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(54) **FILLING SYSTEM WITH THERMAL ACTUATING DEVICE**

(57) The present invention discloses a filling system for connecting a fluid supply to a pressurized fluid circuit. The filling system includes a filling device and a thermal actuating device. The filling device includes a main fluid passageway having an inlet port adapted for connection to the fluid supply and an outlet port adapted for connection to the fluid circuit, a manual valve interposed in the main fluid passageway to open and close a first fluid path defined by the main fluid passageway, and a bypass fluid passageway connected between the inlet port and the

outlet port to conduct fluid around the manual valve. The thermal actuating device is associated with the bypass fluid passageway to open and close a second fluid path defined by the bypass fluid passageway. As the cost of a thermal actuating device is normally only a quarter of the cost of a solenoid valve, and only one manual valve is needed for the filling system, the cost, the size and the complexity in structure and operation of the apparatus can be greatly reduced.

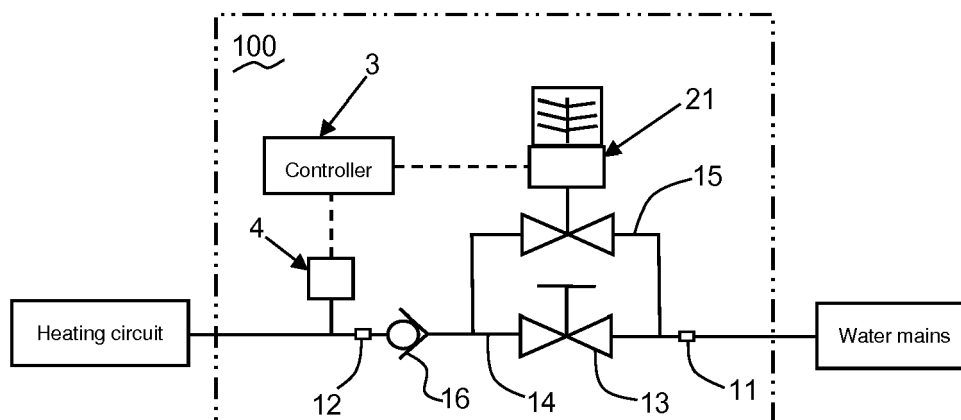


Fig. 2

Description

FIELD OF THE INVENTION

[0001] The present invention relates to a filling system for a pressurized fluid circuit, and more particularly to a filling system for a central heating circuit with a boiler.

BACKGROUND OF THE INVENTION

[0002] A typical domestic central heating circuit includes a gas or oil fired boiler for production of hot water, the hot water is then distributed through a piping system, such as radiators or under floor heating loop, to distribute heat to the facility by having the hot water transfer heat to surrounding air. The boiler circuit includes various components and is operated with water under pressure, however, the seals between the various components are not perfect, and from time to time the pressure falls below a value required for correct operation. In this case, additional water needs to be added manually or automatically to the boiler circuit when the circuit is in a low water condition.

[0003] As a traditional filling system illustrated in Fig. 1, the heating circuit is connected to a pressurized water source, such as a water mains supply via a filling system to be filled with water when a low water condition is detected. The filling system has a manual tap 91 and a manual valve 92 both connected in a direct line 81 between the water mains and the heating circuit, and a solenoid valve 93 is disposed in a line 82 connected after the manual tap 91 and around the manual valve 92. The manual tap 91 is normally open, while the manual valve 92 and the solenoid valve 93 are both normally closed. The manual valve 92 is turned on when the heating circuit needs to be charged with water at a high flow rate. For instance, on first installation of the heating circuit, the circuit needs more than 50 liters of water, so the installer need to turn on both the manual tap 91 and the manual valve 92 to avoid a waste of time. During the daily operation, when a low water condition is detected by a pressure sensor, the solenoid valve 93 is then activated by a controller to allow water from the water mains to flow into the heating circuit at a relative lower flow rate until the pressure sensor detects that a predetermined water pressure is reached.

[0004] However, the existing filling system is relatively complex and costly.

SUMMARY OF THE INVENTION

[0005] It is an object of present invention to provide a filling system that has low cost and complexity.

[0006] According to the present invention there is provided a filling system for connecting a fluid supply to a pressurized fluid circuit. The fluid supply is preferably a mains water supply, and the fluid circuit is preferably a central heating circuit including a boiler. The filling system

includes a filling device and a thermal actuating device. The filling device includes a main fluid passageway having an inlet port adapted for connection to the fluid supply and an outlet port adapted for connection to the fluid circuit, a manual valve interposed in the main fluid passageway to open and close a first fluid path defined by the main fluid passageway, and a bypass fluid passageway connected between the inlet port and the outlet port to conduct fluid around the manual valve. The thermal actuating device is associated with the bypass fluid passageway to open and close a second fluid path defined by the bypass fluid passageway.

