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(54) **Hydraulic device, hydraulic appliance, hydraulic system and method for its use**

(57) The present invention mainly relates to a hydraulic device (1', 1",1'") for hydraulic systems, preferably for water heating systems, provided with a body (4', 4",4"') comprising an inlet duct (6',6",6'"), a first outlet duct (5',5",5'") and a second outlet duct (7', 7", 7"'), as well as with on-off means (2',2",3',3",3"',40",40"') adapted to stop a fluid flow; the on-off means (2',2",3',3",3"', 40",40"') comprise at least two on-off devices (2', 2", 2"', 3', 3", 3"', 40", 40"') adapted to affect a fluid flow in said second outlet duct (7' , 7", 7"'). The present invention also relates to a hydraulic appliance and to a hydraulic system, in particular for heating water, comprising said hydraulic device, as well as to a method of operating such a hydraulic system.

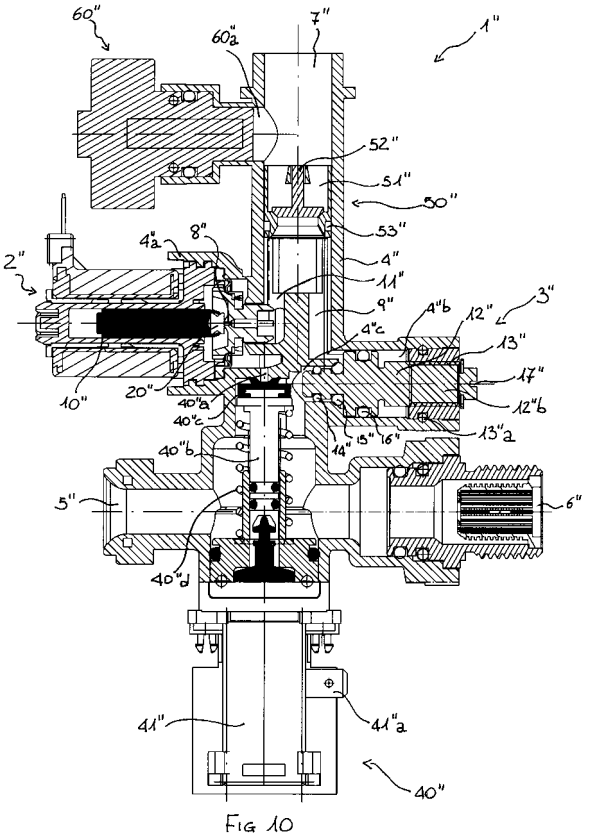

FIG 10

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Description

[0001] The present invention relates to a hydraulic device according to the preamble of claim 1.

[0002] The invention also relates to a hydraulic appliance and to a hydraulic system, in particular for heating water, comprising said hydraulic device, as well as to a method of operating such a hydraulic system.

[0003] The present invention especially applies to the field of household water heating systems, wherein the system is used for heating both the household environments and the water used in sanitaryware.

[0004] These types of systems typically comprise a heating water circuit and a sanitary water circuit.

[0005] The system also comprises at least one heating hydraulic appliance, typically a gas or electric boiler, for heating the water circulating in the system. The heating hydraulic appliance may comprise, for example, only one heater; alternatively, two heaters may be used, one for heating water and the other one for sanitary water, being dependent or independent of each other.

[0006] In hydraulic systems of this kind, before activating the heater it is necessary to fill the heating circuit with heating water; typically, this takes place when the system is turned on for the first time; more precisely, the heating water may, for example, be water taken from the main, possibly with the addition of additives (e.g. antifreeze). As time goes by, the water pressure or level in the heating circuit may decrease, so that the heating circuit must be topped up, i.e. supplied with additional water in order to, for example, restore the proper pressure or level in the circuit and/or to remove air from the plumbing.

[0007] Solutions are available on the market wherein the heating circuit can be filled and topped up by manually operating a tap connected to or associated with a water network plumbing, typically the public water distribution main.

[0008] These solutions suffer from the drawback that filling and topping-up operations must be both carried out manually, so that, for properly operating the system, the user has to check the water pressure or level in the heating circuit periodically and then, if necessary, top up said circuit. In other solutions there is a separate topping-up system, i.e. a plumbing having its own topping-up tap.

[0009] Different solutions use an automatic top-up valve, generally a pressure switch, which opens below a preset pressure and closes when the preset pressure is reached. These automatic valves are subject to malfunctioning due to, for example, seizing caused by a long non-operational time, without providing any indication about their failure.

[0010] All these solutions suffer, however, from the drawback that the topping-up system takes up room, and this may not be acceptable, especially in household applications, due to the little room available. In fact, in household heating hydraulic appliances (typically gas or electric boilers), the available room is often very little both inside the appliance container and in the installation area of the heating appliance.

[0011] The general object of the present invention is therefore to provide a hydraulic device, a hydraulic appliance and a hydraulic system comprising it, which allow to overcome the drawbacks of the prior art, in particular those mentioned above.

[0012] A particular object of the present invention is to fill and top up the system through a single small component which offers the possibility of controlling the topping up of the heating circuit automatically and reliably.

[0013] These and other objects of the present invention are achieved through a hydraulic device, a hydraulic appliance, a hydraulic system and a method to operate the system having the features set out in the appended claims, which are intended as an integral part of the present description.

[0014] The present invention is based on the idea of using at least two hydraulic on-off devices. In particular, these two on-off devices allow to carry out filling and topping-up operations in an effective manner.

[0015] According to the present invention, depending on the different embodiment examples, said at least two on-off devices can be connected, either directly or indirectly, in series and/or in parallel.

[0016] Still according to the present invention, depending on the different embodiment examples, at least one of the on-off devices can be manually or automatically operated; advantageously, the automatic operation can be of the electric type, in particular magnetoelectric or the thermoelectric type, through suitable drive and/or control signals to be sent to the on-off device.

[0017] Some particularly advantageous embodiment examples of the present invention are those which utilize at least three on-off devices, in particular one manually operated device for filling operations and two automatically operated devices (in series or in parallel) for topping-up operations.

[0018] Further objects, features and advantages of the present invention will become apparent from the following detailed description and from the annexed drawings, which are supplied by way of non-limiting example, wherein:

Fig.1 shows a front view of a first embodiment example of the hydraulic device according to the present invention;
Fig.2 shows a side view of the device of Fig.1;
Fig.3 shows a top view of the device of Fig.1;
Fig.4 shows a partially sectional tridimensional view of the device of Fig.1;
Fig.5 shows the device of Fig.1 sectioned along line B-B;
Fig.6 shows the device of Fig.1 sectioned along line A-A;
Fig.7 shows a detail of Fig.6;
Fig.8 shows a tridimensional view of a second embodiment example of the hydraulic device according to the present invention;

Fig.9 shows a partially sectional tridimensional view of the device of Fig.8;
Fig. 10 shows an enlarged sectional front view of the device of Fig.8;
Fig. 11 shows a first tridimensional view of a third embodiment example of the hydraulic device according to the present invention;
Fig.12 shows a second tridimensional view of the device of Fig.11 from a side opposite to Fig. 11;
Fig.13 shows a sectional front view of the device of Fig. 11;
Fig. 14 shows the device of Fig.11 sectioned along line D-D;
Fig. 15 partially shows a first example of a household water heating hydraulic appliance according to the present invention;
Fig. 16 partially shows a second example of a household water heating hydraulic appliance according to the present invention.

[0019] The following description will refer to three embodiment examples of the hydraulic device according to the present invention.

[0020] Said embodiment examples are intended as non-limiting examples of the invention, aiming at providing the man skilled in the art with the information necessary for implementing the invention defined in the claims appended hereto.

[0021] An important feature common to all three embodiment examples of the hydraulic device according to the present invention is the fact that they provide a single component, in particular a small one; thus, these components can be easily and effectively inserted in hydraulic appliances and/or in hydraulic systems, in particular for domestic use.

[0022] Such devices, appliances and systems are particularly adapted to operate with water or watery mixtures, but the use of different fluids should not be excluded.

[0023] A particularly advantageous application of the present invention is found in the field of heating by circulation of water or other liquids; nevertheless, the present invention may also be advantageously applied to the field of conditioning by circulation of water or other liquids.

[0024] In general, the hydraulic device according to the present invention is designated as a whole by reference numeral 1. In the first embodiment example, the device is designated by reference numeral 1'; in the second embodiment example, the device is designated by reference numeral 1"; in the third embodiment example, the device is designated by reference numeral 1"'.

[0025] The following will first describe the first embodiment example (with reference to the drawings from Fig. 1 to Fig.7), followed by the description of the second embodiment example (with reference to the drawings from Fig. 8 to Fig. 10) and, finally, by the description of the third embodiment example (with reference to the drawings from Fig. 11 to Fig. 14).

[0026] For clarity, it is worth mentioning beforehand that the first embodiment example comprises two on-off devices connected together hydraulically in parallel, in particular a manually operated device for filling operations and an automatically operated device for topping-up operations, whereas the second and the third embodiment examples comprise three on-off devices, i.e. one manually operated device for filling operations and two automatically operated devices (connected together hydraulically in series) for topping-up operations.

[0027] Said second and third embodiment examples turn out to be particularly advantageous not only as such, but also in comparison with the first embodiment example, in particular as concerns the safety and reliability of the hydraulic device according to the present invention and/or the diagnostic capability of the hydraulic device according to the present invention.

[0028] Also, it is worth making clear that some advantageous aspects of the present invention in relation to the connection in series of two on-off devices will be described with reference to the second and third embodiment examples, such aspects being nonetheless independent of the presence, in these examples, of a third on-off device connected hydraulically in parallel to the first two.

[0029] In all three embodiment examples, the hydraulic device according to the present invention comprises at least one body having an inlet duct, a first outlet duct and a second outlet duct, as well as on-off means adapted to stop a fluid flow. Furthermore, the on-off means of these examples are adapted to be in at least a first, a second and a third operating configurations; the first operating configuration is such that fluid flow is prevented from the inlet duct to the second outlet duct, the second operating configuration is such that a first amount of fluid flow is allowed from the inlet duct to the second outlet duct, the third operating configuration is such that a second amount of fluid flow is allowed from the inlet duct to the second outlet duct. The first operating configuration has been conceived as a system operating status, i.e. the condition the system is in when it performs its primary function, e.g. when a heating system circulates hot water in radiators.

[0030] In the first embodiment example (Figs. 1-7), the device 1' is essentially a hydraulic T-shaped fitting comprising a hollow body 4', wherein water enters through an inlet duct 6', flows through the hollow body and exits through two outlet ducts 5' and 7', one of which (in the example of Fig. 1, the duct 7') is a controlled outlet, while the second outlet (in the example of Fig. 1, the duct 5') is always open.

[0031] The device 1' comprises on-off means adapted to affect the liquid flow in the duct 7'; preferably, said on-off means are adapted to be in at least three operating configurations and to determine at least three corresponding fluid flows (in the outlet 7'), not necessarily being different from one another.

[0032] Depending of the application, the on-off means

may be manifold type; for example, in systems using liquids at low pressures (preferably lower than 0.1 bar), said on-off means may comprise at least one solenoid valve or a valve adapted to control the opening and closing of the shutter only through the force of its own actuator, preferably by changing the outlet section of the duct 7'; said valve will hereafter also be referred to as a direct on-off valve or a direct-control valve.

[0033] In household heating systems, the water in the mains typically has a pressure between 0.2 and 10 bar, so that the above-described valves cannot be easily used and different on-off means are to be preferred, such as, for example, solenoid valves exploiting the same pressure of the fluid in order to assist the switching of the shutter; these valves will hereafter also be referred to as servo-assisted valves.

[0034] Back to the preferred embodiment example for heating systems, the outlet duct 7' comprises internally a main duct 11' and a by-pass duct 9'.

[0035] The main duct 11' has an aperture 4'c, or through seat, and an aperture 8', which are opened or closed by respective on-off means, in particular by a tap or by-pass valve 3' that allows or prevents water flow through the aperture 4'c, while a direct on-off valve 2' allows or prevents water flow through the aperture 8'.

[0036] The larger the aperture 8', the higher the forces to be countered by the valve 2' in order to close the aperture 8'.

[0037] Being desirable to obtain a small device, and taking into account the above-stated maximum pressure in the water mains, the aperture 8' cannot be too large, otherwise it could not be closed by a standard valve 2', thus requiring valves having too big actuators and excessive forces.

[0038] According to a preferred embodiment, an optimal size of the aperture 8' has been estimated to be about 0.5 mm^2; in this case, the fluid will typically exert a thrust of approximately 50 gr, which can be countered by a spring adapted to exert a thrust of approximately 100 gr in the closed position.

[0039] These values, however, do not provide a large or "important" water flow, i.e. which allows to fill an environmental heating circuit within a relatively short or reasonable time.

[0040] The water flow passing through the aperture 8' is nonetheless still sufficient for topping up the environmental heating circuit.

[0041] The complete filling of the circuit can take place thanks to a by-pass duct 9' in the device 1', through which a higher flow rate of water can be supplied to the outlet duct 7'.

[0042] According to the preferred embodiment, the main duct 11' and the by-pass duct 9' run substantially parallel along an axis AA and can be put in communication by means of a through seat 4'c (transversal to the axis AA) of the by-pass valve 3'.

[0043] Preferably, the by-pass valve 3', which is substantially a manual tap, is integrated with the main body 4' of the device 1' and comprises a mobile shutter 12'; said shutter 12' can slide in the seat 4'c and can therefore stop the fluid flow coming out from the by-pass duct 9' before it enters the main duct 11'.

[0044] At the lower end 12'a of the shutter 12', i.e. the end facing the main duct 11', there is a first sealing element 14', e.g. a gasket or an O-ring, adapted to prevent any leakage from said by-pass duct 9' into the central duct 11', or vice versa, when the tap 3' is in the closed position, i.e. when the end 12'a is housed in the through seat 4'c.

[0045] In the central portion of the shutter 12' there is a second sealing element 15', e.g. a gasket or an O-ring, adapted to prevent any leakage from the by-pass duct 9' to the outside of the device 1'.

