maximum seal positions of the graduated flow control bead **206** corresponding to those of FIGS. **3***a*-**3***d*. Like reference numbers have been for ease of explanation. The flow shut-off bead **208** may be arranged to contact the valve seat **204** to provide a relatively less-graduated transition between an open and a closed state of each control valve compared to the graduated flow control bead.
(79) The flow shut-off bead **420***c*, **420***d*, **420***c*′, **420***d*′, **208** may be a planar bead that extends only in a plane normal to the longitudinal axis, and is provided in addition to the graduated flow control bead **206**. The flow shut-off bead **208** is arranged such that it provides a further sealing contact with the valve seat after the graduated flow control bead **206** has moved into the maximum seal position. In contrast to the graduated flow control bead **206**, the flow shut-off bead **208** has a sealing surface the extent of which forms a simultaneous sealing contact with the valve seat. This provides a secure shut-off to each of the flow control valves.
(80) In some embodiments, the flow shut-off bead **208** may be formed by an O-ring carried by the valve member **204**. In other embodiments, the flow-shut off bead **208** may be formed by a protrusion on an outward facing surface of the valve member **204** or formed as part of a sleeve extending around the valve member **204**. In other embodiments, the flow-shut off bead **208** may be any other suitable shape or configuration, apart from that shown in FIGS. **8***a*-**8***d*, which provides a suitable flow shut-off.
(81) An embodiment of the flow shut-off bead is shown in more detail in FIGS. **9***a* and **9***b*. In these Figures the shaft **419** and valve members **418***a*, **418***b* of FIG. **7***c* are shown separately from the other components of the plumbing component.
(82) In this embodiment, the graduated flow control bead **420***a*, **420***b* and the flow shut-off bead **420***c*, **420***d* are integrally formed as part of a sleeve extending around the respective valve member **418***a*, **418***b*. In this embodiment, the graduated flow control bead **420***a*, **420***b* has approximately the same thickness as the flow shut-off bead **420***c*, **420***d*. They may, for example, each be approximately 0.8 mm in thickness as described in connection with the embodiment of FIGS. **5***a* and **5***b*. These dimensions are however only one example and can be varied according to the specific implementation. For example, in some embodiments, the flow shut-off bead **420***c*, **420***d* may have a different thickness to the graduated flow control bead **420***a*, **420***b*. It may, for example, be thicker than the graduated flow control bead as shown by the second flow shut-off bead **420***d* associated with the second valve member **418***b* in FIGS. **9***a* and **9***b*. In this embodiment, the aperture formed by the valve seat may again be approximately 6 mm (e.g. the diameter in

embodiments where it is circular).
(83) In some embodiments, the plumbing component of any embodiment described herein may further comprise a controller (not shown in the Figures) configured to control any one or more of the first control valve, the second control valve or the flow shut-off mechanism in response to at least one of the water temperature or flow rate within the plumbing component.
(84) Referring again to FIG. **6**, the controller may be configured to receive temperature or flow rate information from a first sensor **312**, the first sensor **312** being arranged to monitor at least one of the temperature or the flow rate of water flowing from the outlet or outlets **308***a*, **308***b*, **308***c* of the plumbing component **300**. The sensor may be arranged to monitor the temperature and/or the flow rate of water flowing along a flow path through the plumbing component between each of the flow control valves and the outlet of outlets. For example, the sensor may provide a measurement of the temperature and/or the flow rate in the mixing chamber **11** in the embodiment of FIG. **2**. In some embodiments, separate flow and temperature sensors may be provided. These separate sensors may be located together in a single housing or in some embodiments may be at suitable separate locations within the plumbing component.
(85) In some embodiments, additional sensors may be included to provide an indication of the flow rate or temperature of the fluid at other positions within the plumbing component **300**. In some embodiments, the controller may be configured to receive temperature or flow rate information from one or more second sensors (not shown in the Figures), the second sensor or sensors may be arranged to monitor at least one of the temperature or the flow rate of the water flowing through the hot and/or the cold inlets of the mixer valve **1**. Other temperature and flow rate sensors may be provided and other suitable positions within the plumbing component **300** as necessary.
(86) The controller may provide control signals to the mixer valve **1** and the mechanical shut-off mechanism (e.g. the solenoids **310***a*, **310***b*, **310***c*) for controlling the flow rate and temperature of the outlet water according to a user selection provided via an interface (not shown in the Figures). The interface may allow a user to select the flow rate and temperature they wish. The interface may comprise a touch sensitive panel for inputting settings and a display that shows the water temperature and flow rate. It will be appreciated that the interface can be of any suitable form for receiving user inputs for controlling the mixer valve and flow shut-off mechanism. It should also be understood that similar types of user interfaces may be employed either as part of, or adjacent to, other plumbing fixtures and fitting discussed herein (e.g., on or adjacent to a shower head or a stem thereof, on or adjacent to a tub spout, etc.).
(87) In some embodiments, the inlets **304**, **404**, **306**, **406** and the outlets **308** *a*, **308** *b*, **308** *c*, **408** may be formed by interchangeable connectors, each adapted to connect to a different water supply system. An example of this is shown in FIG. **6**. This may allow the connectors forming the inlet and outlets to be adapted to connect to different plumbing systems. The plumbing component can therefore be a modular part of a plumbing system that can be easily tailored for use in a particular system. The inlet and outlet connects shown in FIG. **6** are two examples only. The hot water inlet connector may be different from the cold water connector as shown in FIG. **6**, or in other embodiments they may be the same as each other. The connectors shown in FIG. **6** are only examples, and other types of connector may be provided in other embodiments.
(88) In some embodiments, the plumbing component may further comprise one or more flow regulators arranged to regulate the flow of water from the outlet (or outlets). For example, in the embodiment shown in FIG. **6***a*, each of the outlets **308***a*, **308***b*, **308***c* are provided with a corresponding flow regulator **314***a*, **314***b*, **314***c*. In other embodiments, the flow regulators may be absent.
(89) The plumbing component of any of the described embodiments may further comprise a cold water outlet and a hot water outlet. For example, in the embodiment shown in FIG. **6**, the plumbing component further comprises a cold water outlet **316** and a hot water outlet **318**. In this embodiment, the cold water inlet **304** may be fluidly coupled to both an inlet of the first flow

