

ELECTRONIC DEVICE FOR MIXING WATER AND REGULATING THE FLOW RATE

DESCRIPTION

5 The present patent concerns the devices for mixing water and regulating the flow rate, and in particular it concerns a new electronic device for mixing water and regulating the flow rate for hydraulic systems for sanitary water of the type with one single pipe.

Hydraulic systems for the supply of sanitary water are known, which are commonly installed in civil, commercial, industrial buildings, that is, 10 wherever there are civil and industrial users to which water must be provided.

Hydraulic systems for sanitary water are known and widespread, which comprise two distinct piping lines, one for cold water and the other for hot water, that convey water to every single sanitary fixture, that is, basin, 15 shower, etc., and wherein water is mixed and the flow rate of the supplied water is regulated at the level of the mixer and of the tap.

Taps for sanitary fixtures like basins, showers, etc are known, which comprise one tap with one or more knobs or levers for regulating the water flow rate and for mixing water.

20 Said knobs or levers have the function to open or close to a varying degree the hydraulic valves, or gate valves, positioned inside the pipes leading to the sanitary fixture.

Taps and mixers are known that are equipped with a lever suited to be rotated on the horizontal plane, that is, to the right or to the left, in order to 25 regulate the ratio between the hot and cold water flows and consequently to regulate the water temperature, and suited to be lifted or lowered, that is, to be rotated on the vertical plane, to regulate the water flow delivered by the

mixer.

The operation of said known taps is thus mechanic and involves the use of special components, commonly called cartridges, which are inserted in the taps in such a way as to be able to be manoeuvred by means of said
5 regulating lever.

Said cartridges are devices comprising a substantially cylindrical external body, whose base is provided with two or more holes, and wherein inside said cylindrical body there are suitable moving elements, usually flat and circular in shape.

10 The known cartridges are inserted in the tap and are equipped, on the top, with a small lever connected to the regulating lever of said tap.

When the user shifts said regulating lever laterally, to the right or to the left, this rotary movement is transmitted to the discs contained in the cylindrical body and these discs open or close, partially or completely, the holes present
15 in said base of the cylindrical body itself.

In this way it is possible to regulate the rate of the hot and cold water flows that pass through the holes and therefore substantially to regulate the temperature of the water dispensed.

If the user, on the other hand, lifts or lowers the regulating lever, the small
20 lever of the cartridge is moved to an inclined position, thus opening or closing, totally or partially, the hole through which the water to be dispensed can reach the tap and flow out.

The greater or smaller opening of said hole, determined by the greater or smaller inclination of the regulating lever, determines the flow rate of the
25 dispensed water.

Hydraulic systems with two distinct water pipes, on the other hand, present several drawbacks, first of all the high labour cost for installation and

maintenance.

It is also known that said hydraulic systems with double piping need demolition work for any replacement or repair, and/or for any modification of the position of the sanitary fixtures, with the consequence that the part of the wall involved by the work must also be rebuilt, with the corresponding additional costs for both labour and materials.

Single-pipe hydraulic systems for sanitary water are also known, that is, systems comprising a single pipe that supplies the already mixed water to the corresponding sanitary fixture.

In this case water is mixed before being conveyed into the supply pipe, and mixing takes place in a manifold-mixer, where the two hot and cold water pipes arrive and from which a single supply pipe branches off for each sanitary fixture.

The water, properly mixed in such a way as to obtain the desired temperature and flow rate, reaches the sanitary fixture through said single supply pipe, made of a flexible plastic material.

In this way the use of two pipes is avoided, thus sparing a considerable amount of time and reducing material and installation costs.

Said mixed water supply pipe is housed in sheaths, channels, hoses or the like, so that in case of replacement it can be simply withdrawn from its seat, with no need for any wall demolition work.

Hot and cold water are thus mixed before being conveyed into the supply pipe, and mixing takes place in said manifold-mixer, usually in proximity to the boiler.

Said manifold-mixer comprises, for this purpose, at least one three-way solenoid valve, connected to the hot and cold water pipes and to the water supply pipe.

Each supply pipe thus brings water to the corresponding sanitary fixture, the mixing ratio and the flow rate of the water to be dispensed being regulated by said solenoid valve, one solenoid valve being provided for each water supply pipe.

5 In particular, the mixing ratio is regulated by the user through a regulating knob, preferably positioned near the sanitary fixture, that, via electric wires connected to the solenoid valve or to the corresponding control circuit, controls the operation of the manifold-mixer.

10 By changing the position of the regulating knob it is possible to change the position of the solenoid valve and therefore to regulate the mixing ratio of hot and cold water and the flow rate of the water to be dispensed.