[0046] The upper portion 12'b of the shutter has a threaded structure adapted to cooperate with a threaded plug or element 13' being present in the seat 4'b of the by-pass valve 3'.

[0047] Substantially at one end of the threaded element 13' there is a groove 13'a, which is used for the insertion of a catch or locking pin, e.g. a U-shaped, in order to keep the threaded element 13' in its position.

[0048] At the upper end, the shutter 12' has a seat 17' for a suitable tool or wrench, such as an Allen key, in order to allow the tap 3' to be operated, preferably by qualified personnel.

[0049] Returning now to the on-off means of the aperture 8', according to the preferred embodiment shown in the annexed drawings, the direct on-off valve is a solenoid valve 2' connected to the end 4'a of the main body 4' of the hydraulic device 1', and is, for example, of a type having an internal structure similar to the one shown and detailed, for example, in the American patent US 4,776,559 to the present Applicant (to be precise, it should be noted that, in this American patent, the actuator is electrothermal type, not electromagnetic type as in the hydraulic device 1').

[0050] According to the present invention, the solenoid valve 2' is direct-control type, i.e. the opening and closing of said solenoid valve takes place through direct driving of a shutter 10', which is moved by the magnetic field generated within a magnetic core due to electric current running through a coil . The magnetic field therefore causes the movement of the shutter 10', on which a rubber piece 20' is mounted which opens and/or closes the aperture 8'. In this configuration, the movement of the shutter 10' is countered only by a spring being present within the magnetic core, the force of which is opposite to the force exerted by the water column or pressure.

[0051] From a functional point of view, the present invention would be equally advantageous even if the solenoid valve 2' were replaced with a different type of valve, such as, for instance, a valve being servo-assisted by fluid pressure (not shown in the annexed drawings pertaining to the first embodiment example). A servo-assisted valve having suitable features for use in the hydraulic device 1' may have, for example, an internal struc-

ture being similar to the one described in detail, for example, in the European patent application EP 0 599 341 to the present Applicant.

[0052] However, servo-assisted valves suffer from the drawback that, if the pressure of the water in the duct 11' is higher than the pressure of the water supplied from the inlet duct 6', the necessary servo-assistance forces will not be provided and water will flow back from the hydraulic circuit downstream of the outlet duct 7' to the inside of the device 1, i.e. to the ducts 5' and 6'.

[0053] In order to avoid this problem, which could nevertheless also arise in the event of a faulty solenoid valve, a non-return valve 50', or unidirectional valve, is preferably mounted to the outlet duct 7' of the hydraulic device 1'.

[0054] The non-return valve 50', which is known to the man skilled in the art, is of the type comprising at least one hollow cylindrical body 51' inserted in the duct 7' through a respective sealing element or 0-ring 53'.

[0055] The valve 50' also comprises an inner shutter 52', e.g. having a substantially "mushroom-like" shape, i.e. comprising a stem which can slide in a central seat of said hollow cylindrical body 51' and an end cap adapted to close a suitable seat, thus stopping the water flow.

[0056] According to the present invention, said non-return valve 50' may advantageously comprise some elements, e.g. the hollow cylindrical body 51', obtained directly from the body 4' of the device 1'. This solution turns out to be advantageous for several reasons: on the one hand, it reduces the risks of leakage in the contact areas between the main body 4' of the hydraulic device 1' and the cylindrical body 51' of the non-return valve 50', while on the other hand the gasket 53' is no longer necessary (thus reducing the number of components used, and therefore the cost of the device).

[0057] The hydraulic device 1' may also advantageously comprise a sensor for detecting a significant parameter of the fluid flowing in the device, e.g. temperature, hardness, flow rate, etc.

[0058] In the preferred embodiment example, an axial-turbine flow meter 30' is housed in a seat located on the outlet duct 5'.

[0059] The flow meter 30' comprises a mobile element 18' and at least one magnetic element 19', which are adapted to generate or modify a magnetic field; the electric detector 21' is adapted to detect said magnetic field; according to the present invention, the electric detector 21' may be a Hall-effect sensor or, alternatively, a Reed sensor.

[0060] The mobile element 18' may have any shape and be moved by a fluid flow in different ways; for example, it may be translated or rotated or rotated and translated or turned by the fluid flow; the motion of the mobile element may be free or braked or countered or subject to a reaction, for example, for effect of an elastic element, in particular a spring, acting directly or indirectly onto it.

[0061] In the preferred embodiment of a hydraulic device according to the invention, shown in Figs. 1 to 6, the mobile element is an "impeller", since it is turned by the fluid flow.

[0062] The magnetic element 19' is an element capable of generating or modifying a magnetic field, and may be a permanent magnet, a magnetized element or an element made of ferromagnetic material, or any other element adapted to produce a signal variation in a magnetic sensor.

[0063] The magnetic element 19' may be fixed or mobile, in particular mounted to or built in the mobile element 18'; moreover, the mobile element 18' itself may be magnetic as well, e.g. it may be at least partly magnetized or made of ferromagnetic material.

[0064] The preferred embodiment of a hydraulic device according to the invention, shown in Figs. 1 to 6, employs an impeller to which at least one permanent magnet is mounted.

[0065] The hydraulic device 1' is so provided that, in the presence of fluid flowing through it, a magnetic field is generated the value and/or variation of which depends on the fluid flow, in particular on the velocity and/or quantity and/or flow rate thereof.

[0066] The electric detector 21' is a unit capable of detecting said magnetic field value and/or variation and, consequently, of generating directly or causing the generation of an electric signal, e.g. an analog or digital signal.

[0067] In general, this unit may consist of several mechanic, electric and electronic components, but it comprises at least one magnetic sensor, i.e. an electric or electronic component which is capable of sensing a magnetic field or a variation in a magnetic field.

[0068] The electric signal generated or caused by the electric detector 21' may be detected and/or used by a control unit of a user apparatus, such as the control unit of a water heater (in particular a boiler) in a water heating system.

[0069] In fact, the hydraulic device 1' is adapted to be included in, for example, a water heating system like that shown in Figs. 15 and 16. Said flow meter may however be of any other known type.

[0070] According to the present invention, and with reference to the second embodiment example (Figs. 8 to 10), the hydraulic device is designated as a whole by reference numeral 1".

[0071] Like the device 1' (Figs. 1 to 7), also the device 1" (Figs. 8 to 10) is essentially a hydraulic T-shaped fitting comprising a hollow body 4", wherein water enters through an inlet duct 6", flows through the hollow body and exits through two outlet ducts 5" and 7", one of which (in the example of Figs. 8-10, the duct 7") is a controlled outlet, while the second outlet (in the example of Figs. 8-10, the duct 5") is always open.

[0072] The device 1" comprises on-off means adapted to affect the liquid flow in the duct 7"; preferably, said on-off means are adapted to be in at least three operating configurations and to determine at least three corresponding fluid flows (in the outlet duct 7"), not necessarily

being different from one another.

[0073] The outlet duct 7" comprises internally a main duct 11" and a by-pass duct 9".

[0074] The main duct 11" has an aperture 4"c, or through seat, an aperture 8" and an aperture 40"a which are opened or closed by respective on-off means; in particular, a tap or by-pass valve 3" allows or prevents water flow through the aperture 4"c, while a servo-assisted valve 2", preferably an electrically controlled one, allows or prevents water flow through the aperture 8" and a direct on-off solenoid valve 40", e.g. actuated by an electrothermal element, allows or prevents water flow through the aperture 40"a; the two on-off means 2" and 40" are arranged in series.

[0075] As far as the direct on-off valve 40" is concerned, the respective aperture is preferably small (otherwise too big and strong valve mechanisms and actuators would be needed) and therefore the quantity of water allowed to flow therethrough is small, especially if we consider the supply requirements of a hydraulic system like a household heating system. The fact that there is an additional servo-assisted valve 2" downstream of the direct-on-off valve 40" does not affect the above considerations about the dimensions of the aperture associated with the latter.

[0076] In order to allow the system to be filled, the device 1" is provided with a by-pass duct 9", through which a higher flow rate of water can be supplied to the outlet duct 7".

[0077] In the preferred embodiment, the main duct 11" and the by-pass duct 9" run at least partly substantially parallel to each other along an axis AA.

[0078] Preferably, the by-pass valve 3" is integrated with the main body 4" of the device 1" and comprises a mobile shutter 12" which can slide in a seat 4"c communicating with the duct 9" and can thus stop the fluid flow entering the duct 9"; the seat 4"c is a through hole being transversal, in particular substantially orthogonal, to the axis A-A, and is used for housing at least partly the valve 3"; in particular, said hole leads into a chamber immediately upstream of the main duct 11".

[0079] At the lower end of the shutter 12", i.e. the end facing the ducts 5" and 6", in particular facing a chamber immediately upstream of the main duct 11", there is a first sealing element 14", e.g. a gasket or an O-ring, adapted to prevent any leakage from said by-pass duct 9" into the ducts 5" and 6", in particular into a chamber immediately upstream of the main duct 11", or vice versa, when the tap 3" is in the closed position, i.e. when the end 12"a is housed in the through seat 4"c.

[0080] In the central portion of the shutter 12" there are a second and a third sealing elements 15" and 16", e.g. a gasket or an O-ring; the element 15" provides additional sealing onto the duct 4"c, i.e. works in aid of the element 14"; the element 16" is adapted to prevent any leakage from the by-pass duct 9" to the outside of the device 1".

[0081] The upper portion 12"b of the shutter has a threaded structure adapted to cooperate with a threaded element 13" being present in the seat 4"b of the by-pass valve 3".

[0082] Substantially at one end of the threaded element 13" there is a groove 13"a, which is used for the insertion of a catch or locking pin, e.g. U-shaped, in order to keep the threaded element 13" in its position.

[0083] At the upper end, the shutter 12" has a seat 17" for a suitable tool or wrench, such as a screwdriver, in order to allow the tap 3" to be operated, preferably by qualified personnel.

[0084] Referring now again to the on-off means of the aperture 8", in the preferred embodiment shown in the annexed drawings the valve 2" is a solenoid valve which is servo-assisted by fluid pressure and is, for example, of a type having an internal structure similar to the one illustrated and described in detail, for example, in the European patent EP 0 599 341 to the present Applicant.

[0085] According to the present invention, the solenoid valve 2" is servo-assisted type and the opening and closing of said solenoid valve takes place through a shutter 10" which is moved by the magnetic field generated within a magnetic core due to electric current running through a coil. The magnetic field thus causes the movement of the shutter 10", on which a rubber piece 20" is mounted which opens and/or closes the aperture 8"; the opening of the passage 8", which is small, determines pressure variations in the chamber housing the core or shutter 10", which variations move a second mobile shutter, i.e. the one in which the passage 8" is obtained, which in turn opens a larger duct; this operation is typical of servo-assisted valves. In this configuration, the movement of the shutter 10" is counteracted by a spring being present inside the magnetic core.

[0086] From a functional point of view, this second embodiment example, like the first one, would be equally advantageous should the solenoid valve 2" be replaced with a different type of valve, such as a direct on-off valve.

[0087] In order to avoid the loss of the necessary servo-assistance forces in the event of a solenoid valve failure, resulting in water flowing back from the hydraulic circuit downstream of the outlet duct 7" to the inside of the device 1", a non-return valve 50" is mounted on the outlet duct 7" of the hydraulic device 1".

[0088] The non-return valve 50", which is known to the man skilled in the art, is of a type comprising at least one hollow cylindrical body 51" inserted in the duct 7" through a respective sealing element or O-ring 53".

[0089] The valve 50" also comprises an inner shutter 52", e.g. having a substantially "mushroom-like" shape, i.e. comprising a stem which can slide in a central seat of said hollow cylindrical body 51" and an end cap adapted to close a suitable seat, thus stopping the water flow.

[0090] According to the present invention, said non-return valve 50" may advantageously comprise some elements, e.g. the hollow cylindrical body 51", obtained directly from the body 4" of the device 1". This solution turns out to be advantageous for several reasons: on the

one hand, it reduces the risks of leakage in the contact areas between the main body 4" of the hydraulic device 1" and the cylindrical body 51" of the non-return valve 50", while on the other hand the gasket 53" is no longer necessary (thus reducing the number of components used, and therefore the cost of the device).

[0091] Referring now again to the on-off means of the aperture 40"a, in the preferred embodiment shown in the annexed drawings the valve is controlled by an electrothermal shutter.

[0092] According to the present invention, the valve 40" is direct-control type, i.e. the opening and closing of the valve take place through a shutter 40"b, ending with a sealing element 40"c, moved by a thermoelectric element 41" which is actuated electrically through terminals 41"a. Said terminals are advantageously connected to an electric source or to a drive or control circuit through wires not shown in the drawing for simplicity's sake.

[0093] The thermoelectric element 41" is, for example, of a type having an internal structure similar to the one illustrated and described in detail, for example, in the European patent application EP 0 940 577 to the present Applicant.

[0094] It is worth remarking that, in the present example, the thermoactuator 41" is "pull" type, i.e. when supplied with power it exerts a pulling action towards its own body, although its thermic element is "push" type; of course, the thermic element is suitably oriented for this purpose inside the element 41", in opposition to a reaction element or spring 40"d.

[0095] According to the present invention, the thermoelectric element 41" is advantageously coupled mechanically to the shutter 40"b, e.g. by means of a plug-in or bayonet type coupling system. The electromechanical drive of the thermoelectric element 41" moves the shutter 40"b, which is pulled towards said thermoelectric element 41".

[0096] The larger the aperture 40"a, the higher the force that must be exerted by the valve 40" in order to keep the aperture 40"a closed through said contrast spring 40"d adapted to push the shutter 40"b, and therefore the higher the forces to be overcome by the thermoelectric element 41".

[0097] Being desirable to use a small valve, and taking into account the actual pressures involved, the aperture 40"a cannot be too large, otherwise it could not be closed by a standard valve 40", thus requiring bigger valves.

[0098] The above considerations pertaining to the connection between forces and sections generally apply to all direct on-off valves used in the embodiment examples described herein, in particular to the direct on-off valve 2' of the first embodiment example.