control valve **9** and the cold water outlet **316**. Similarly, the hot water inlet **306** may be fluidly coupled to both an inlet of the second flow control valve **10** and the hot water outlet **318**. The supply of hot water entering the plumbing component **300** via the hot water inlet **306** is therefore directed partly to the second flow control valve **10** and partly to the hot water outlet **318**. Similarly, the supply of cold water entering the plumbing component **300** via the cold water inlet **304** is therefore directed partly to the first flow control valve **9** and partly to the cold water outlet **316**.
(90) The hot and cold water outlets **316**, **318** are adapted to be connectable to the hot and cold water inlets of another plumbing component. This may allow a plurality of plumbing components to be conveniently stacked or cascaded together. For example, the cold water outlet of a first plumbing component may be fluidly coupled to the cold water inlet of a second plumbing component; and the hot water outlet of the first plumbing component may be fluidly coupled to the hot water inlet of the second plumbing component. This means that two or more plumbing components can be connected in series to the same supply of hot and cold water, rather than being connected in parallel. This may make installation easier and reduce the pipe work required to carry the water supply.
(91) In such an embodiment, the first and second plumbing components may be controlled by a controller arranged to receive temperature and flow information from sensors in each plumbing component as described above. The controller may be arranged to control the flow control valves of the first and second plumbing components such that the temperature of water flowing from the outlet of the first plumbing component is different from that of the second plumbing component.
(92) In use the flow control valves and final shut-off mechanism of the plumbing component described herein may be used to adjust the flow rate and/or temperature of water leaving the outlet. FIGS. **10***a* and **10***b* show plots of the outlet flow as a function of the relative distance between the valve member and the valve seat.
(93) FIG. **10***a* shows the resulting flow rate (line **502**) for embodiments which include a graduated flow control bead and a flow-shut off mechanism formed by a solenoid. The flow rate in FIG. **10***a* may therefore be provided by a plumbing component according to the embodiment shown in FIGS. **5***a*, **5***b* and **6**.
(94) As can be seen in FIG. **10***a*, in the minimum seal position (e.g. FIG. **3***a*) of the valve member a maximum flow rate from the outlet is provided. As the relative distance between the valve member and the valve seat reduces the flow from the outlet reduces. A minimum flow level is provided when the valve member is in the maximum seal position (e.g. FIG. **3***d*). At this position there is some residual level of flow from the outlet. A zero flow rate is provided when the solenoid is in the shut-off position.
(95) FIG. **10***b* shows an example of the outlet flow rate for embodiments which include a graduated flow control bead and a flow-shut off mechanism formed by a flow shut-off bead. FIG. **10***b* shows the rate of flow as a function of the movement of the valve member where the graduated flow control bead is provided (line **504**) and a comparison with an embodiment where no graduated flow control bead is provided (line **506**). In both cases the rate of flow varies from a maximum flow rate when the valve member is in a minimum seal position and a minimum flow rate when the valve member is in a maximum seal position. FIG. **10***b* shows that by providing a graduated flow control bead a greater graduation of flow is provided compared to that provided by only the flow shut-off bead. In other words, the reduction of flow caused by the graduated flow control bead is less in comparison to the reduction of flow caused by the flow-shut of bead for the same degree of relative movement between the valve member and valve seat. This may provide a finer resolution of adjustment of the flow rate, particularly at lower levels of flow.
(96) The embodiments described above and shown in the Figures are to be understood as non-limiting examples only. Various modifications will be apparent to the skilled person. For example, the mixer valve **1** shown in FIG. **2** comprises two separate flow control valves each of which comprises two cooperating pairs of valve members and valve seats. In other embodiments, each