[0007] The thermal actuating device preferably includes a casing, a thermal actuator received in the casing, and a movable member cooperating with the thermal actuator to be actuated to move between a first and a second positions relative to the casing; wherein the movable member is disposed in the casing and has one end extending out of the casing, the end of the movable member blocks the bypass fluid passageway when the movable member is located at the first position and unblocks the bypass fluid passageway when the movable member is located at the second position.

[0008] The filling device may have a body, and the body has a periphery wall defining the main fluid passageway therein; wherein the bypass fluid passageway preferably includes a channel defined in the periphery wall, and the channel has one end communicating with the main fluid passageway and the other end forming an opening on an outer surface of the periphery wall; wherein the end of the movable member abuts against the opening of the channel to close the second fluid path when the movable member is located at the first position.

[0009] Preferably, the channel has a section size smaller than that of the main fluid passageway.

[0010] The bypass fluid passageway preferably includes a through hole defined in the periphery wall and communicating with the main fluid passageway, and a chamber defined by projection walls projecting from the periphery wall; wherein the chamber communicates with both the channel and the through hole.

[0011] Preferably, the projection walls define an aperture in communication with the chamber, and a membrane covers the aperture and has a central bore for being extended through by the movable member into the chamber, wherein the central bore of the membrane has a diameter smaller than that of the movable member.

[0012] In one embodiment, the thermal actuator has thermally expandable material contained therein; when the thermally expandable material expands, the movable member moves relative to the casing from the first position to the second position; when the thermally expandable material contracts, the movable member moves relative to the casing from the second position to the first position.

[0013] The filling system preferably includes a pressure sensor for monitoring pressure of fluid circulating in the fluid circuit and a controller communicating with the

pressure sensor and the thermal actuator.

[0014] The controller may activate the thermal actuator by heating the thermally expandable material to actuate the movable member to move from the first position to the second position for opening the second fluid path after the controller receives a signal representing that the fluid pressure falls below a first pressure threshold from the pressure sensor.

[0015] The controller may also estimate a remaining time when the fluid pressure reaches a second pressure threshold equal to or greater than the first pressure threshold; and the controller may further deactivate the thermal actuator by stopping heating the thermally expandable material when the remaining time is equal to a fixed time interval, thereby actuating the movable member to move from the second position to the first position as the thermally expandable material cools down.

[0016] In one embodiment, the controller estimates the remaining time based on the monitoring information of the pressure sensor.

[0017] Preferably, the thermal actuating device further includes a biasing element cooperating with the movable member for biasing the movable member from the second position to the first position.

[0018] Preferably, the manual valve is in a normally closed condition for closing the first fluid path, and is manually operable to an open condition for opening the first fluid path.

[0019] In this way, as the cost of a thermal actuating device is normally only a quarter of the cost of a solenoid valve, and only one manual valve is needed for the filling system, the cost, the size and the complexity in structure and operation of the apparatus can be greatly reduced. In addition, the nature of the thermally expandable material employed by the thermal actuating device can cause delays in control, and the aforementioned filling system resolves this problem by using a new control algorithm of calculating the remaining time of the filling operation and stopping heating the thermally expandable material for a fixed time interval ahead of the end of the filling operation.

BRIEF DESCRIPTION OF THE DRAWINGS

[0020] For a more complete understanding of the present invention, and the advantages thereof, reference is now made to the following descriptions taken in conjunction with the accompanying drawings, in which:

Fig. 1 is a schematic diagram illustrating a conventional filling system connected between a water mains supply and a heating circuit;

Fig. 2 is a schematic diagram illustrating a filling system in accordance with one embodiment of present invention, wherein the filling loop system is connected between the water mains supply and the heating circuit;

Fig. 3 is a schematic sectional view of a combination of a filling device and a thermal actuating device used in the filling system shown in Fig. 2, wherein the filling device is in a closed condition;

Fig. 4 is a schematic sectional view similar to Fig. 3, wherein the filling device is operated to feed water at a high flow rate;

Fig. 5 is a schematic sectional view similar to Fig. 3, wherein the filling device is operated to feed water at a low flow rate.

DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENTS

[0021] Reference will now be made to the drawing figures to describe the preferred embodiments of the present invention in detail. However, the embodiments can not be used to restrict the present invention. Changes such as structure, method and function obviously made to those of ordinary skill in the art are also protected by the present invention.

[0022] Fig. 2 illustrates an embodiment of an filling system for connecting a water mains supply to a pressurized heating circuit to automatically feed water to the heating circuit when a low water condition is detected in the heating circuit. In this embodiment, the heating circuit includes a gas or oil fired boiler for production of hot water, the hot water is then distributed through a piping system, such as radiators or under floor heating loop, to distribute heat to the facility by having the hot water transfer heat to surrounding air. Those skilled in the art will also understand that the filling system of present invention could also be used in any other cases that a pressurized fluid circuit needs to be automatically filled with fluid from a fluid supply.