[0099] As in the device 1', in a preferred embodiment of the hydraulic device 1" an optimal size of the aperture associated with the direct on-off valve has been estimated to be about 0.5 mm^2; in this case, the fluid will typically exert a thrust of approximately 50 gr, which can be counteracted by a spring adapted to exert a thrust of approximately 100 gr when in the closed position.

[0100] These values, however, do not provide an "important" water flow, i.e. which allows to fill up an environmental heating circuit within a reasonable time. The water flow passing through the aperture 40" is nonetheless still sufficient for topping up the environmental heating circuit.

[0101] The two valves 40" and 2" provide a "double safety function", in that they are hydraulically connected together in series; should one of them fail, the other one will still ensure the closing of the inlet duct, thus preventing the circuit from being over filled and avoiding any risks of damage or waste of water.

[0102] The use of two different types of valves, i.e. an electromagnetic valve (which operates rapidly) and a thermoelectric valve (which operates slowly), can improve the performance of the system, e.g. by providing a slow closing, thus preventing the known phenomenon called "water hammer".

[0103] To this end, the electric connection of said valves may be distinct, so that they can be opened or closed at different times or in different ways; however, in general, an electric connection of said valves in parallel should not be excluded either.

[0104] Moreover, the presence of valves of different types may improve safety, because they are subject to different potential causes of failure.

[0105] The hydraulic device 1" may also advantageously comprise a sensor for detecting a significant parameter of the fluid flowing in the device, e.g. flow rate, temperature, hardness, pressure, etc.

[0106] In the preferred embodiment example, a pressure sensor 60" is housed in a seat 60"a located on the outlet duct 7" and is electrically connected, for example, to a system control unit (the wiring harness for the electronic connection between the sensor and the control unit and the control unit itself are not shown for simplicity's sake).

[0107] The pressure sensor 60" is adapted to detect the pressure in the outlet duct 7"; said sensor 60" can therefore be useful for detecting any anomalous pressure increase or decrease in the system.

[0108] The electric signal generated or caused by the pressure sensor 60" can be detected and/or utilized by a control unit, for example, in order to control topping up or filling operations automatically of the system.

[0109] The hydraulic device 1" is also adapted to be included in a water heating system, as shown in Figs. 15 and 16.

[0110] According to the present invention, and with reference to the third embodiment example (Figs. 11 to 14), the hydraulic device is designated as a whole by reference numeral 1"'.

[0111] Like the hydraulic devices 1' and 1", also the hydraulic device 1"' is essentially a hydraulic T-shaped fitting.

[0112] The hydraulic device 1"' bears many conceptual similarities to the device 1", though it features a number of advantageous implementation differences.

[0113] Like the hydraulic device 1", also the hydraulic device 1'" comprises two on-off devices 2'" and 40'" arranged in series; however, in this example, they are two electromagnetically controlled solenoid valves (though they may alternatively be both electro thermally controlled valves or different types of valves) of the type being servo-assisted by fluid pressure.

[0114] The main duct 11"' is subdivided into three sections 11"'a, 11"'b, 11"'c arranged in series. The valve 2"', through the servo-assisted movement of its shutter driven by the core 10"', allows to connect the section 11"'b to the downstream section 11"'c. The valve 40"', through the servo-assisted movement of its shutter driven by the core 10"", allows to connect the section 11"'a to the downstream section 11"'b.

[0115] The inlet duct 6"' and the outlet duct 5"' are substantially aligned (in particular coaxial) and substantially the same size (a filter applied to the inlet duct 6'" may alternatively be incorporated in the duct itself).

[0116] The duct 11"' extends in a substantially linear direction being transversal, in particular substantially orthogonal, to the axis of the duct 5"' and/or of the duct 6"', up to the duct 7"'.

[0117] The by-pass duct 9"' is somewhat shorter than the main duct 11"'; it extends in a substantially linear direction being transversal, in particular substantially orthogonal, to the axis of the duct 5"' and/or of the duct 6"', up to the seat 4"'c of the tap 3"'; the seat 4"'c is located in the immediate vicinity of the duct 7"', i.e. close to the outlet of the device 1"'; advantageously, the ducts 9"' and 11"' have substantially parallel axes.

[0118] In the body 4"' of the device 1"' there are two seats 4"'a and 4""a adapted to house at least partly the valves 2'" and 40"', respectively. The two valve seats are close side by side, and preferably have an axis which is transversal, in particular substantially orthogonal, to the duct 11"'. Also the tap seat has an axis being transversal, in particular substantially orthogonal, to the duct section 11"'c. For the purpose of optimizing the arrangement of the various items in the device 1 "', the axes of the seats 4"'a, 4"'b and 4"'c are advantageously substantially parallel to one another; in particular, the tap seat is located on a side opposite to both valve seats.

[0119] In this third embodiment example, since both valves are servo-assisted type, there are theoretically no limits to the choice of the respective flow sections, and thus there are theoretically no limits to the flow in the duct 11"'. Said configuration may therefore allow for a rapid automatic filling of the whole system.

[0120] Thanks to the arrangement of the various items according to this third embodiment example (or to similar arrangements), it is possible to provide a double pressure measurement without any increase in dimensions. In this regard, one may use a pressure sensor 60'" comprising a first measuring element 61"' and a second measuring element 62"'; the element 61"' is adapted to measure the pressure in the inlet duct 6"', whereas the element 62'" is adapted to measure the pressure in the outlet duct 7"'. As an alternative to the above, it would likewise be possible to use a sensor capable of directly providing a pressure difference.

[0121] The sensor 60'" features very clever mechanical solutions; in fact, it utilizes a cylindrical body from which two ducts come out, in particular two small tubes preferably having a circular cross-section; one tube is associated with the element 61"', while the other is associated with the element 62"'.

[0122] Said tubes are inserted in two adjacent holes or seats in the body 4"' of the hydraulic device 1"'. Thus the tubes are in communication with the main duct 11'" and with the by-pass duct 9"'; in particular, one duct is in communication with the section 11"'c downstream of the shutter 10'" of the valve 2"" (i.e. with the outlet duct 7"', too), while the other duct is in communication with the duct 9"' immediately upstream of the seat 4"'c of the tap 3"'. Therefore, the two elements 61"' and 62"', which are preferably located in the body of the sensor 60'" in a position close to its outer surface, are able to carry out the above-mentioned pressure measurements.

[0123] The vicinity of said two elements 61'" and 62'" and/or of the respective seats in the body 4"' allows to manufacture a single pressure sensor having a dual inlet and small dimensions.

[0124] As shown in Fig.14, the elements 61"' and 62'" are associated with a support element which may typically be a printed circuit or an electronic circuit; electric connections are then associated with said circuit for carrying the signals of both detection elements out of the body of the sensor 60"'; in Fig. 12, said electric connections are represented by four electric leads, but one may also use a suitable electric connector or welded contacts, or else a different number or type of connections. Additional electric and/or electronic components may be associated with the support element, in particular with the printed circuit; thus, the signals of both elements 61"' and 62'" may, for example, be amplified and/or processed and/or stored (e.g. by a microcontroller or even a simpler circuitry); in such a case, the measurements carried out may also be sent, for example, to an electronic control unit through two electric leads only, e.g. by means of a serial connection.

[0125] From a construction viewpoint, for the purpose of applying or coupling the sensor 60'" easily to the body 4"', e.g. by inserting the small tubes of the sensor 60'" into the body 4"', the respective axes shall be substantially parallel. Also, for obtaining a proper arrangement of the sensor 60"', it is advantageous that these axes are transversal, in particular substantially orthogonal, to both the duct 9'" and the duct 11'"; more in particular, said axes shall also be substantially orthogonal both to the axes of the seats 4"'a and 4""a of the valves and to the seat 4"'c of the tap; thus, the sensor body will be positioned on one side of the body 4"' of the hydraulic device.

[0126] Of course, the body of the pressure sensor (single or double) may also be at least partly built in the body of the hydraulic device. In this case, the removable part

may be the support (e.g. the printed circuit) of the measurement element(s) (at least during the assembly stage).

[0127] Thanks to the system providing a double pressure measurement or a pressure difference measurement, it is possible to avoid to associate a non-return valve (which in fact is not shown in Fig.11 to Fig.14) with the hydraulic device 1"'. In fact, it is conceivable that both on-off devices 2'" and 40'" are opened only when the pressure at the inlet of the device (substantially in the duct 6"') is higher than the pressure at the outlet of the device (substantially in the duct 7"'), in particular higher than a predetermined value; thus, there can be no risk of a backflow from the outlet of the device to the inlet of the device. In this case, it is preferable that at least one of the two devices is direct-control type, since this type can ensure the interruption of the flow between the inlet and the outlet even in the presence of anomalous pressures. In any case, a non-return valve may nonetheless be used as a safety measure should the solenoid valves fail.

[0128] In general, the hydraulic device according to the present invention comprises electric connection means for at least the on-off devices; said connection means are so connected that the operation or control of the on-off devices can take place either jointly or separately, in particular through same or respective electric signals.

[0129] In the hydraulic device according to the present invention, it is conceivable to use at least one printed circuit (not shown in the drawings) which connects to at least some actuation or on-off devices and/or some sensor means; such a printed circuit incorporates or is provided with at least one electric connector, preferably obtained from the printed circuit itself, which is shaped suitably for this purpose, in particular for its connection to the user apparatus, at least a portion of said printed circuit being preferably housed at least partly in a seat of the body (not shown in the drawings).

[0130] Two similar applications of hydraulic devices according to the present invention will now be described. These applications are embodiment examples of hydraulic appliances according to the present invention and will be described with reference to Fig.15 and Fig.16.

[0131] As said, the hydraulic device according to the present invention may advantageously be used, for example, in a gas or electric boiler, typically for domestic use, in order to provide both the filling, in particular the manual filling, and the topping up, in particular the automatic topping up, of the same.

[0132] In Fig. 15 and Fig. 16, the hydraulic appliance is designated by numerals 100' and 100", respectively.

[0133] It should be noted that reference numerals will hereafter be indicated without any apostrophe when referring to both appliances, with one apostrophe when referring to the first appliance only, i.e. the one of Fig.15, or with two apostrophes when referring to the second appliance only, i.e. the one of Fig.16.

[0134] The hydraulic device according to the present invention, which is a single component, is designated by reference numeral 101, in particular 101' in the case of Fig. 15 and 101" in the case of Fig.16. In the non-limiting examples of said figures, for simplicity's sake, the devices 101' and 101" are schematized as a solenoid valve and a tap connected together in parallel, and are located essentially in the same position as the flow meter 130. However, said solenoid valve may advantageously be replaced with two or more valves, e.g. arranged in series, as in the case of the devices 1" and 1"' according to the invention; also, said manual tap may be replaced with an automatic or controlled valve.

[0135] The device 101 comprises an inlet duct 106, a first outlet duct 105 and a second outlet duct 107, and the flow meter 130 is associated with the first outlet duct 105.

[0136] It should be noted that reference numerals higher than one hundred have been used for describing the applications of Fig.15 and Fig.16 in order to have the elements of the hydraulic devices comprised in said applications match the elements of the hydraulic devices described above; in particular, the reference of the first outlet duct 105 of the devices 101 corresponds to the reference of the first outlet duct 5 of the devices 1, the reference of the second outlet duct 107 of the devices 101 corresponds to the reference of the second outlet duct 7 of the devices 1, and the reference of the inlet duct 106 of the devices 101 corresponds to the reference of the inlet duct 6 of the devices 1.

[0137] In both of the appliances schematized in the drawings, the components 101' and 101", in particular their inlet ducts 106' and 106", are respectively connected to the main inlet of the appliance; said inlet is typically connected to the water supply network of the hydraulic system of the house or building, i.e. connected to the water meter through suitable plumbing.

[0138] In the following description of the appliances, reference will be made to hydraulic connections among the various components; such connections may be either direct or indirect, i.e. provided through one or more hydraulic devices such as, for example, valves or meters.

[0139] Both of the appliances schematized in the drawings comprise first hydraulic coupling means 180 to be connected to a first hydraulic circuit for sanitary water and second hydraulic coupling means 190 to be connected to a second hydraulic circuit for heating water. In particular, the first means 180 comprise a main inlet 181 (for cold water), an outlet 182 for hot sanitary water, an outlet 192 for heating water (the "delivery" of the heating hydraulic circuit), an inlet 191 for heating water (the "return" of the heating hydraulic circuit).

[0140] It is now worth making a few considerations regarding household hydraulic systems, which generally comprise at least one hydraulic circuit for heating water and at least one hydraulic circuit for sanitary water.

[0141] The heating circuit is substantially a "closed circuit", i.e. a liquid circulates continuously between a boiler and suitable radiators adapted to heat the environment;

the liquid is generally water, with the possible addition of additives, e.g. antifreeze, etc.

[0142] On the contrary, the sanitary circuit is substantially an "open circuit", in which water (from the public main) flows in, is heated and then flows out through the taps of the house (generally for alimentary or hygienic use); usually a drain is available at each tap for draining the water (e.g. into the public drainage system).

[0143] The two circuits (i.e. the heating and the sanitary circuits) are substantially independent of each other.

[0144] In Fig.15, the first outlet 105' is connected to the inlet 106' through a duct which is preferably always open; near the outlet 105', there is preferably at least one sensor 130', such as a flow meter; said sensor may however be mounted or connected hydraulically in another location or to another part of the appliance or of the system. The second outlet 107' is connected to the inlet 106' through two fluid flow on-off means connected in parallel, in particular a tap 103' and at least one solenoid valve 102'; preferably at least one non-return valve 150' is associated with the outlet 107'.

[0145] The device 101' has been described in a very concise manner because detailed descriptions of devices according to the present invention have already been provided above. However, it should be taken into account that the appliance 100' may use different hydraulic devices according to the teachings of the present invention; for example, the hydraulic device employed may be fitted with two solenoid valves in series instead of the single solenoid valve 102' shown in Fig. 15.

[0146] The appliance of Fig. 15 comprises one section dedicated to the treatment of sanitary water and one section dedicated to the treatment of heating water.