flow control valve may comprise only a single pair of a cooperating valve member and a valve seat, or any other suitable number of valve members and valve seats (e.g. the second valve members **18***b* and **18***b′* and associated valve seats may be omitted or additional pairs may be included).
(97) In the described embodiment, the graduated flow control bead is provided on each of the valve members of the first and second flow control valves. However, in some embodiments, not all of the valve members may be provided with a graduated flow control bead. For example, a graduated flow control bead may be provided to give a graduated flow transition for only one of the hot and cold water flow to the outlet.
(98) The embodiments described above relate to mixer valves. However, the flow control valves **9**, **10** could be used individually to control fluid flow. As an example, the flow control valve **9** shown in FIG. **2** could be employed separately from the flow control valve **10** in any application where it is desired to control the flow rate of a water supply.
(99) In such an application, the mixing chamber **11** of the mixer valve **1** shown in FIG. **2** may be replaced with an outlet chamber which directs the flow from the outlets **14***a*, **14***b* of the flow control valve **9** to an outlet (not shown) for the intended application. The flow control valve **9** operates to control flow rate in similar manner to previous embodiments. In such an application the second flow control valve **10** is absent.
(100) One application for such a flow control valve could be in an instantaneous water heater of the type in which a supply of water is heated as it passes through a heater tank to provide a source of hot water on demand. In such instantaneous water heaters (sometimes referred to as continuous flow water heaters), for a given power input to the heater tank, the temperature of the outlet water is determined by the flow rate of the water through the heater tank and control of flow rate may be used to achieve and maintain a selected outlet water temperature. One application for such water heaters is in an electric shower to supply water to one or more shower outlets such as a handset or fixed shower handset. Other applications of the flow control valve will be apparent to those skilled in the art.
(101) Any of the embodiments described herein may be modified so that the hot water inlet and the cold water inlet are reversed. For example, the hot water inlet may be adapted to instead receive a supply of cold water and vice versa. In some embodiments, the hot and cold water inlets may be configurable by the user. In such an embodiment, a supply of either hot or cold water may be connected to each inlet as desired by the user and then the configuration of the plumbing component set by the user to match the connections made. In some embodiments, the water inlets may be configured to act as hold or cold water inlets via the controller. In this example, the configuration is performed by software run by the controller, rather than requiring any mechanical or physical change of the inlets themselves by the user.
(102) In the embodiments previously described a graduated flow control bead is provided to give a graduated flow transition between a maximal and minimum flow rate. In other embodiments, the valve seat may be additionally or alternatively adapted to provide the graduated flow transition.
(103) In some embodiments, the plumbing component may therefore comprise a graduated flow control mechanism that may be formed by the graduated flow control bead(s) and/or a graduated flow control portion(s) of the associated valve seat. In such an embodiment, the graduated flow control portion of the valve seat may comprise a tapered portion of the bore forming the valve seat (e.g. the sealing surface of the valve seat which contacts the valve member may be tapered). For example, the internal sealing surface (labelled **15** in FIG. **2**) of the aperture which seals to the valve member may be shaped to provide a graduated flow transition. In other embodiments the flow control portion may comprise any other complex shape that may engage with the valve member to causes a graduated flow transition.
(104) The graduated flow control mechanism may comprise one or more sealing surfaces which are arranged to seal against a corresponding sealing surface of the associated valve seat or valve member. The flow rate through the respective flow control valve may therefore be determined by