[0023] Referring to Figs. 2 and 3, the filling system 100 includes a filling device 1, a thermal actuating device 21, a controller 3, and a pressure sensor 4. As shown in Fig. 3, the filling device 1 includes a generally tubular body 10 with a periphery wall and a central main fluid passageway 14 defined by the periphery wall. The body 10 has an inlet port 11 adapted for connection to the water mains supply and an outlet port 12 adapted for connection to the heating circuit. A manual valve 13 is interposed in the main fluid passageway to open and close a first fluid path defined by the main fluid passageway 14, and a bypass fluid passageway 15 is connected between the inlet port 11 and the outlet port 12 to conduct water around the manual valve 13. In this embodiment, the body 10 has a lower vertical portion (not shown) upstanding from the periphery wall and defining the inlet port 11 therein, and an upper vertical portion upstanding from the periphery wall and defining the outlet port 12 therein.

[0024] The manual valve 13 may take forms of a plug valve provided at the bottom of the body 10 with its plug portion being insertable into the main fluid passageway

14. Fig. 3 and Fig. 5 show a normally closed condition of the manual valve 13, wherein the plug portion of the manual valve is inserted into the main fluid passageway 14 to block water flow from the water mains supply via the inlet port to enter the main fluid passageway 14. Fig. 4 shows an opened condition of the manual valve 13, wherein the manual valve is rotated with its plug portion exiting from the main fluid passageway 14 to allow water flow from the water mains supply passing through the inlet port to enter the main fluid passageway 14. If the manual valve 13 is rotated to have its plug portion retreat to a maximum position as shown in Fig. 4, the water flow will have a high flow rate.

[0025] The bypass fluid passageway 15 includes a channel 151 defined in the periphery wall. As shown in Fig. 3, the channel 151 has one end at its bottom for communicating with the main fluid passageway 14 and the other end forming an opening on an outer surface of the periphery wall. The channel 151 has a section size much smaller than that of the main fluid passageway 14, by this means, the water flow passing through the channel 151 has a flow rate much lower than that only passing through the main fluid passageway 14. The bypass fluid passageway 15 also includes a through hole 152 defined in the periphery wall and communicating with the main fluid passageway 14, and a chamber 153 defined by projection walls projecting from the periphery wall for communicating with both the channel 151 and the through hole 152. The projection walls define an aperture in communication with the chamber 153, and a membrane 154 is attached to the projection walls for covering the aperture. The membrane 154 has a central bore for cooperating with a movable member of the thermal actuating device 21 that will be described in detail hereinafter. In addition, a non-return valve 16 is provided in the main fluid passageway 14 to prevent water in the heating circuit from flowing into the water mains. Refer to Fig. 3, in this embodiment, the non-return valve 16 is disposed in the upper vertical portion and close to the outlet port 12.

[0026] As illustrated in Figs. 3 to 5, the thermal actuating device is associated with the bypass fluid passageway 15 to open and close a second fluid path defined by the bypass fluid passageway. The thermal actuating device may include a casing 210, a thermal actuator 211 retained in the casing, and a movable member 212 cooperating with the thermal actuator. The casing 210 is usually made of thermoplastic material and mounted fixedly with respect to the filling device 1. The thermal actuator is a small electric linear motor based on a temperature sensitive element, and it can perform a linear stroke with a considerable load with a silent and slow movement. In this embodiment, the thermal actuator 211 has a body made of electrically and thermally conductive material (e.g. steel) and containing thermally expandable material, such as was therein, and a piston 2111 at least partially immersed into the body. The piston 2111 engages with and drives the movable member 212 to move between a first position (as shown in Figs. 3 and 4) and a second

position (as shown in Fig. 5) relative to the casing 210. The body is in contact with an electrical heater (not shown), usually a PTC (Positive Temperature Coefficient) thermistor, so that the heat produced by the PTC thermistor is transferred to the thermally expandable material to make it expand.

[0027] The movable member 212 is received in the casing 210 and has a shaft portion extending out of the casing. The shaft portion has a distal end that is able to abut against the opening of the channel 151 to close the second fluid path when the movable member 212 is located at the first position and uncover the opening to open the second fluid path when the movable member 212 is located at the second position. The shaft portion of the movable member 212 extends through the central bore of the membrane 154 and has a diameter a bit larger than that of the central bore for avoidance of a fluid leakage through the connection between the shaft portion and the membrane 154. The thermal actuating device further includes a biasing element 213 cooperating with the movable member 212 for biasing the movable member from the second position to the first position. In present embodiment, the biasing element 213 can be a spring disposed between an inner wall of the casing 210 and the other end of the movable member 212 opposing to the end of the movable member 212 extending out of the casing 210. The spring 213 is able to be stretched and compressed along the movement direction of the movable member 212.