[0147] The heating water section comprises the respective inlet 191', the respective outlet 192', a fuel burner 171', such as a gas burner, a primary heat exchanger 172', a circulator 175', an expansion tank 176', and a number of connection pipes. According to a possible operation example, the heating water enters the appliance through the inlet 191' (called "return"), flows through the circulator 175', flows through the exchanger 172' (which warms up the water by using the heat received from the burner 171'), and exits the appliance through the outlet 192' (called "delivery").

[0148] The section for sanitary water comprises the respective inlet 181' (called "main inlet"), the respective outlet 182', and a secondary exchanger 200'. According to a possible operation example, cold sanitary water enters the appliance through the inlet 181' and flows through the exchanger 200', after which hot water exits the appliance through the outlet 182'.

[0149] The two sections described above (for heating water and for sanitary water), though being distinct, they are essentially connected together through a hydraulic device according to the invention, in particular through the device 101'.

[0150] The appliance shown in Fig. 15 comprises a solenoid valve 205' which connects two sections of the heating circuit; the solenoid valve 205' is a diverting valve adapted to allow the flow of the heating circuit to be distributed between the two exchangers 172' and 200' .

[0151] The diverting solenoid valve 205' is connected to four pipes. With reference to Fig. 15, the pipe at the top is connected directly to the secondary exchanger 200', the pipe at the bottom is connected to the inlet 191' or heating return of the appliance, the pipe on the left is connected to the circulator 175', the pipe on the right is connected to the exchanger 172'; in said hydraulic connections there are also unidirectional valves 206' and 207'.

[0152] In a first operating condition, the heating water circulates not only in the primary exchanger 172' (associated with the burner 171'), but also in the secondary exchanger 200'; thus the heating water is also used for heating the sanitary water, thanks to the secondary exchanger.

[0153] In a second operating condition, the heating water only circulates in the primary exchanger 172', not in the secondary exchanger 200'; thus the heating water is only used for the heating system.

[0154] The component 101' is connected to the sanitary water section as follows: the inlet 106' is connected to the outlet of the exchanger 200', the outlet 105' is connected to the outlet 182' of the appliance. The component 101' is also connected to the heating water section as follows: the outlet 107' is connected through a T-shaped fitting to an inlet of the exchanger 200' and (indirectly) to the solenoid valve 205'.

[0155] Based on the above-described connections, the filling or topping-up operation is preferably carried out when the solenoid valve 205' is in the first operating condition, i.e. when the device 101' is in hydraulic communication with the whole system.

[0156] In the presence of hydraulic configurations being different from the one described herein by way of non-limiting example, the filling or topping-up operation may also be carried out in different phases or conditions.

[0157] The appliance 100" of Fig. 16 differs from the appliance 100' of Fig. 15 in the way in which the hydraulic device according to the present invention has been included in said appliance.

[0158] The component 101" is connected to the sanitary water section as follows: the inlet 106" is connected to the inlet 181" of the appliance, the outlet 105" is connected to an inlet of the exchanger 200" of the appliance. The component 101" is also connected to the heating water section as follows: the outlet 107" is connected through a T-shaped fitting to an inlet of the exchanger 200" and (indirectly) to the solenoid valve 205".

[0159] Although not shown in Fig.15 and Fig.16, the appliance according to the present invention may advantageously comprise an electronic control unit to control the operation of the hydraulic appliance.

[0160] As aforementioned, a hydraulic device according to the present invention, and therefore also a hydraulic appliance according to the present invention, may

comprise on-off means, e.g. one or more solenoid valves (designated by way of example 2' , 2" and 40" in the drawings) of the same type or of different types, and/or sensor means, e.g. one or more sensors (designated by way of example 30' and 60" in the drawings) of the same type or of different types. The solenoid valves and the sensors typically have electric connections; in the solenoid valves, the electric connections are used at least for driving or controlling their on-off action; in the sensors, the connections are used at least for detecting or receiving their readings.

[0161] The electronic control unit may therefore be connected electrically at least to the on-off means of the hydraulic device and/or to the sensor means of the hydraulic device, in particular to the electric connections thereof, in order to control them.

[0162] The appliance according to the present invention will typically include a control unit or system performing the task, among other things, of controlling the hydraulic device according to the present invention (101 with reference to the examples of Fig.15 and Fig.16). In this respect, the hydraulic device according to the present invention may have its own control circuit as well. The latter may be at least partly applied to or built in the hydraulic device and be at least partly housed, for example, in the body of the hydraulic device. The control circuit of the hydraulic device may be adapted to be connected to or integrated into the control system of the appliance.

[0163] These connections allow, for example, the heating circuit to be topped up automatically and/or the hydraulic device to be diagnosed automatically; this will be explained further below when describing the methodological aspects of the present invention.

[0164] As aforesaid, an aspect of the present invention also relates to a hydraulic system; said hydraulic system may be, for example, of the type adapted to heat and/or cool water, in particular for domestic use. In general, a hydraulic system according to the present invention can supply hot and/or cold water for different purposes, e.g. both sanitary water and heating water, and can be installed, for example, in an apartment, a house or a building.

[0165] A hydraulic device according to the present invention (e.g. like those described above) can be included to advantage in such a system in order to allow said system to be filled, in particular manually or automatically, and/or topped up, in particular automatically.

[0166] In the case of a water heating system, the system may comprise a hydraulic appliance according to the present invention (e.g. like those described above).

[0167] The system according to the present invention may comprise at least a first hydraulic circuit for sanitary water and a second hydraulic circuit for heating water. Said two hydraulic circuits may be both connected to one hydraulic device according to the present invention; in particular, the hydraulic circuit for sanitary water will typically be connected to the uncontrolled outlet of the hydraulic device (i.e. referring to the previously described examples, to the duct 5', 5", 5"', 105' or 105"), whereas the hydraulic circuit for heating water will typically be connected to the controlled outlet of the hydraulic device (i.e. referring to the previously described examples, the duct 7', 7", 7"', 107' or 107"). As regards the inlet of the hydraulic device (i.e. referring to the previously described examples, the duct 6', 6", 6"', 106' or 106"), it may be connected to or associated with a plumbing of a water network, e.g. the public water main; in this latter case, some pipes providing a connection to a meter will typically be provided between the plumbing and the device inlet.

[0168] Also the hydraulic system according to the present invention may advantageously comprise an electronic control unit. Said control unit may provide at least all of the advantageous aspects described above with reference to the hydraulic appliance, which aspects will not be described again in this context.

[0169] So far this description has tackled the structural aspects of the present invention, relating to a hydraulic device, a hydraulic appliance and a hydraulic system.

[0170] The methodological or functional aspects of the present invention will now be described.

[0171] The operations for filling and/or topping up a hydraulic system can be made comfortable and easy by using the device according to the present invention. Furthermore, if said hydraulic device is provided as a single component, such comfort and easiness of use are achieved with very small outer dimensions, which are typically much smaller than those of existing solutions.

[0172] The fluid flow supplied to the system during a system topping-up operation is typically different from (preferably lower than) the fluid flow supplied to the system during a system filling operation. In fact, filling a hydraulic system (or a hydraulic circuit thereof) requires a large quantity of fluid to be supplied to the system (e.g. several tens of litres for a heating system), whereas topping up a hydraulic system (or a circuit thereof) only requires a small quantity of fluid to be supplied to the system (e.g. less than one litre); therefore, in order to fill up the system within a reasonable time (e.g. a few tens of minutes), it is advantageous that the fluid flow is high (e.g. 1 litre per minute), whereas in order to top up the system in an accurate way it is acceptable or advantageous that the fluid flow is low (e.g. 1 cl per minute).

[0173] The hydraulic device according to the present invention provides a method for topping up the system automatically; this is obtained by appropriately actuating the controllable on-off means, e.g. the solenoid valve 2' with reference to the first device example or the solenoid valves 2" and 40" or 2'" and 40'" with reference to the second or the third device examples, respectively.

[0174] The fluid flow rate may be either constant or variable. The taps 3', 3" and 3"', for example, provide a high flow, which can be adjusted manually by the user; this fluid flow can be used for filling a system. The solenoid valves 2', 2", 2"', 40" and 40"', for example, provide a fluid flow (low for the solenoid valves 2' and 40", high for the solenoid valves 2", 2"' and 40"') which can be

adjusted automatically, for example, by having an electronic control unit (not shown in the drawings) send them suitable electric signals.

[0175] For filling and/or topping up the system, on-off means may be arranged which are adapted to set or adjust the fluid flow.

[0176] Advantageously, from a construction viewpoint, the filling fluid flow and the topping-up fluid flow may be supplied through the same duct (with reference to the drawings, the ducts 7' and 7"); thus, the hydraulic system or the hydraulic appliance requires only one hydraulic connection point for both purposes. Alternatively, said flows may be supplied through two distinct ducts.

[0177] The topping-up method turns out to be particularly effective if topping-up operations are controlled or performed automatically under the control of an electronic control unit and through on-off means, of course operated or controlled by the same unit.

[0178] The control unit may be operated manually through, for example, push-buttons of a keypad associated with the device by means of cables and/or by radio. In this way, the user can decide to start a topping-up operation (e.g. by pressing a "top-up start" push-button) when desired or required; the topping-up operation will continue automatically; the topping-up operation may then be terminated, for example, at the user's discretion (e.g. by pressing a "top-up stop" push-button); it is therefore a semi-automatic topping-up operation. Of course, safety systems may be employed for preventing the user from making control mistakes which may cause damage to hydraulic appliances and/or systems.

[0179] Alternatively, the control unit may be operated or controlled by one or more sensors; in this way, the whole topping-up operation can take place automatically, i.e. it can start, continue and terminate without the user's intervention; it is therefore a fully automatic topping-up operation. A sensor suitable for operating or controlling the topping-up operation is typically a sensor adapted to detect the presence and/or the pressure of a fluid in a system. In fact, topping up may be required, and therefore a topping-up operation may be started, for example, when the fluid pressure is lower than a predetermined lower threshold value or when there is not a sufficient quantity of fluid in the circuit. The topping-up operation may then be terminated, for example, when the fluid pressure exceeds a predetermined upper threshold value. Still as far as the automatic topping-up function is concerned, the control unit may check periodically the pressure of the fluid in the system or the level of the fluid in the system.

[0180] Of course, in the same appliance and/or in the same system it is possible to provide both a semi-automatic topping-up operation and a fully automatic topping-up operation.

[0181] As to the system filling function, all of the above-described embodiment examples provide for filling operations being carried out or controlled manually (through the taps 3' and 3").

[0182] According to the present invention, the advantageous possibility of providing semi-automatic or fully automatic filling operations should not however be excluded; of course, hydraulic devices being different from those described above should be employed; it is nonetheless worth pointing out that the third embodiment example (drawings from Fig. 11 to Fig. 14) uses a solution with two servo-assisted solenoid valves in series which may also apply to such a purpose (of course, the tap would become unnecessary or redundant). In this case, filling operations, which are generally carried out by qualified personnel (e.g. an installer or a service technician), may substantially take place, for example, as previously described with reference to topping-up operations.

[0183] In many applications of the hydraulic device according to the present invention, it may be useful to monitor the fluid which flows, for example, in a system and/or in one of the hydraulic circuits of the system (e.g. the heating water circuit and/or the sanitary water circuit); it may be interesting to monitor, for example, the quantity of fluid flowed, the fluid flow rate, and the velocity of the fluid. Said monitoring operation may be provided, for example, through one or more flow sensors associated with or built in the device according to the present invention; in the presence of built-in sensors, said monitoring operation can be carried out without a significant increase in outer dimensions. Said monitoring is particularly effective when performed through an electronic control unit, e.g. with a microcontroller, electrically connected to the sensor(s); in fact, this arrangement not only allows to detect the sensor readings, but also allows to store them, compare them with predefined data tables, process them (e.g. statistically) and re-send them to a remote monitoring system. The applications of such a monitoring function include, for example, hot sanitary water consumption and heating circuit leaks.

[0184] In many applications of the hydraulic device according to the present invention, it may be useful to monitor the temperature of the fluid which flows, for example, in a system and/or in one of the hydraulic circuits of the system (e.g. the heating water circuit and/or the sanitary water circuit). Said monitoring operation may be provided, for example, through one or more temperature sensors associated with or built in the device according to the present invention; in the presence of built-in sensors, said monitoring operation can be carried out without a significant increase in outer dimensions. Said monitoring is particularly effective when performed through an electronic control unit electrically connected to the sensor(s); in fact, this arrangement not only allows to detect the sensor readings, but also allows to store them, process them (e.g. statistically) and re-send them to a remote monitoring system. The applications of such a monitoring function include, for example, signalling a dangerous situation when the water temperature approaches 0 °C (e.g. by setting a threshold value to 4 or 5 °C), i.e. close to freezing.

[0185] In some applications of the hydraulic device ac-

cording to the present invention, it may be useful to monitor the pressure of the fluid at the inlet or upstream of the hydraulic device according to the present invention. Said monitoring operation may be provided, for example, through a pressure sensor associated with or built in the device according to the present invention; in the presence of a built-in sensor, said monitoring operation can be carried out without any significant increase in outer dimensions. The applications of such a monitoring function include, for example, preventing any topping-up or filling operations if the inlet pressure of the hydraulic device is inappropriate, e.g. lower than a predetermined threshold value, or preventing any topping-up or filling operations if the inlet pressure of the hydraulic device is lower than another measured value, such as the pressure in the heating circuit (this application is made possible by the hydraulic device according to the third embodiment example); in said conditions, the control circuit will not open one or more valves adapted to top up or fill the system, so as to prevent any backflow towards the device inlet or the main. This latter problem can also be at least partly solved by using a non-return valve, as provided for in the first two embodiment examples described above.

[0186] As already described, a preferred embodiment of the hydraulic device according to the present invention (which includes both the second and the third embodiment examples) comprises two on-off devices which are controlled electrically and connected in series; thus, the automatic topping-up system is safer (mostly as concerns undesired topping-up operations), since it is unlikely that two on-off devices can fail at the same time.