The known manifolds-mixers of the hydraulic systems for sanitary water with one single pipe are thus reached by the two hot and cold water pipes, and said pipes have as many branches as the number of solenoid valves.

15 In this way, however, the system of pipes and pipe fittings may be rather bulky and too complex and difficult to carry out, especially in the presence of several solenoid valves.

20 Said knobs and said solenoid valves for mixing water and regulating the flow rate, furthermore, are not sufficiently compact and are also difficult to install; when one of said solenoid valves must be replaced, the operation is excessively complex and requires even a temporary interruption of the supply of water in the whole system.

However, the use of regulating devices different from the known taps poses some drawbacks.

25 First of all, the installation of a new, single-pipe hydraulic system for sanitary water would make it necessary to replace the taps with which the sanitary fixtures are provided and which, as known, are extremely expensive.

Furthermore, it is important to consider that the custom of using traditional taps, with regulating knobs or lever, is deep-rooted, which makes said known regulating devices almost indispensable.

5 Furthermore, the aesthetic value of traditional taps is undoubted, in fact they often serve as real pieces of furniture, so much that the elimination of said known devices may not be acceptable.

10 In order to overcome the drawbacks mentioned above, the invention proposes a new electronic device for mixing water and regulating the flow rate of the water dispensed by the tap of hydraulic systems for sanitary water, in particular of the single-pipe type, wherein said new device is connected to one or more solenoid valves and/or to one or more electric control units.

15 The main object of the present invention is to carry out the mixing of hot and cold water before the water is conveyed into the supply pipe, so that when the water to be dispensed reaches the sanitary fixture it has already been mixed, and can be dispensed at the temperature and flow rate desired by the user.

Another object of the present invention is to allow the flow rate of the water reaching the sanitary fixture to be regulated according to the user's needs.

20 Another object of the present invention is to carry out a device that is compact and easy to install.

A further object of the present invention is to carry out a device that does not require the replacement of the common mixer taps with regulating lever, since the new device can be installed in mixer taps of known type.

25 A further object of the present invention is to make it possible to transform any pre-existing traditional mixer tap with manual regulating levers into a tap or mixer tap with electronically operated knobs/levers, while keeping its

appearance and functionality unchanged.

Another object of the present invention is to allow the installation of knobs and/or levers and/or button panels for regulating the flow rate and the temperature of the water to be dispensed even not in proximity to the taps.

5 These and other direct and complementary objects are achieved by the new electronic device for mixing water and regulating the flow rate of the water dispensed by the tap of hydraulic systems for sanitary water, in particular of the single-pipe type, wherein said new device is connected to one or more solenoid valves and/or to one or more electric control units.

10 The new electronic device for mixing water and regulating the flow rate of the water dispensed comprises at least one electronic board or circuit, connected, directly or indirectly, to at least one regulating lever of a mixer tap, for example of single-pipe hydraulic systems for sanitary water, and/or to button panels and/or to interface displays.

15 Said new electronic device can be applied in particular to hydraulic systems for sanitary water comprising at least one control and supply unit, at least one manifold-mixer with one or more solenoid valves, one or more supply pipes suited to deliver water to users or sanitary fixtures of various type and one or more taps with levers and/or button panels and/or displays and/or
20 other devices by means of which the user can mix water and regulate the flow rate of the water dispensed by the tap itself.

Said manifold-mixer is preferably installed upstream of the sanitary water supply pipe, typically in proximity to the boiler.

The manifold-mixer comprises one or more solenoid valves, each one of
25 which is connected to the two hot and cold water pipes and to at least one supply pipe.

Said supply pipe is a flexible pipe made of plastic material resistant to

thermal and mechanic stress due to the passage of the water conveyed to the different sanitary fixtures.

Each solenoid valve is provided with two through holes in which the hot and cold water pipes are inserted and connected, both pipes being provided with suitable holes and pipe fittings for allowing water to be fed into the supply pipe.

Said solenoid valve comprises two motors for hydraulic valves that control the opening and closing of said holes and is electrically connected, through two or more electric wires, to at least one of said electronic adjusting devices, each one of which in its turn is directly or indirectly connected to one or more regulating levers and/or button panels and/or to said electric control and supply unit.

The user can modify the position of said hydraulic valves by means of said electronic regulating device, thus regulating the rate of the hot and cold water flows, or the mixing ratio and consequently the temperature and flow rate of the water to be dispensed.

In the preferred embodiment of the invention, said supply pipe with at least one solenoid valve is connected to one or more sanitary fixtures, and each solenoid valve is controlled by said electronic regulating device that in its turn is connected, for example, to one or more regulating levers for each sanitary fixture.