[0028] Also referring to Fig. 2, the filling system 100 further includes a pressure sensor 4 for monitoring pressure of water circulating in the heating circuit and a controller 3 electrically connecting with the pressure sensor 4 and the thermal actuator 211. The controller 3 may be embodied in hardware or software as a digital microcontroller or microprocessor or an analog circuit, for example, and/or by a digital IC such as a digital signal processor or an application specific integrated circuit (ASIC). In this embodiment, the filling system 100 is embedded in the heating circuit, that is, the filling device 1 and the thermal actuating device 21 are installed in the boiler as parts of the boiler, and the controller 3 can be an existing boiler management unit with new water filling instructions, and the pressure sensor 4 is the existing one located in the heating circuit. Person skilled in the art will recognize that the filling system could also be a separate apparatus with part or all of the components including the filling device, the thermal actuating device, a controller specific for automatic filling operation, and so on. This separate filling system can be connected to the heating circuit and the water mains supply via pipe lines/fittings and electrical lines/connectors to perform the automatic filling operation.

[0029] Referring to Fig. 3, in conjunction with Fig. 5, during the daily operation, the pressure sensor 4 monitors pressure of water circulating in the heating circuit. When the detected water pressure is larger than a first pressure threshold indicating a critical pressure level be-

low which the heating circuit is in a low water condition, no water filling operation is needed. In this case, the manual valve 13 keeps the normal closed condition to block the main fluid passageway 14, and the end of the movable member 212 abuts against the opening of the channel 151 to block the bypass fluid passageway 15. When the detected water pressure falls below the first pressure threshold, which means the heating circuit is in a low water condition, on receiving the signal representing this low water condition from the pressure sensor 4, the controller 3 activates the thermal actuator 211 by energizing the PTC thermistor, the thermally expandable material contained in the thermal actuator is then heated and expands accordingly. The piston 2111 is pushed with the expansion of the thermally expandable material, and the movable member 212 is driven by the piston 2111 to move inward the casing 210 from the first position toward the second position. During the period, the end of the movable member 212 out of the casing 210 uncovers the opening of the channel 151 to unblock the bypass fluid passageway, therefore, water flow from the water mains supply via the inlet port 11 sequentially passes through the channel 151, the chamber 153, and the through hole 152 and enters the main fluid passageway 14, and further exits from the outlet port 12 to be filled in the heating circuit. Meanwhile, the spring 213 is compressed by the other end of the movable member 212 within the casing 210 against the inner wall of the casing 210.

[0030] As water flows through the bypass fluid passageway 15 at a lower and steady flow rate, the controller 3 can estimate how much time the water pressure of the heating circuit can reach a second pressure threshold indicating an acceptable pressure level above which the normal heating operation can be conducted, in other words, the controller can estimate a remaining time when the filling operation is supposed to be ended. For example, the controller 3 continuously receives the monitoring information of the pressure sensor 4 and can get to know how much time it need to increase the pressure of 0.1 bar, and then estimates how much time the filling operation can finish. The second pressure threshold may be equal to or greater than the first pressure threshold. The controller 3 will deactivate the thermal actuator 211 by de-energizing the PTC thermistor for a fixed time interval before the end of the filling operation, thus, the thermally expandable material stops being heated and contracts accordingly, and the movable member 212 together with the piston 2111 is driven by the biasing means 213 under the effect of elastic restoring force of the compressed spring to move relative to the casing from the second position toward the first position. When the thermally expandable material completely cools down, the movable member 212 returns to the first position where the opening of the channel 151 is covered again by the end of the movable member 212 so that the bypass fluid passageway 15 is blocked again, at this time, the water pressure of the heating circuit reaches the second pressure threshold. The fixed time interval can be determined based on

the relationship between the cooling time and the contracted stroke of the thermally expandable material. For example, the controller 3 can know in advance the time required for the thermally expandable material to completely cool down during the movement of the movable member 212 from the second position to the first position, e.g. two minutes, therefore, the controller stops heating when the remaining time is equal the two minutes.

[0031] The cost of a thermal actuating device is normally only a quarter of the cost of a solenoid valve, and only one manual valve is needed for the filling system, therefore, the cost, the size and the complexity in structure and operation of the apparatus can be greatly reduced. In addition, the nature of the thermally expandable material employed by the thermal actuating device can cause delays in control, and the aforementioned filling system resolves this problem by using a new control algorithm of calculating the remaining time of the filling operation and stopping heating the thermally expandable material for a fixed time interval ahead of the end of the filling operation.