the extent of the contact between the sealing surface or surfaces and the associated valve seat or valve member. The relative movement between the valve member and the valve seat may comprise movement between the a minimum seal position, a first partial seal position, a second partial seal position and a maximum seal position as described above. For example, the movement may be between any of the following positions: i) a minimum seal position in which there is no sealing contact between the, or each, sealing surface of the graduated flow control mechanism and the associated valve seat or valve member; ii) a first partial seal position in which part of the or each sealing surface of the graduated flow control mechanism is in sealing contact with the associated valve seat or valve member; iii) a second partial seal position in which part of the or each sealing surface of the graduated flow control mechanism is in sealing contact with the associated valve seat or valve member, wherein in the second partial seal position a greater extent of the sealing surface is in sealing contact with the associated valve seat or valve member in comparison to the first partial seal position; and iv) a maximum seal position in which a maximum extent of the or each sealing surface of the graduated flow control mechanism is in sealing contact with the associated valve seat or valve member. These positions correspond to those described in relation to FIGS. **3***a*-**3***d*.
(105) It will be appreciated that while the embodiments of the mixer valve and the flow control valve described herein are shown as being incorporated into plumbing fittings, they have wider application. The combination of graduated flow transition and/or separate flow shut-off may have advantageous uses in other implementations such as process control valves, pneumatic and hydraulic systems, medical equipment or in automotive components or other components where control of flow rate of a fluid and/or mixing of two fluids having different characteristics is required. Thus, the plumbing component may not be limited to mixing fluids having different temperatures and may be applied to other fluids apart from water. Either or both of the hot water inlet and cold water inlet may therefore be a described more broadly as fluid inlets configured to receive a supply of a fluid. In such embodiments, the plumbing component may be described more broadly as a valve or a mixer valve if mixing two or more fluids.

## Claims

1. A plumbing component comprising: a water inlet configured to receive a supply of water; an outlet configured to output water received from the water inlet; and a flow control valve configured to control a flow of water from the water inlet to the outlet; wherein the flow control valve comprises a valve member and valve seat, wherein the valve member is movable with respect to the valve seat to control the flow of water through the flow control valve to the outlet; and wherein the valve member comprises a graduated flow control bead selectively sealing against the valve seat to provide a graduated flow transition between a maximum flow state and a minimum flow state of the flow control valve.
2. The plumbing component of claim 1, wherein the water inlet comprises a cold water inlet configured to receive a supply of cold water and a hot water inlet configured to receive a supply of hot water.
3. The plumbing component of claim 2, wherein the flow control valve comprises: a first flow control valve configured to control the flow of cold water from the cold water inlet to the outlet; and a second flow control valve configured to control the flow of hot water from the hot water inlet to the outlet.
4. The plumbing component of claim 1, wherein the graduated flow control bead comprises a sealing surface which is arranged to seal against a corresponding sealing surface of the valve seat, and wherein the flow rate through the flow control valve is determined by the extent of the contact between the sealing surface of the graduated flow control bead and the valve seat.
5. The plumbing component of claim 4, wherein the graduated flow control bead is arranged to

move relative to the valve seat, and wherein the movement is between any of the following positions: i) a minimum seal position in which there is no sealing contact between the graduated flow control bead and the valve seat; ii) a first partial seal position in which part of the sealing surface of the graduated flow control bead is in sealing contact with the valve seat; iii) a second partial seal position in which part of the sealing surface of the graduated flow control bead is in sealing contact with the valve seat, wherein in the second partial seal position a greater extent of the sealing surface of the graduated flow control bead is in sealing contact with the valve seat in comparison to the first partial seal position; and iv) a maximum seal position in which a maximum extent of the sealing surface of the graduated flow control bead is in sealing contact with the valve seat.

6. The plumbing component of claim 1, wherein one or both of the shape and configuration of the graduated flow control bead compared to the shape and configuration of the valve seat provides the graduated flow transition.

7. The plumbing component of claim 1, wherein the valve member has a longitudinal axis, and wherein the longitudinal axis is arranged parallel to a first direction in which the graduated control bead is arranged to move relative to the valve seat.

8. The plumbing component of claim 7, wherein one or more of: a) the graduated flow control bead is a non-planar bead that extends only in a plane normal to the longitudinal axis; b) at least part of a sealing surface of the graduated flow control bead is shaped so that it is inclined relative to a plane normal to the longitudinal axis; c) the graduated flow control bead has a shape that extends between a first extent and a second extent along the length of the valve member, the distance between the first extent and the second extent being greater than a thickness of the graduated flow control bead; and d) the graduated flow control bead is shaped to follow a path having three or more turning points around the valve member.