[0187] Moreover, the use of both an electromagnetic-control solenoid valve and an electrothermal-control solenoid valve for performing topping-up operations offers not only a higher level of safety, but also a higher degree of immunity to interference (in fact, while the electromagnetic solenoid valve might be activated accidentally by electromagnetic noise being present, for example, on the private or public power supply network, the electrothermal solenoid valve would be very unlikely to suffer such an effect). In this case, during a topping-up operation it will be necessary to operate or control both on-off devices at the same time.

[0188] The use of two different types of valves, i.e. an electromagnetic valve (which operates rapidly) and a thermoelectric valve (which operates slowly) can improve the performance of the system, e.g. by providing a slow closing, thus preventing the known phenomenon called "water hammer". To this end, the electric connection of said valves may be distinct, so that they can be opened or closed at different times or in different ways; however, in general, an electric connection of said valves in parallel should not be excluded either.

[0189] Said preferred embodiment (which includes both the second and the third embodiment examples) allows to establish a diagnostic procedure, in particular a self-diagnosis procedure when carried out through an electronic control station connected to the on-off means and to the sensor means of the hydraulic device, for the hydraulic device according to the present invention. It is therefore a matter of verifying the proper operation of both on-off devices; with non-limiting reference to the second embodiment example (shown in Fig.8, Fig.9 and Fig. 10), said devices are the direct-control electrothermal solenoid valve 40" and the servo-assisted electromagnetic solenoid valve 2".

[0190] The self-diagnosis procedure will be described below with non-limiting reference to the second embodiment example; said procedure starts from an initial situation wherein both the solenoid valve 2" and the solenoid valve 40" are operated or controlled through electric signals which keep them in the closed condition, so that no water flows in the duct 7" (of course, the tap 3" shall typically be kept closed), after which it can proceed, for example, with at least one of the following steps:

A) with the solenoid valve 40" not activated and therefore closed, the solenoid valve 2" is operated or controlled through suitable electric signals so as to be opened, and the pressure variation in the circuit connected to the duct 7" is detected through the sensor 60"; if there is a pressure variation, it means that the solenoid valve 40" is blocked in an improper partially or wide open position; subsequently, the solenoid valve 2" is operated or controlled through suitable electric signals so as to be closed;

B) with the solenoid valve 2" not activated and therefore closed, the solenoid valve 40" is operated or controlled through suitable electric signals so as to be opened, and the pressure variation in the circuit connected to the duct 7" is detected through the sensor 60"; if there is a pressure variation, it means that the solenoid valve 2" is blocked in an improper partially or wide open position; subsequently, the solenoid valve 40" is operated or controlled through suitable electric signals so as to be closed;

C) the solenoid valves 2" and 40" are operated or controlled through suitable electric signals so as to be opened, and the pressure variation in the circuit connected to the duct 7" is detected through the sensor 60"; if no pressure variation occurs, it means that the solenoid valve 2" and/or the solenoid valve 40" are blocked in a closed position; subsequently, the solenoid valves 2" and 40" are operated or controlled through suitable electric signals so as to be closed.

[0191] If during any of these steps said electronic control unit detects an anomalous situation, i.e. a valve blocked in the closed position or in a partially or wide open position, it is advantageous to provide an alarm indication, e.g. through visual and/or acoustic signals, and/or to send alarm signals to a remote electronic system; of course, these operations can be performed easily and effectively by the electronic control unit.

[0192] If a fault is detected, the control system may also stop the operation of the entire apparatus, or else it

may activate other safety devices or valves, such as an on-off valve located upstream of said system or connection to the water main.

[0193] Also, it is conceivable that such a signalling is provided as soon as a faulty condition is detected; for example, if step A) is performed and the solenoid valve 40" is found to be defective, steps B) and C) can be omitted.

[0194] According to the above-described self-diagnosis procedure, the solenoid valves are operated or controlled sometimes simultaneously and sometimes alternately; said procedure may be carried out repeatedly or periodically (e.g. once a day, once a week, once a month, once a year), preferably automatically. This especially applies, for example, to environmental heating boilers for use in houses and buildings.

[0195] The advantages of the present invention are apparent from the above description.

[0196] Of course, the primary advantage of the present invention is that it allows for automatic and/or semi-automatic topping-up and/or filling operations; among other things, this can be attained without any significant increase in outer dimensions, especially if the hydraulic device according to the present invention is provided with only one hydraulic component, in particular a device in which various parts or components are integrated into a single body or a single assembly. The filling operations can thus be carried out in a fully manual manner or in a semi-automatic manner; however, they may also be carried out in a fully automatic manner.

[0197] If said operations (either one or both) are carried out through electric on-off means allowing to adjust the fluid flow, they can provide very accurate results even in the presence of variable fluid flows.

[0198] One or more sensors of the same type or of different types may be used for different monitoring functions; in this case as well, this is attained without any substantial increase in outer dimensions, especially if the hydraulic device according to the present invention is provided with only one hydraulic component.

[0199] By using two on-off devices connected in series, it is advantageously possible to increase the inherent operational safety of the hydraulic device.

[0200] Furthermore, thanks to the presence of said two devices, it is possible to provide a diagnosis or self-diagnosis function for the hydraulic device.

[0201] These advantages of the hydraulic device bring similar advantages also to the applications of said device, for example hydraulic appliances, typically gas boilers for household use or buildings, and to hydraulic systems using it.

Claims

1. Hydraulic device (1', 1", 1"') for hydraulic systems, preferably for water heating systems, comprising at least one body (4', 4", 4"') provided with an inlet duct (6', 6", 6"'), a first outlet duct (5', 5" , 5"') and a second outlet duct (7', 7", 7"'), and with on-off means (2', 2", 2"', 3', 3", 3"', 40", 40"') adapted to stop a fluid flow, **characterized in that** said on-off means (2', 2", 2"', 3', 3", 3"', 40", 40"') comprise at least two on-off devices (2', 2", 2"', 3', 3", 3"', 40", 40"') adapted to affect a fluid flow in said second outlet duct (7', 7", 7"').

2. Hydraulic device (1', 1", 1"') according to claim 1, **characterized in that** said on-off means (2', 2", 2"', 3', 3", 3"', 40", 40"') are adapted to be in at least a first, a second and a third operating configurations, said first operating configuration being such that fluid flow is prevented from said inlet duct (6', 6", 6"') to said second outlet duct (7', 7", 7"'), said second operating configuration being such that a first amount of fluid flow is allowed from said inlet duct (6', 6", 6"') to said second outlet duct (7', 7", 7"'), said third operating configuration being such that a second amount of fluid flow is allowed from said inlet duct (6', 6", 6"') to said second outlet duct (7', 7", 7"').

3. Hydraulic device (1', 1", 1"') according to claim 2, **characterized in that** said first amount is smaller than said second amount.

4. Hydraulic device (1', 1", 1"') according to claim 2 or 3, **characterized in that** said first amount and/or said second amount are adjustable.

5. Hydraulic device (1', 1", 1"') according to any of claims 2 to 4, wherein said first operating configuration corresponds to a system operating status.

6. Hydraulic device (1', 1", 1"') according to any of claims 2 to 5, wherein said second operating configuration corresponds to a system topping-up operation.

7. Hydraulic device (1', 1", 1"') according to any of claims 2 to 6, wherein said third operating configuration corresponds to a system filling operation.

8. Hydraulic device (1', 1", 1"') according to any of claims 1 to 7, **characterized in that** said second outlet duct (7', 7", 7"') comprises a by-pass duct (9', 9", 9"') and a main duct (11', 11", 11"') connected in parallel.

9. Hydraulic device (1', 1", 1"') according to any of the previous claims, **characterized by** comprising at least a first on-off device (3', 3", 3"') adapted to stop a fluid, in particular in said by-pass duct (9', 9", 9"').

10. Hydraulic device (1', 1", 1"') according to claim 9, **characterized in that** said first on-off device (3', 3", 3"') is adapted to control or adjust a fluid flow in said by-pass duct (9', 9", 9"').

11. Hydraulic device (1', 1", 1"') according to claim 10, **characterized in that** said first on-off device (3', 3", 3"') comprises a manually operated tap.

12. Hydraulic device (1', 1", 1"') according to any of claims 8 to 11, **characterized in that** said by-pass duct (9', 9", 9"') is adapted to be used for system filling operations.

13. Hydraulic device (1', 1", 1"') according to any of the previous claims, **characterized by** comprising at least a second on-off device (2', 2", 2"') adapted to stop a fluid, in particular in said main duct (11', 11", 11"').

14. Hydraulic device (1', 1", 1"') according to claim 13, **characterized in that** said second on-off device (2', 2", 2"') is adapted to control or adjust a fluid flow in said main duct (11', 11", 11"').

15. Hydraulic device (1', 1", 1"') according to claim 13 or 14, **characterized in that** said second on-off device (2', 2", 2"') is adapted to be operated or controlled by at least one electric signal.

16. Hydraulic device (1', 1", 1"') according to claim 15, **characterized in that** said second on-off device (2', 2", 2"') comprises an electromagnetic or electrothermal control solenoid valve providing a direct or servo-assisted on-off action.

17. Hydraulic device (1', 1", 1"') according to any of claims 13 to 16, **characterized in that** said main duct (11', 11", 11"') is adapted to be used for system topping-up operations.

18. Hydraulic device (1', 1", 1"') according to any of claims 1 to 17, **characterized by** comprising at least a third on-off device (40", 40"') adapted to affect a fluid flow in said second outlet duct (7', 7", 7'").

19. Hydraulic device (1', 1", 1"') according to any of claims 13 to 17 and according to claim 18, **characterized in that** said second on-off device (2', 2", 2"') and said third on-off device (40", 40"') are arranged in series with respect to the fluid flow in said main duct (11', 11", 11'").

20. Hydraulic device (1', 1", 1"') according to claim 18 or 19, **characterized in that** said third on-off device (40", 40"') is adapted to control or adjust a fluid flow in said main duct (11', 11", 11'").

21. Hydraulic device (1', 1", 1'") according to claim 17 or 18 or 19 or 20, **characterized in that** said third on-off device (40", 40"') is adapted to be operated or controlled by at least one electric signal.

22. Hydraulic device (1', 1", 1"') according to claim 21, **characterized in that** said third on-off device (40", 40"') comprises an electromagnetic or electrothermal control solenoid valve, in particular providing a direct or servo-assisted on-off action.

23. Hydraulic device (1', 1", 1"') according to any of claims 1 to 22, **characterized in that** said body (4', 4", 4"') has two seats (4'a, 4'c, 4"a, 4"c, 4"'a, 4"'c, 4""a) respectively adapted to house at least partly said two on-off devices (2', 2", 2"', 3', 3", 3"', 40", 40"'), in particular said second on-off device (2"') and said third on-off device (40"'), said seats (4"'a, 4""a) being preferably close or side by side and/or preferably transversal, in particular substantially orthogonal, to said second outlet duct (7'"), in particular to said main duct (11'").

24. Hydraulic device (1', 1", 1"') according to any of claims 1 to 23, **characterized in that** said two on-off devices (2', 2", 2"', 3', 3", 3"', 40", 40"'), in particular said second on-off device (2', 2", 2"') and said third on-off device (40", 40"'), comprise electric connection means, preferably so connected that said on-off devices can be operated or controlled jointly or separately, in particular through same or respective electric signals.

25. Hydraulic device (1', 1", 1"') according to any of the previous claims, **characterized in that** said first outlet duct (5', 5", 5"') communicates directly with said inlet duct (6',6",6'").

26. Hydraulic device (1', 1", 1"') according to any of the previous claims, **characterized by** comprising a non-return valve (50', 50") built in or applied to or associated with said second outlet duct (7', 7").

27. Hydraulic device (1', 1", 1"') according to any of the previous claims, **characterized by** comprising sensor means (30', 60", 60"'), in particular at least one flow, temperature or pressure meter, adapted to generate, either directly or indirectly, a corresponding electric measurement signal.

28. Hydraulic device (1', 1", 1'") according to claim 27, **characterized in that** at least a first sensor (30') is built in or applied to or associated with said inlet duct (6') or said first outlet duct (5').

29. Hydraulic device (1', 1", 1"') according to claim 28, **characterized in that** said first sensor (30') is a flow meter.

30. Hydraulic device (1', 1", 1"') according to claim 27 or 28 or 29, **characterized in that** at least a second sensor (60", 60"') is built in or applied to or associated with said second outlet duct (7", 7'").

31. Hydraulic device (1', 1", 1"') according to claim 30, **characterized in that** said second sensor (60", 60"') is a pressure or pressure difference meter.

32. Hydraulic device (1"') according to claim 30 or 31, **characterized in that** said second sensor (60"') comprises a first pressure measuring element (61"') and a second pressure measuring element (62"').

33. Hydraulic device (1"') according to claim 32, **characterized in that** said first measuring element (61"') is adapted to measure the pressure in said inlet duct (6"') and that said second measuring element (62"') is adapted to measure the pressure in said second outlet duct (7'").

34. Hydraulic device (1"') according to claims 8 and 33, **characterized in that** said first measuring element (61"') is at least partly associated with said by-pass duct (9"') and is located upstream of said first on-off device (3"').

35. Hydraulic device (1"') according to claims 8 and 33 or according to claim 34, **characterized in that** said second measuring element (62"') is at least partly associated with said main duct (11"') and is located at said second outlet duct (7"').

36. Hydraulic device (1"') according to claim 8 and according to any of claims 30 to 35, **characterized in that** said second sensor (60", 60"') is transversal, in particular substantially orthogonal, to said main duct (11"') and preferably also to said second on-off device (2"') and/or said third on-off device (40'").

37. Hydraulic device (1', 1", 1"') according to claim 8 and according to any of claims 30 to 36, **characterized in that** said second sensor (60", 60"') is located upstream or downstream of a non-return or unidirectional valve (50").

38. Hydraulic device (1', 1", 1"') according to any of the previous claims, **characterized by** being a single component adapted to allow for both system filling operations and system topping-up operations.