[0032] It is to be understood, however, that even though numerous, characteristics and advantages of the present invention have been set forth in the foregoing description, together with details of the structure and function of the invention, the disclosed is illustrative only, and changes may be made in detail, especially in matters of number, shape, size, and arrangement of parts within the principles of the invention to the full extent indicated by the broadest general meaning of the terms in which the appended claims are expressed.

Claims

1. A filling system (100) for connecting a fluid supply to a pressurized fluid circuit, **characterized in that** said filling system comprises:
 - a filling device (1) comprising a main fluid passageway (14) having an inlet port (11) adapted for connection to the fluid supply and an outlet port (12) adapted for connection to the fluid circuit, a manual valve (13) interposed in the main fluid passageway to open and close a first fluid path defined by the main fluid passageway, and a bypass fluid passageway (15) connected between the inlet port and the outlet port to conduct fluid around the manual valve; and
 - a thermal actuating device (21) associated with the bypass fluid passageway to open and close a second fluid path defined by the bypass fluid passageway.
2. A filling system according to claim 1, **characterized in that** the thermal actuating device comprises a casing (210), a thermal actuator (211) received in the casing, and a movable member (212) cooperating

with the thermal actuator to be actuated to move between a first and a second positions relative to the casing; wherein the movable member is disposed in the casing and has one end extending out of the casing, said end of the movable member blocks the bypass fluid passageway when the movable member is located at the first position and unblocks the bypass fluid passageway when the movable member is located at the second position.

3. A filling system according to claim 2, **characterized in that** the filling device has a body (10), and the body has a periphery wall defining said main fluid passageway (14) therein; wherein the bypass fluid passageway comprises a channel (151) defined in the periphery wall, and the channel has one end communicating with the main fluid passageway and the other end forming an opening on an outer surface of the periphery wall; wherein said end of the movable member abuts against the opening of the channel to close the second fluid path when the movable member is located at the first position.
4. A filling system according to claim 3, **characterized in that** the channel has a section size smaller than that of the main fluid passageway.
5. A filling system according to claim 3, **characterized in that** the bypass fluid passageway further comprises a through hole (152) defined in the periphery wall and communicating with the main fluid passageway, and a chamber (153) defined by projection walls projecting from the periphery wall; wherein the chamber communicates with both the channel and the through hole.
6. A filling system according to claim 5, **characterized in that** said projection walls define an aperture in communication with the chamber, and a membrane (154) covers said aperture and has a central bore for being extended through by the movable member into the chamber, wherein said central bore of the membrane has a diameter smaller than that of the movable member.
7. A filling system according to claim 2, **characterized in that** said thermal actuator has thermally expandable material contained therein; when the thermally expandable material expands, the movable member moves relative to the casing from the first position to the second position; when the thermally expandable material contracts, the movable member moves relative to the casing from the second position to the first position.
8. A filling system according to claims 7, **characterized in that** said system further comprise a pressure sensor (4) for monitoring pressure of fluid circulating in

the fluid circuit and a controller (3) communicating with the pressure sensor and the thermal actuator.

9. A filling system according to claims 8, **characterized in that** said controller activates the thermal actuator by heating the thermally expandable material to actuate the movable member to move from the first position to the second position for opening the second fluid path after the controller receives a signal representing that the fluid pressure falls below a first pressure threshold from the pressure sensor.
10. A filling system according to claims 9, **characterized in that** the controller estimates a remaining time when the fluid pressure reaches a second pressure threshold equal to or greater than the first pressure threshold; and the controller deactivates the thermal actuator by stopping heating the thermally expandable material when the remaining time is equal to a fixed time interval, thereby actuating the movable member to move from the second position to the first position as the thermally expandable material cools down.
11. A filling system according to claim 10, **characterized in that** the controller estimates the remaining time based on the monitoring information of the pressure sensor.
12. A filling system according to claims 2 or 10, **characterized in that** the thermal actuating device further comprises a biasing element (213) cooperating with the movable member for biasing the movable member from the second position to the first position.
13. A filling system according to claims 1, **characterized in that** the manual valve is in a normally closed condition for closing the first fluid path, and is manually operable to an open condition for opening the first fluid path.