Each solenoid valve also comprises an electric control and supply unit that provides for decoding and processing the data coming from said electronic regulating device and for feeding the solenoid valve that regulates the mixing ratio and the flow rate of the water to be conveyed to the sanitary fixture.

In particular, said electronic device sends the data regarding the hot and cold

water flow rates to said electronic control and supply unit, which operates the motors of the hydraulic valves of the corresponding solenoid valve, so that the flows of hot and cold water can be properly mixed according to the user's requirements.

5 In the preferred embodiment of the invention, said electronic device comprises an external containment body substantially cylindrical in shape, for example having shape and size similar to those of the cartridges of known type, and therefore suited to be inserted in the mixer taps with regulating lever that are currently used.

10 The new electronic device comprises an upper small lever, projecting from said containment body and connected to the regulating lever of the mixer tap, said small lever being furthermore hinged to a block inside said containment body and comprising a upper and a lower shell, integral with each other and suited to contain at least one further translating element,
15 hereinafter called slide.

Said slide is directly or indirectly connected to said small lever, so that the rotation of the small lever on the vertical plane, that is, its change in inclination, causes the slide to be displaced.

Said slide is integral with at least one first magnetic element or translating
20 magnet that, as a consequence of the translation of said slide, approaches/moves away from an opposing linear magnetic sensor, in its turn belonging to an electronic board or circuit positioned below said slide and said lower shell of the internal block.

Said electronic board or circuit comprises, in addition to the electric
25 contacts with the wires for connection to the solenoid valve, at least one further magnetic rotation sensor.

At least one second magnetic element or fixed magnet is constrained to a

position corresponding to and opposite said magnetic rotation sensor, integrally attached to a fixed lower base.

Said small lever and said block, integrally attached to said electronic circuit, can also rotate around a vertical axis with respect to said fixed lower base and to said containment body, so that said second fixed magnet rotates with respect to said magnetic rotation sensor.

The operation of the new electronic device is such that the relative displacement of each magnet with respect to the corresponding magnetic sensor, be it a linear or a rotation sensor, induces a potential difference (Hall effect) in the sensor itself, said potential difference being transmitted, through said electric cables, to the solenoid valve of the manifold-mixer.

The rotation of the small lever on the horizontal plane causes at the same time the rotation of said block with respect to the lower fixed base and the fixed magnet, thus creating a potential difference that, when transmitted to said solenoid valve, regulates the rate of the individual flows of cold and hot water, thus regulating the mixing and the temperature of the dispensed water. Said fixed magnet, in fact, creates an alternate field between positive and negative, thus allowing said rotation sensor to decode an extremely precise flow rate value.

The electric signal is transmitted, through two or more electric wires, to the corresponding solenoid valve of said manifold-mixer, where the mixing of cold and hot water is regulated, and/or to said electric control and supply unit.

When, on the contrary, said lever is lifted/lowered, this causes the slide and the translating magnet to move backward or towards the linear magnetic sensor, thus creating a potential difference that is transmitted to the solenoid valve to regulate the flow rate of the water being dispensed, said regulation

being achieved by opening or closing to a different extent the hole for the passage of the solenoid valve.

In particular, the electric signal is sent, through two or more electric wires, to said electric control and supply unit and/or to the solenoid valve of said manifold-mixer, where the position of said solenoid valve determines the flow rate of the water to be dispensed.

Said lifting/lowering of the small lever is achieved by the user who lifts/lowers the mixer tap lever, while said rotation of the small lever is achieved by the user who rotates said mixer tap lever to the right or to the left, as in a normal mixer.

Substantially, in order not to lose the obvious advantages deriving from the installation of the single-pipe hydraulic system for sanitary water and to be able to use it comfortably, thanks to the installation of said new electronic device the mixer taps can thus be exactly like the known devices, that is, mixer taps with regulating lever.

According to a further possible embodiment of the invention, even simpler and more economic than the previous ones, said electronic device that controls the solenoid valves can be regulated with common knobs or joysticks and contained in a simple case that can be integral with the sanitary fixture or positioned on a wall, not necessarily in proximity to the sanitary fixture itself.

According to the invention, the system also comprises one or more sensors (flood, temperature, pressure sensors, etc) that improve the operation and use of the hydraulic system for sanitary water.

For example, through the installation of flood probes inside or in proximity to the manifold-mixer, said electric control and supply unit may cause the interruption of the supply of water in case of uncontrolled water outflows.

The installation of a temperature sensor connected to an adjusting device allows the user to read and consequently set the temperature of the water to be dispensed through the tap of the sanitary fixture before its use.

The characteristics of the invention will be highlighted in greater detail in the following description, with reference to the drawings attached as non-limiting examples.