39. Method for managing a hydraulic system, in particular a water heating system, including system filling operations and system topping-up operations, **characterized by** providing the system with a hydraulic device (1', 1", 1"'), preferably as a single component, adapted to allow for both system filling operations and system topping-up operations

40. Method according to claim 39, **characterized in that** said hydraulic device (1', 1", 1"') has the features set out in one or more of claims 1 to 38.

41. Method according to claim 39 or 40, **characterized in that** during a system topping-up operation the system is supplied with a first amount of fluid flow, while during a system filling operation the system is supplied with a second amount of fluid flow.

42. Method according to claim 41, **characterized in that** said first amount is smaller than said second amount.

43. Method according to claim 41 or 42, **characterized in that** said first amount and/or said second amount are adjustable or controlled.

44. Method according to any of claims 41 to 43, **characterized in that** said flows are supplied to the system through the same duct (7', 7", 7'").

45. Method according to any of claims 39 to 44, **characterized in that** topping-up operations are controlled or carried out automatically, preferably under the control of an electronic control unit and through on-off means (2', 2", 2"', 3', 3", 3"', 40", 40"').

46. Method according to claim 45, **characterized by** the detection of the presence and/or pressure of a fluid in said system or in a water network connected to or associated with said system, preferably through said control unit and at least one sensor (60", 60"').

47. Method according to claim 46, **characterized in that** the start and/or the end of a topping-up operation is bound to said detection of the presence and/or pressure of a fluid in said system or in a water network connected to or associated with said system.

48. Method according to any of claims 39 to 47, **characterized in that** filling operations are controlled or carried out manually and/or automatically.

49. Method according to any of claims 39 to 48, **characterized by** monitoring the quantity of fluid flowing in said system or in a water network connected to or associated with said system, in particular through a flow sensor (30') and an electronic control unit.

50. Method according to any of claims 39 to 49, **characterized by** monitoring the temperature of the fluid flowing in said system or in a water network connected to or associated with said system, in particular through a temperature sensor and an electronic control unit.

51. Method according to claim 49 or 50, **characterized in that** the fluid in said system is heated in relation to said quantity of fluid and/or to said fluid temperature, in particular under the control of an electronic control unit.

52. Method according to any of claims 39 to 51, **characterized in that** during a system topping-up operation the system is supplied with a fluid flow through at least two on-off devices (2", 2"', 40", 40"') connected in series.

53. Method according to claim 52, **characterized in that** said two on-off devices (2", 2"', 40", 40"') are operated or controlled simultaneously and/or alternately.

54. Method according to claim 52 or 53, **characterized by** including a step for verifying the proper operation of said two on-off devices (2", 2"', 40", 20"').

55. Method according to claim 54, **characterized in that**, during said verification step, said two on-off devices (2", 2"', 40", 40"') are operated or controlled alternately and the pressure in at least a portion of said system is detected.

56. Method according to claim 55, **characterized in that**, during said verification step, after said two on-off devices (2", 2"', 40", 40"') have been operated or controlled alternately, said two on-off devices (2", 2"', 40", 40"') are operated or controlled simultaneously and the pressure in said system is detected.

57. Method according to claim 55 or 56, **characterized in that** a signal, such as an alarm, is generated or sent based on the result of said verification step.

58. Hydraulic appliance, in particular a water heating appliance, **characterized by** comprising at least one hydraulic device according to any of claims 1 to 38.

59. Hydraulic appliance according to claim 58, comprising first hydraulic coupling means to be connected to a first hydraulic circuit for sanitary water and second hydraulic coupling means to be connected to a second hydraulic circuit for heating water, **characterized in that** said coupling means are connected to said hydraulic device.

60. Hydraulic appliance according to claim 59, **characterized in that** said first outlet duct (5', 5", 5"') is connected to said first coupling means and said second outlet duct (7', 7", 7"') is connected to said second coupling means.

61. Hydraulic appliance according to claim 59 or 60, **characterized in that** said inlet duct (6', 6", 6"') is adapted to be connected to or associated with a plumbing of the water main.

62. Hydraulic appliance according to any of claims 58 to 61, **characterized by** comprising an electronic control unit electrically connected to said on-off means (2', 2", 2"', 3', 3", 3"', 40", 40"') to drive or control their on-off action and/or to said sensor means (30', 60", 60"') to detect or receive their readings.

63. Hydraulic appliance according to claim 62, **characterized in that** said control unit is adapted to carry out automatic and/or semi-automatic and/or manual topping-up operations as well as automatic and/or semi-automatic and/or manual filling operations.

64. Hydraulic appliance according to claim 63, **characterized in that** said control unit is adapted to carry out automatic diagnoses.

65. Hydraulic appliance according to any of claims 58 to 64, **characterized by** being adapted to implement the method according to any of claims 39 to 57.

66. Hydraulic system, in particular a water heating system, **characterized by** comprising at least one hydraulic device according to any of claims 1 to 38.

67. Hydraulic system according to claim 66, comprising a first hydraulic circuit for sanitary water and a second hydraulic circuit for heating water, **characterized in that** said hydraulic circuits are connected to said hydraulic device.

68. Hydraulic system according to claim 67, **characterized in that** said first outlet duct (5', 5", 5"') is connected to said hydraulic circuit for sanitary water and said second outlet duct (7', 7", 7"') is connected to said hydraulic circuit for heating water.

69. Hydraulic system according to claim 67 or 68, **characterized in that** said inlet duct (6', 6", 6"') is adapted to be connected to or associated with a plumbing of the water main.

70. Hydraulic system according to any of claims 66 to 69, **characterized by** comprising an electronic control unit electrically connected to said on-off means (2', 2", 2"', 3', 3", 3"', 40", 40"') to drive or control their on-off action and/or to said sensor means (30', 60", 60"') to detect or receive their readings.

71. Hydraulic system according to claim 70, **characterized in that** said control unit is adapted to carry out automatic and/or semi-automatic and/or manual topping-up operations as well as automatic and/or semi-automatic and/or manual filling operations.

72. Hydraulic system according to claim 71, **characterized in that** said control unit is adapted to carry out automatic diagnoses.

73. Hydraulic system according to any of claims 66 to 72, **characterized by** comprising a hydraulic appliance according to one or more of claims 58 to 65.

74. Hydraulic system according to any of claims 66 to 73, **characterized by** being adapted to implement the method according to one or more of claims 39 to 57.

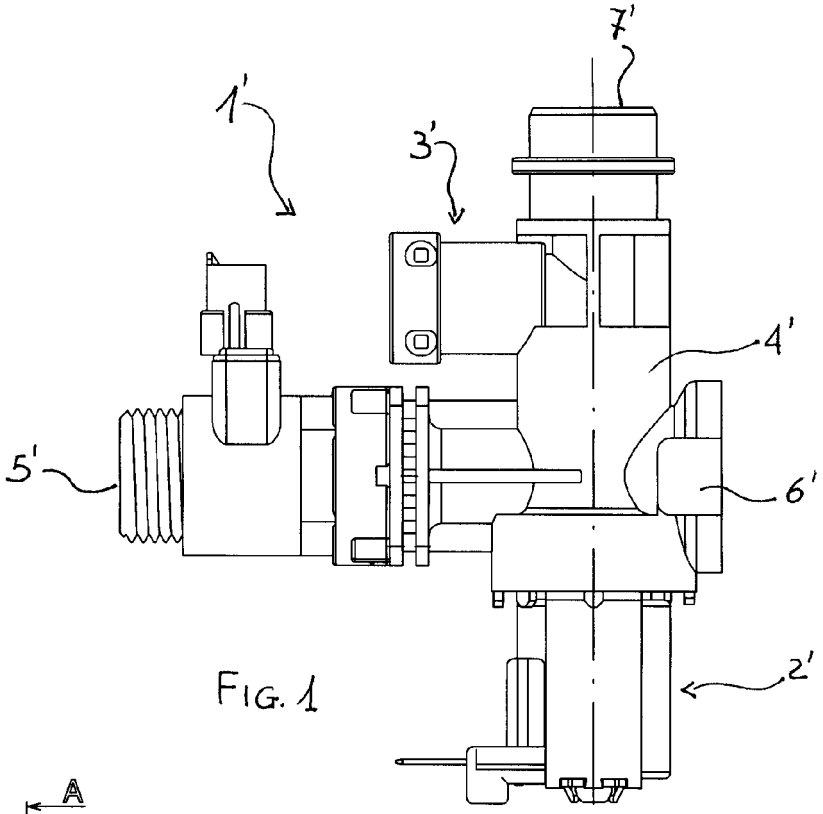


FIG. 1

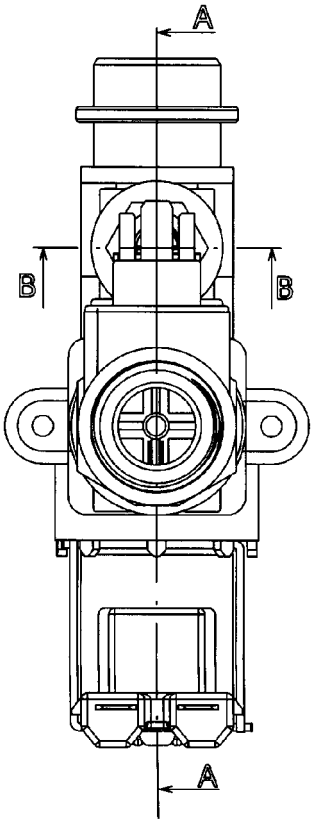


FIG. 2

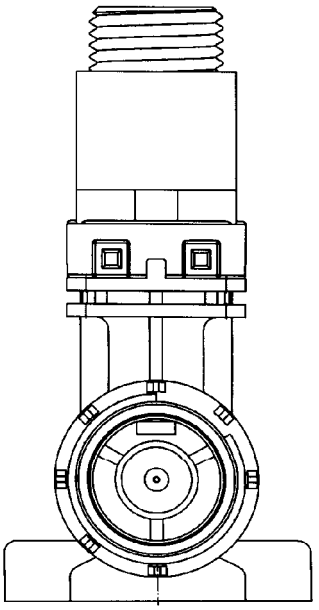


FIG. 3

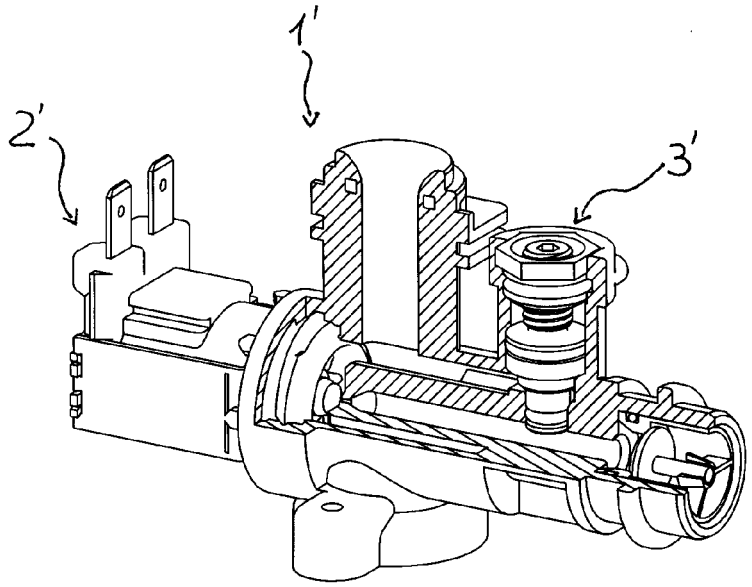
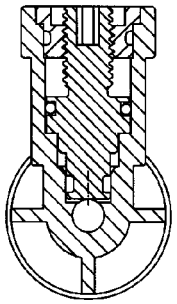