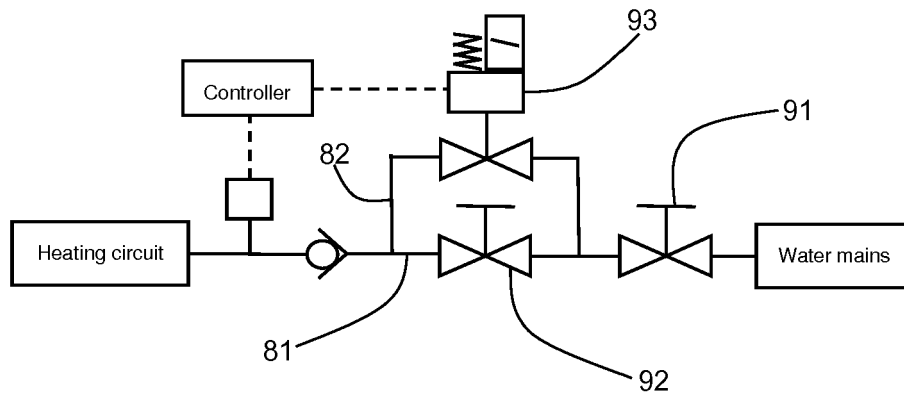


Fig. 1

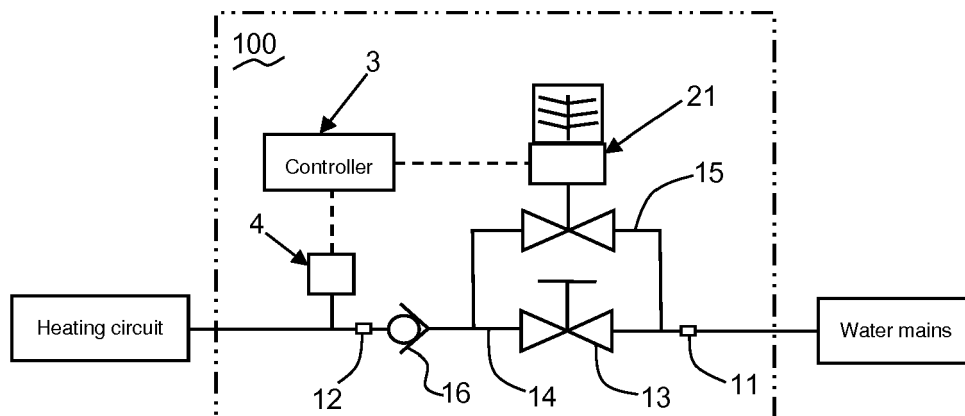


Fig. 2

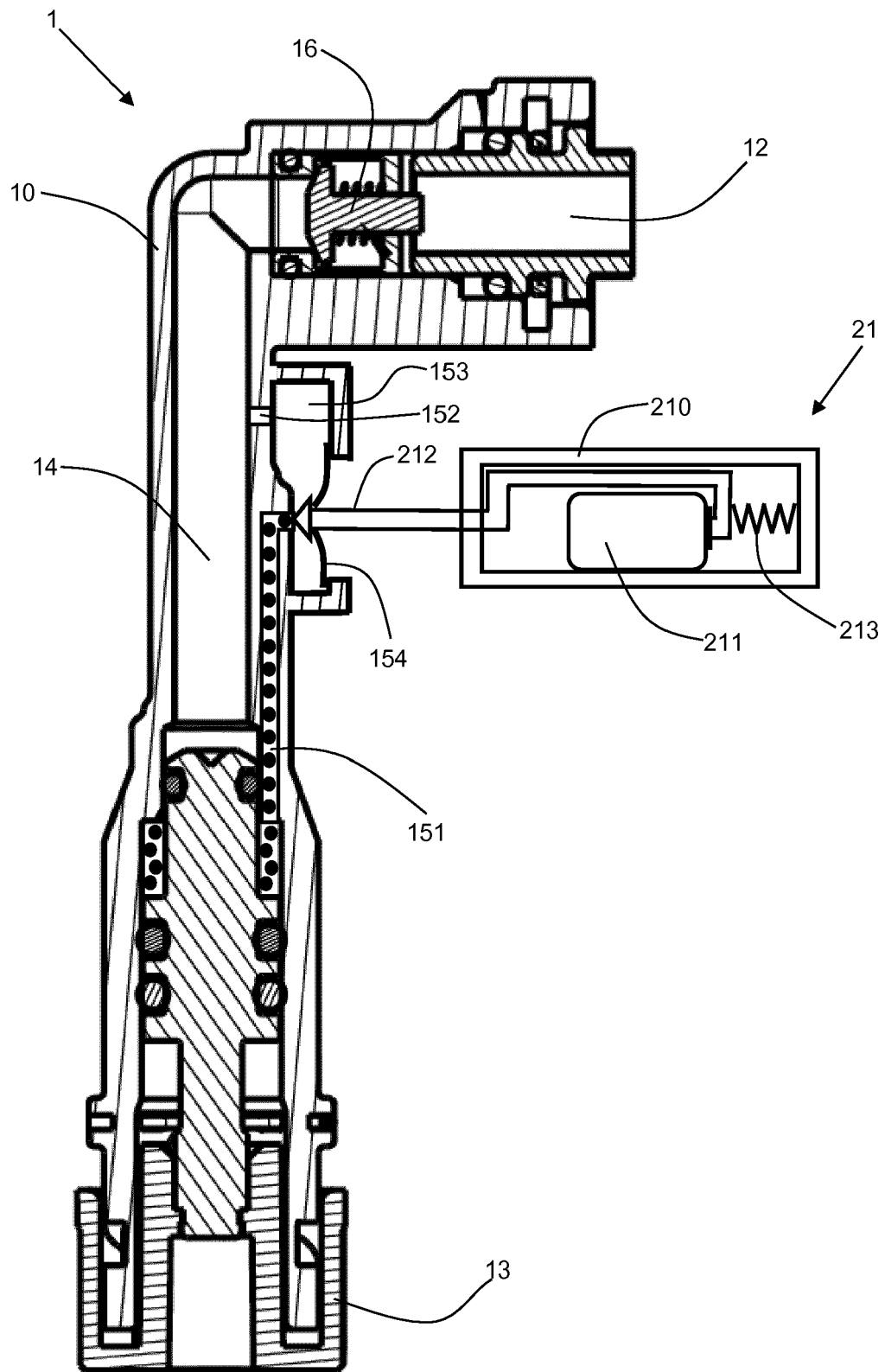


Fig. 3

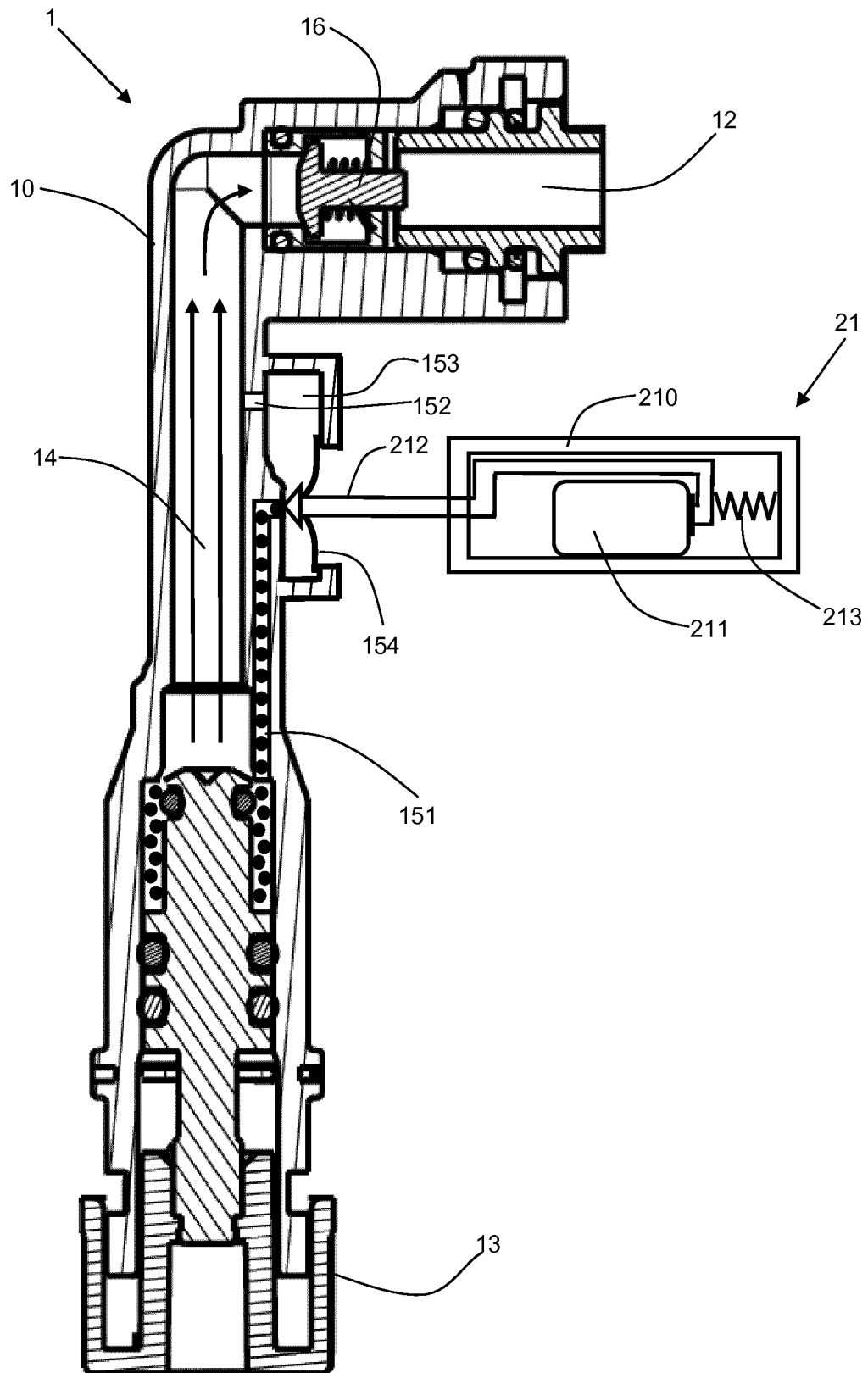


Fig. 4

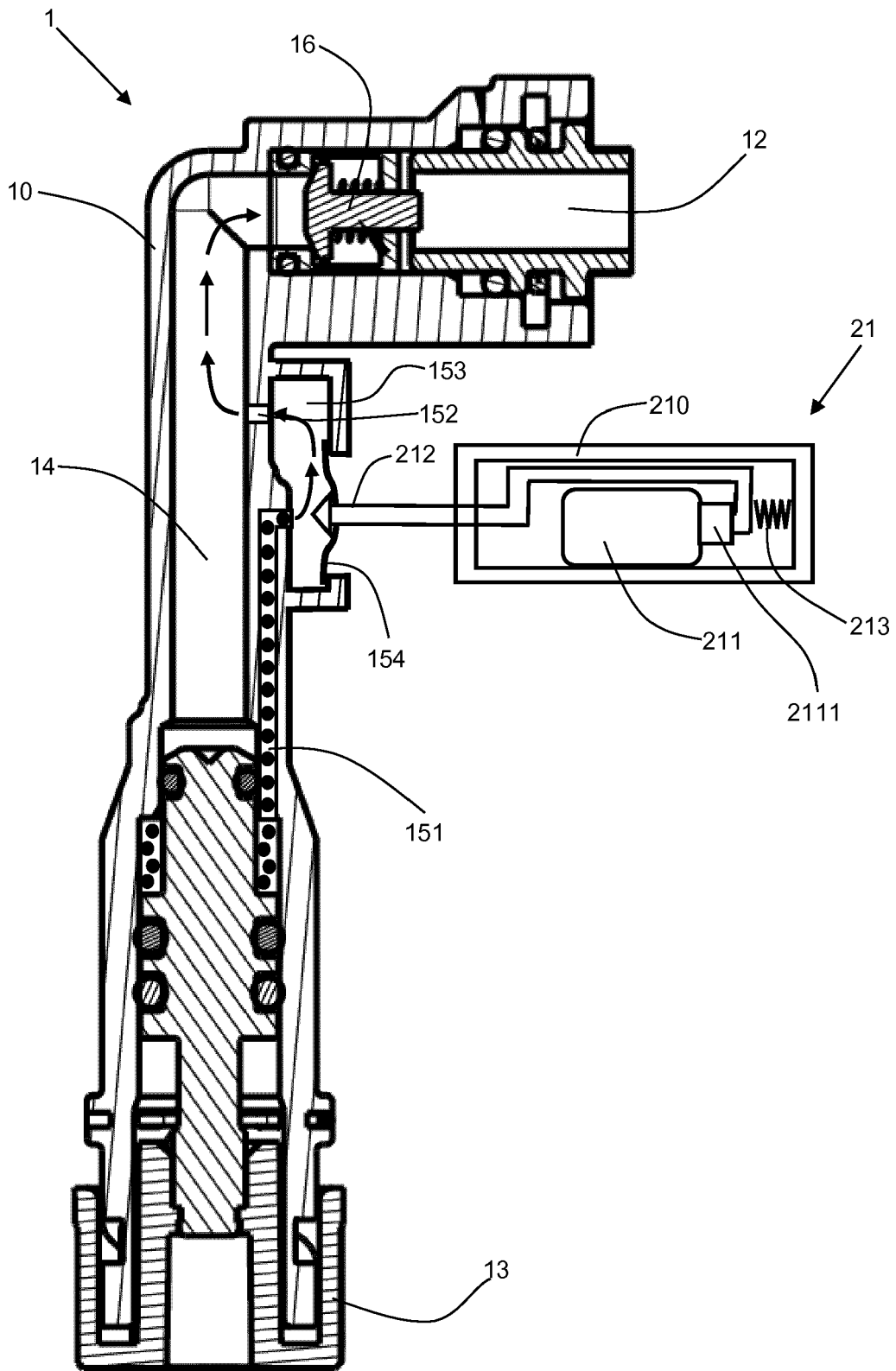


Fig. 5



EUROPEAN SEARCH REPORT

Application Number
EP 19 15 6186

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A	* column 2, paragraph 18 - page 23, paragraph 188; claims 7,8,9,10,11,12,13,14,16; figures 6,10,13,15 *	6,10,11	
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The present search report has been drawn up for all claims			
Place of search Munich		Date of completion of the search 16 July 2019	Examiner Hoffmann, Stéphanie
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EPO FORM 1503 03/02 (P04C01)

**ANNEX TO THE EUROPEAN SEARCH REPORT
ON EUROPEAN PATENT APPLICATION NO.**

EP 19 15 6186

5 This annex lists the patent family members relating to the patent documents cited in the above-mentioned European search report.
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16-07-2019

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