9. The plumbing component of claim 1, wherein one or more of: a) a movement of between 0 mm and 9 mm of the graduated flow control bead relative to the valve seat causes a change in flow rate between the minimum flow state and the maximum flow state; b) a thickness of the graduated flow control bead is between 0.5 mm and 1.5 mm; and c) each valve member is mounted on a shaft and the graduated flow control bead comprises a sleeve around an outer surface of the valve member.

10. The plumbing component of claim 1, further comprising a flow shut-off mechanism configured to selectively restrict the flow of water from the outlet.

11. The plumbing component of claim 10, wherein the flow shut-off mechanism is formed by a flow shut-off bead forming part of the valve member, wherein the flow shut-off bead selectively contacts the valve seat to provide a transition between an open and a closed state of the flow control valve.

12. The plumbing component of claim 11, wherein the valve member has a longitudinal axis, and wherein the longitudinal axis is arranged parallel to a first direction in which the graduated control bead is arranged to move relative to the valve seat and, wherein the flow shut-off bead is a planar bead that extends only in a plane normal to the longitudinal axis.

13. The plumbing component of claim 10, wherein the flow shut-off mechanism comprises an electronic shut-off mechanism that is movable between a shut-off position in which the flow of water out of the outlet is restricted and an open position in which flow of water out of the outlet is unrestricted, and one or both of: a) the water flows through the plumbing component along a water flow path, and wherein the electronic shut-off mechanism is provided at a point along the water flow path between the flow control valve and an aperture forming the outlet; or b) the outlet is one of a plurality of outlets, each outlet being arranged to receive water from the flow control valve, and wherein the flow shut-off mechanism comprises a plurality of solenoids arranged to independently control the flow of water through each of the plurality of outlets.

14. A plumbing assembly comprising: a first plumbing component comprising: at least one water inlet configured to receive a supply of water; at least one outlet configured to output water received

from the at least one water inlet; and a flow control valve configured to control a flow of water from the at least one water inlet to the at least one outlet; wherein the flow control valve comprises a valve member and valve seat, wherein the valve member is movable with respect to the valve seat to control the flow of water through the flow control valve to the at least one outlet; and wherein the valve member comprises a graduated flow control bead selectively sealing against the valve seat to provide a graduated flow transition between a maximum flow state and a minimum flow state of the flow control valve; and a second plumbing component; wherein the at least one outlet of the first plumbing component is coupled to at least one water inlet of the second plumbing component.

15. The plumbing assembly of claim 14, wherein: the at least one water inlet of the first plumbing component comprises a cold water inlet configured to receive a supply of cold water and a hot water inlet configured to receive a supply of hot water; and the at least one water inlet of the second plumbing component comprises a cold water inlet configured to receive a supply of cold water and a hot water inlet configured to receive a supply of hot water.

16. The plumbing assembly of claim 15, wherein: the at least one outlet of the first plumbing component comprises a cold water outlet and a hot water outlet; the cold water outlet of the first plumbing component is fluidly coupled to the cold water inlet of the second plumbing component; and the hot water outlet of the first plumbing component is fluidly coupled to the hot water inlet of the second plumbing component.

17. The plumbing assembly of claim 14, wherein the graduated flow control bead comprises a sealing surface which is arranged to seal against a corresponding sealing surface of the valve seat, and wherein the flow rate through the flow control valve is determined by the extent of the contact between the sealing surface of the graduated flow control bead and the valve seat.

18. The plumbing assembly of claim 14, wherein one or both of the shape and configuration of the graduated flow control bead compared to the shape and configuration of the valve seat provides the graduated flow transition.

19. A plumbing component comprising: a cold water inlet configured to receive a supply of cold water; a hot water inlet configured to receive a supply of hot water; an outlet configured to output water received from the cold water inlet and/or the hot water inlet; a flow control valve configured to control a flow of water from the cold water inlet and/or the hot water inlet to the outlet, wherein the flow control valve comprises a valve member and valve seat, wherein the valve member is movable with respect to the valve seat to control the flow of water through the flow control valve to the outlet, and wherein the valve member comprises a graduated flow control bead selectively sealing against the valve seat to provide a graduated flow transition between a maximum flow state and a minimum flow state of the control valve; and a flow shut-off mechanism operable to restrict the flow of water out of the outlet.

20. The plumbing component of claim 19, further comprising a controller configured to control the flow control valve and/or the flow shut-off mechanism in response to the water temperature, the water flow rate, or a combination thereof.