FIG. 4



SEZ. B-B

FIG. 5

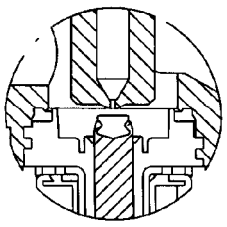


FIG. 7

SEZ. A-A

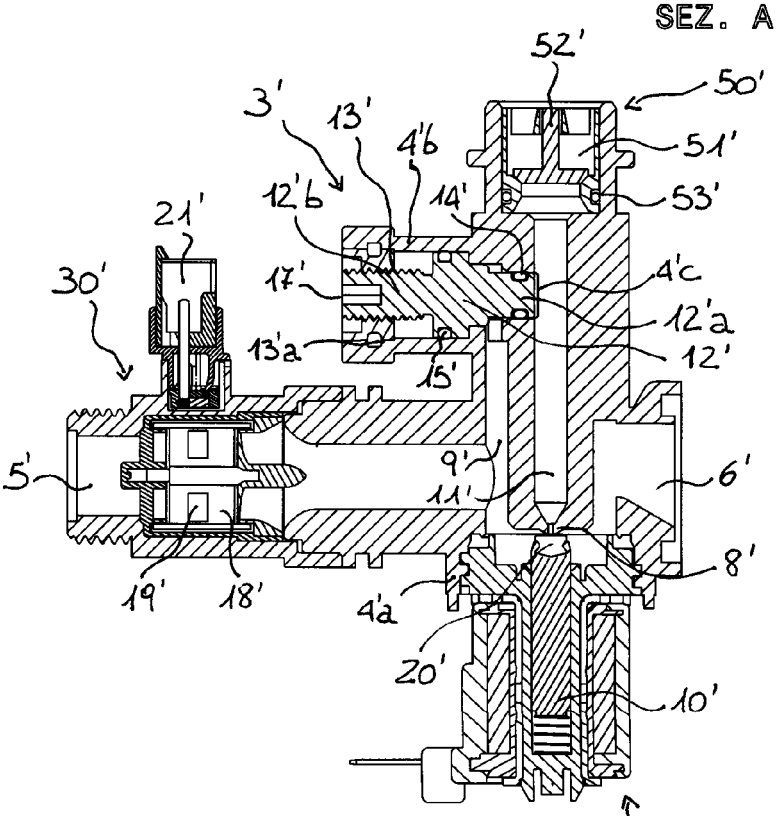


FIG. 6

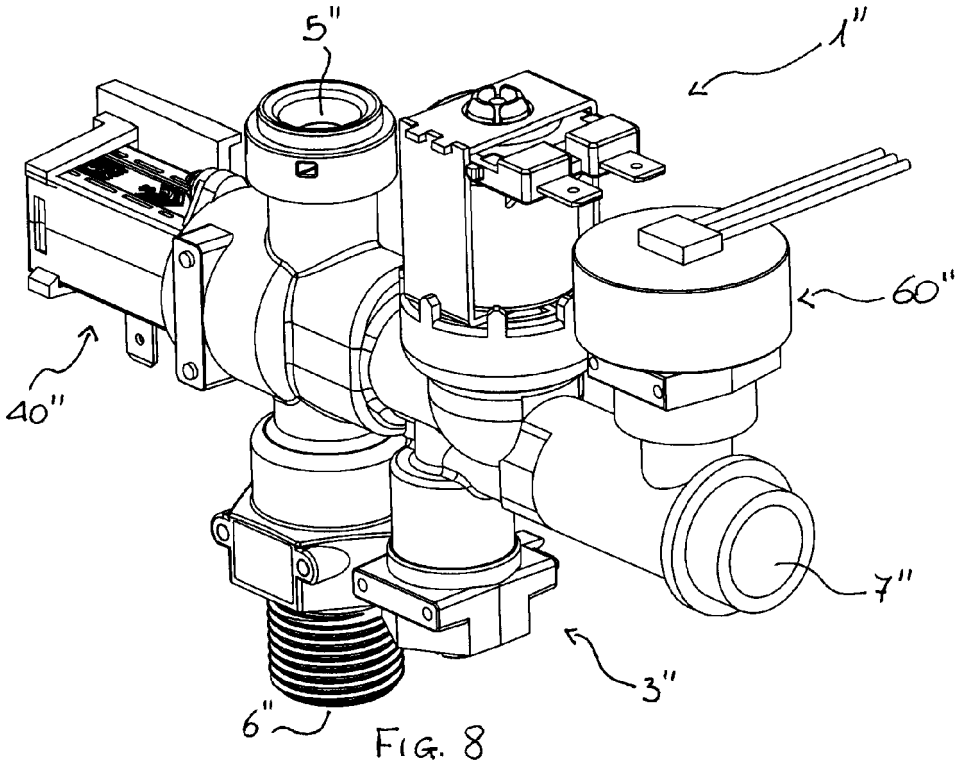


FIG. 8

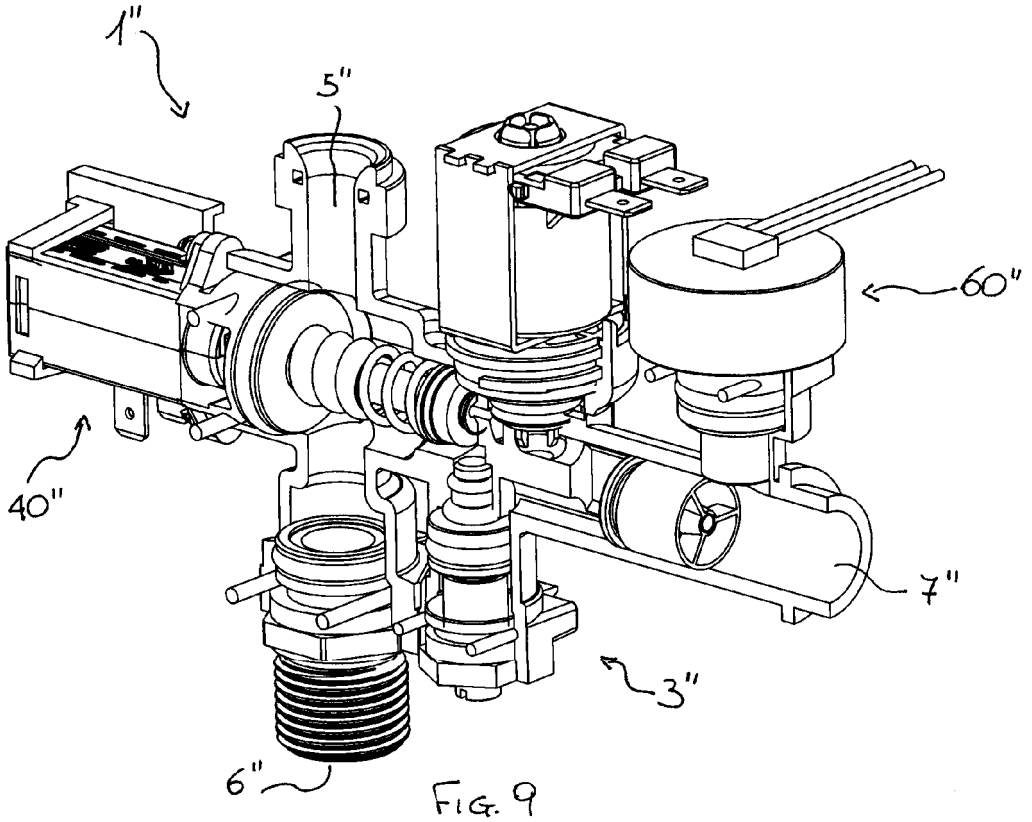


FIG. 9

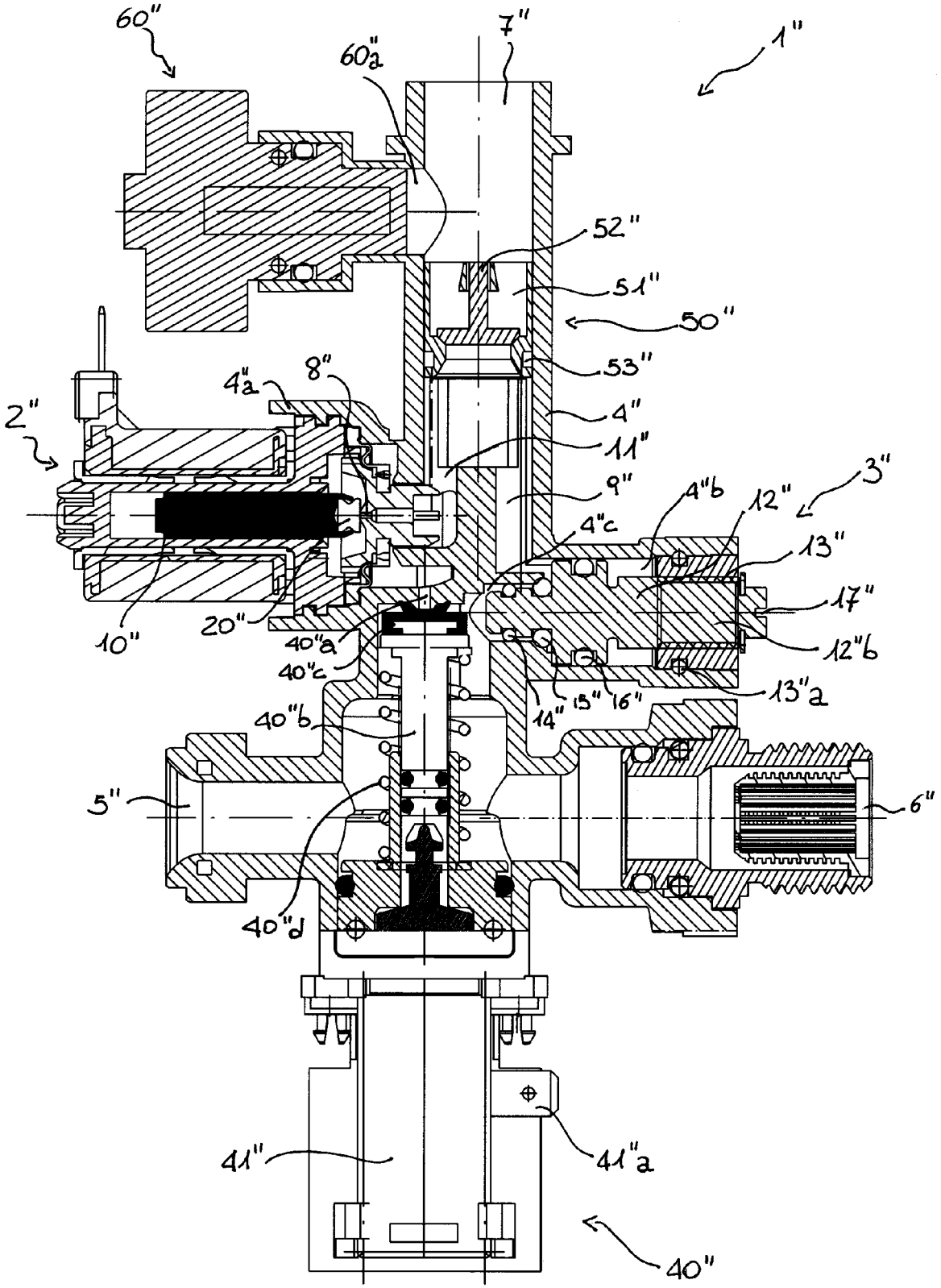

60"
60"a
7"
1"
52"
51"
50"
53"
8"
4"a
2"
4"
11"
9"
4"b
12"
3"
4"c
13"
17"
10"
20"
40"a
40"c
12"b
13"a
15"
16"
14"
40"b
5"
6"
40"d
41"
41"a
40"

FIG 10

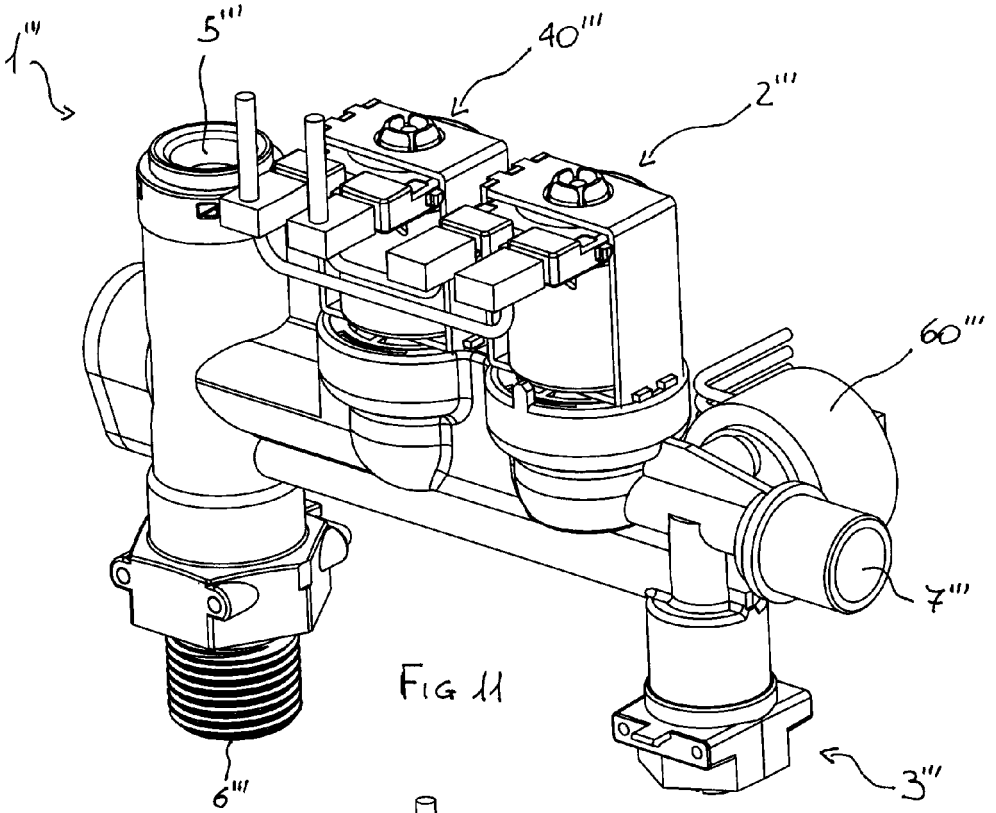


FIG 11

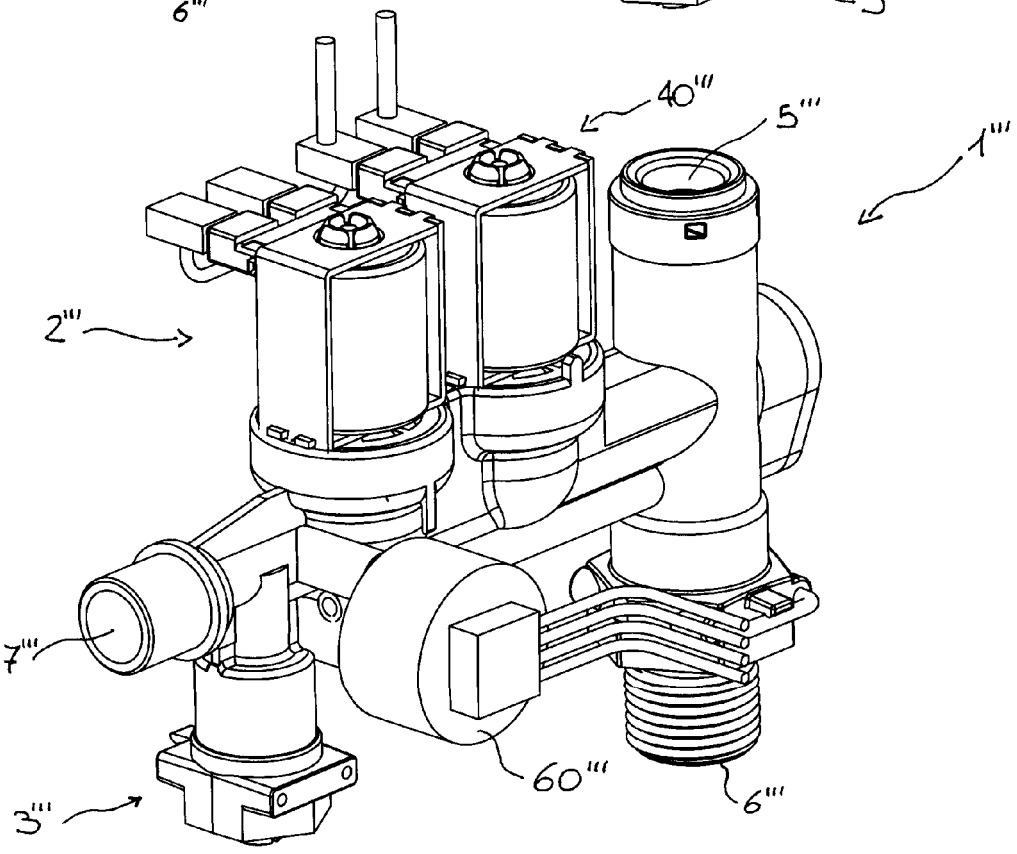


FIG 12

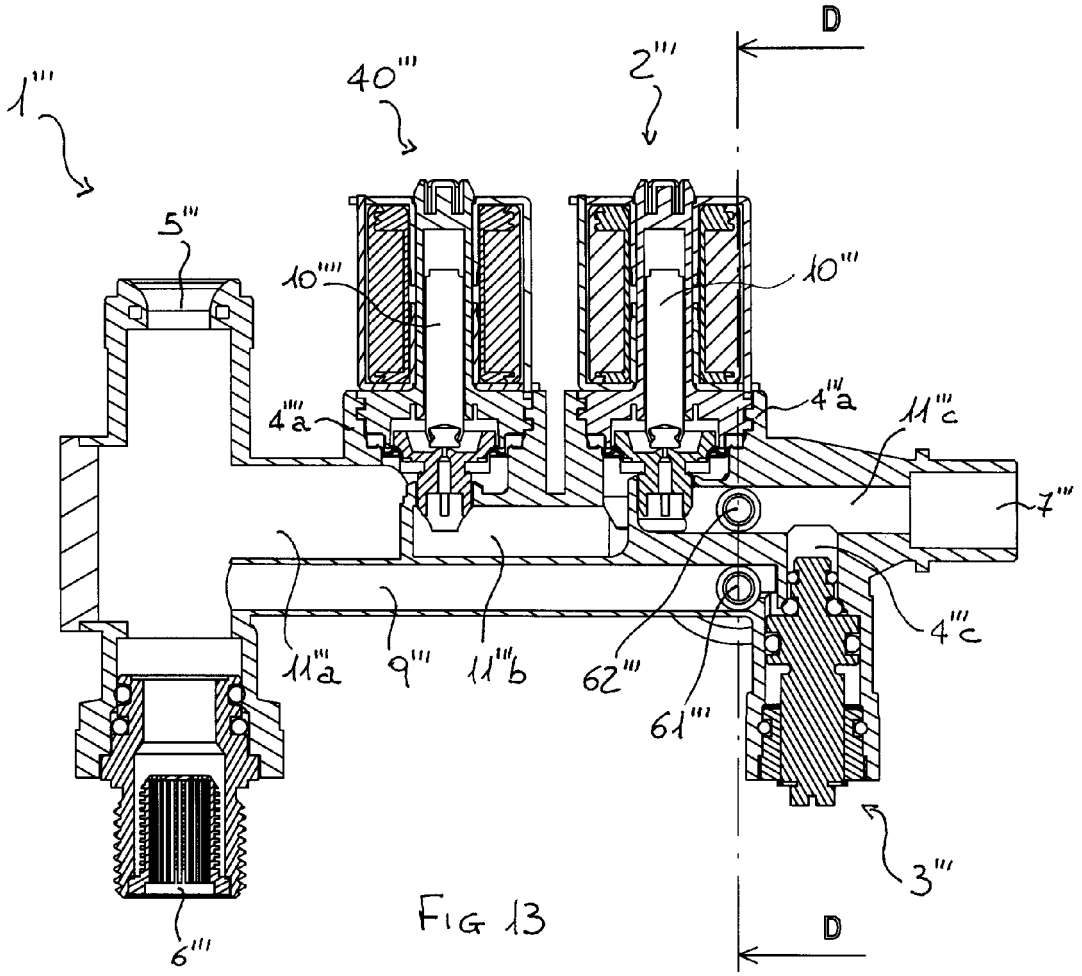


Fig 13

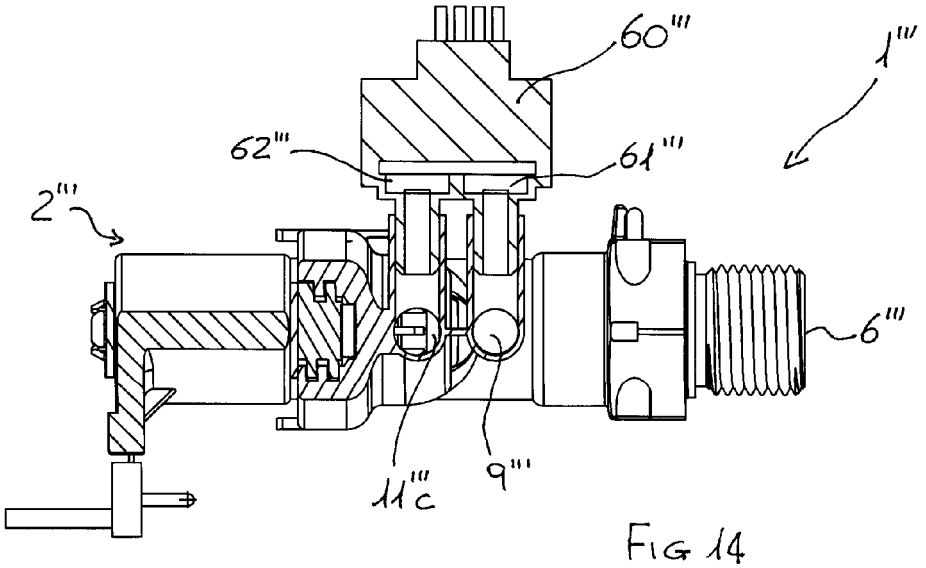


Fig 14

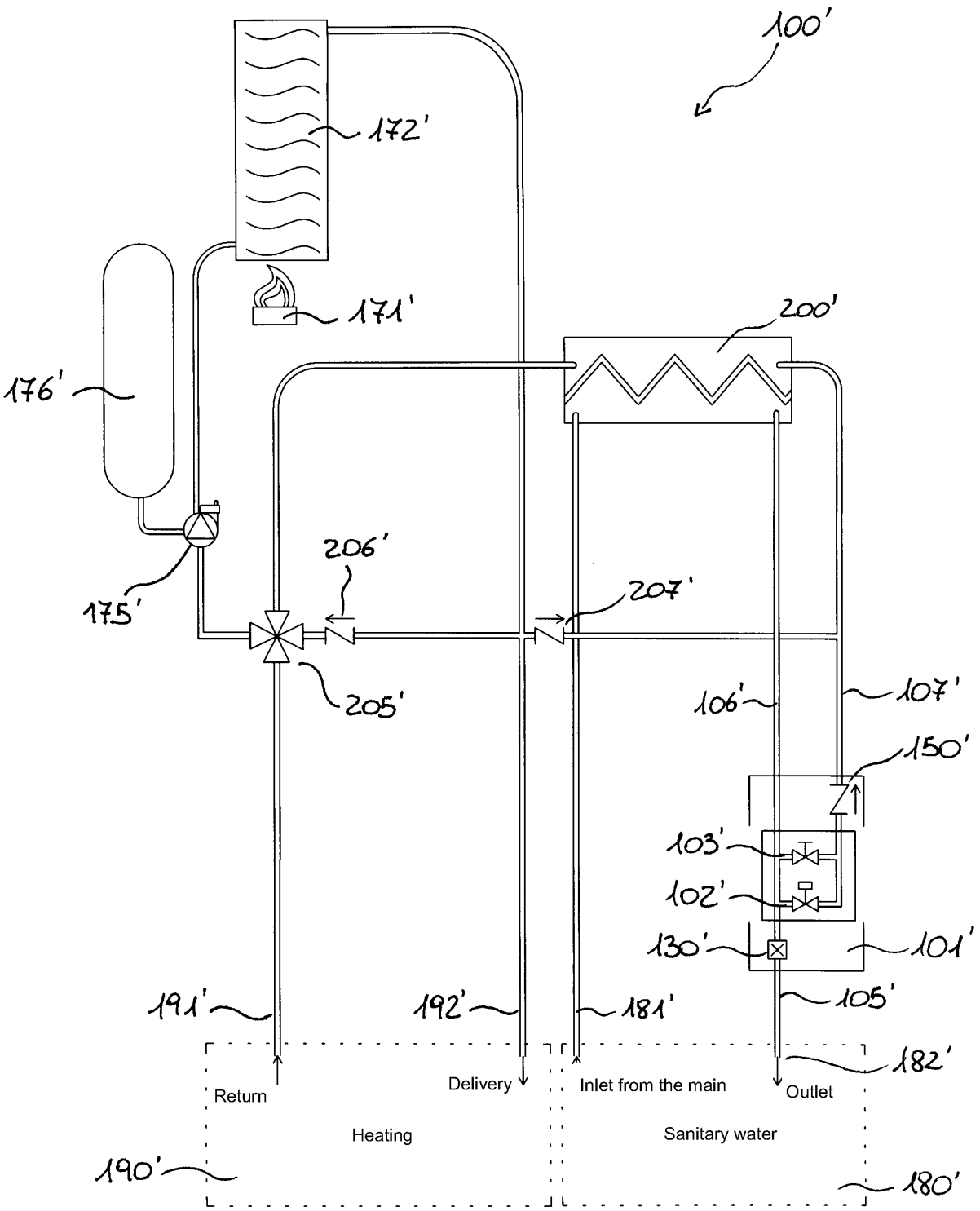

100'
172'
171'
200'
176'
206'
207'
175'
205'
106'
107'
150'
103'
102'
130'
101'
191'
192'
181'
105'
182'
Return
Delivery
Inlet from the main
Outlet
Heating
Sanitary water
190'
180'

FIG. 15

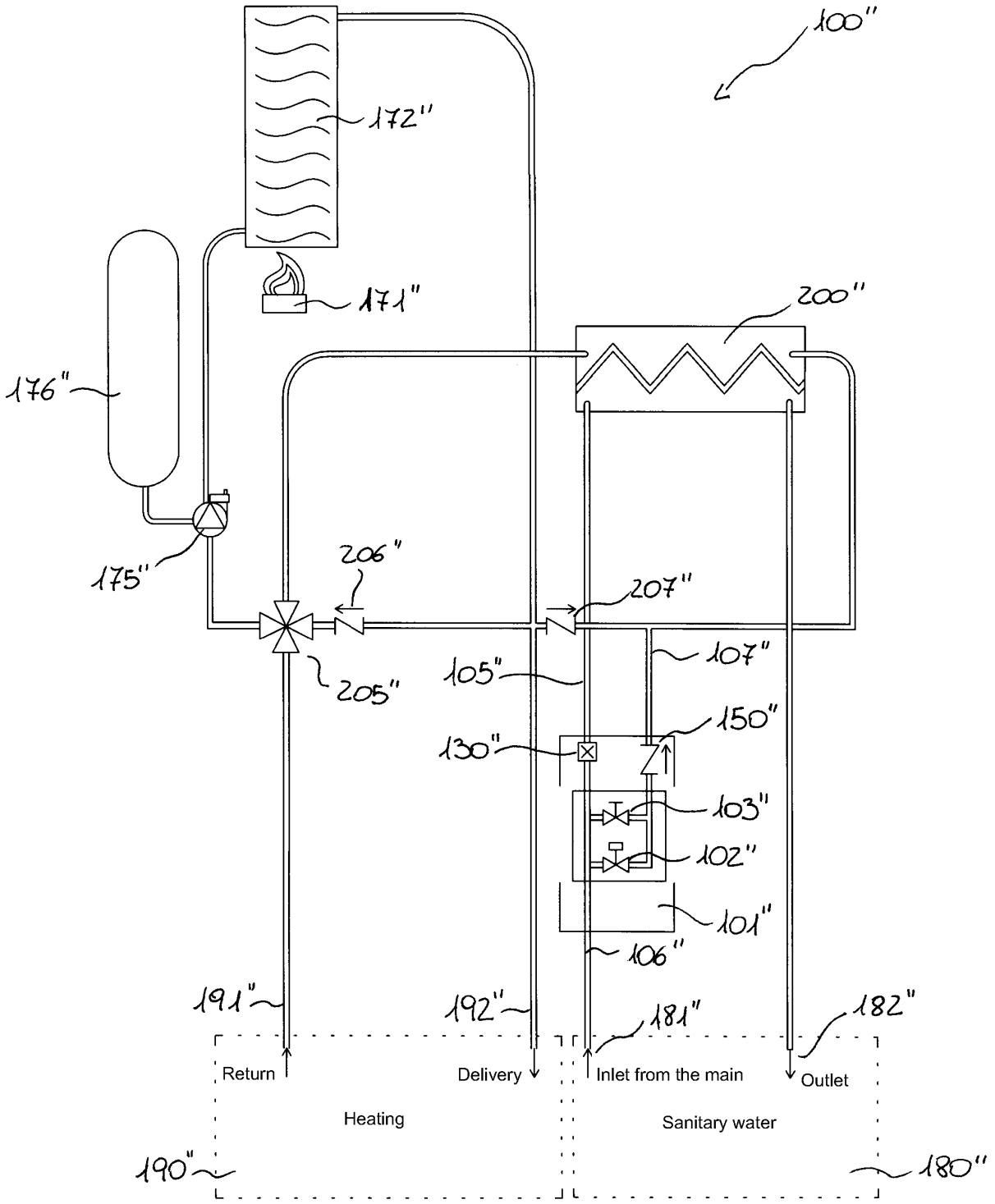

100"
172"
171"
200"
176"
175"
206"
207"
205"
105"
107"
150"
130"
103"
102"
101"
106"
191"
192"
181"
182"
Return
Delivery
Inlet from the main
Outlet
Heating
Sanitary water
190"
180"

FIG 16

REFERENCES CITED IN THE DESCRIPTION

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Patent documents cited in the description

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- EP 0599341 A **[0051] [0084]**
- EP 0940577 A **[0093]**