Figure 1 shows an exploded view of the new electronic device (G), while Figures 2a-i show side views, in detail, of the individual components of the device (G).

Figure 3 shows a three-dimensional view of the internal block (10), positioned above the lower fixed base (8), assembled without the upper shell (2), while Figure 3a shows only the electronic board or circuit (6) of the electronic device (G).

Figure 4 shows an example of application of the electronic device (G) to a tap (Ri) with regulating lever (L), said tap (Ri) being connected to a solenoid valve (Ei) of a single-pipe system for sanitary water through a supply pipe (Ti).

Said solenoid valve (Ei) is shown in a sectional view and in a three-dimensional view in Figures 5 and 5a, respectively, while Figure 6 shows a manifold-mixer (C) of a single-pipe system for sanitary water, with a diagram of a possible layout of said solenoid valves (Ei).

Figure 7 shows a diagram of a sanitary fixture (Ui) connected to the supply pipe (Ti), while Figure 8 shows a control display (D).

The manifold-mixer (C) comprises one or more solenoid valves (Ei), for example one for each sanitary fixture (Ui), wherein each solenoid valve (Ei) is provided with two through holes (Fc) and (Ff), for the insertion of the hot water pipe (Tc) and of the cold water pipe (Tf), respectively.

Said solenoid valves (Ei), being provided with said through holes (Fc) and (Ff), may all be connected to the same two hot water (Tc) and cold water (Tf) pipes, and can be positioned side by side or overlapped, as shown in Figure 6.

5 The solenoid valve (Ei) is provided with a further hole (F3) for inserting the supply pipe (Ti) that conveys water from said solenoid valve (Ei) to the sanitary fixture (Ui).

Each solenoid valve (Ei) also comprises two motors (M1) and (M2) that control the hydraulic valves (W1) and (W2) responsible for regulating the
10 flow rates of the hot and cold water coming from the pipes (Tc) and (Tf).

Each one of said solenoid valves (Ei) of the manifold-mixer (C) is also connected to at least one regulating device, preferably positioned in proximity to the sanitary fixture (Ui), through two or more electric wires (B). In the preferred embodiment of the invention shown in Figures 1, 2 a-i, 4,
15 said electronic device (G) is regulated by means of one or more regulating levers (L) of a mixer tap (Ri) of the sanitary fixture (Ui) or on a electric control and supply unit (Zi).

Said electric control and supply unit (Zi) has the function to receive, decode and process the data sent by said electronic device (G) and/or by any other
20 sensors used, such as flood sensors, temperature sensors, or any other sensor. The invention may also comprise a display (D), connected to said temperature sensor, that indicates, in addition to the value of the flow rate, also the value of the temperature of the water present in the supply pipe (Ti) and ready to be dispensed.

25 In this way the user can read the temperature and the flow rate of the water that is going to be dispensed by the taps (Ri) and if necessary decide whether to use the button panel and/or the regulating levers (L) in order to

modify the mixing ratio and the flow rate of the water before use.

This configuration is particularly useful for showers or other sanitary fixtures, in fact the user comes in contact with the water only when the desired temperature has been reached, which allows unpleasant sensations of excessive cold or hot to be avoided.

Once the data have been received and processed, the position of the solenoid valve (Ei) is adjusted via said motors (M1) and (M2) that, by opening/closing said hydraulic valves (W1, W2), consequently determine the mixing ratio, temperature and flow rate of the water conveyed to the sanitary fixtures (Ui) through the supply pipe (Ti).

Each one of said mixer taps (Ri) with regulating lever (L) is connected to the corresponding supply pipe (Ti) that in its turn is connected to said manifold-mixer (C) wherein the position of the solenoid valve (Ei) determines the mixing ratio and the flow rate of the dispensed water.

Said solenoid valve (Ei) is connected, through two or more electric wires (B), to said electronic device (G), which in its turn is inserted and fixed into the tap (Ri), as shown in Figure 4, and connected to the adjusting lever (L) of the tap itself. For this purpose, said electronic device (G) comprises an external containment body (9) suited to be inserted in the mixer taps (Ri) with regulating lever (L) currently in use.

The new electronic device (G) comprises a small upper lever (1), projecting from said containment body (9) and hinged to a block (10), in its turn comprising a upper (2) and a lower shell (5), integral with each other and suited to contain a translating slide (3).

Said slide (3) is directly or indirectly connected to the lower part (11) of said small lever (1), so that the rotation of the small lever (1) on the vertical plane causes the slide (3) to be displaced.

Said slide (3) is integral with a translating magnet (4) that, as a consequence of the translation of said slide (3), approaches/moves away from an opposing linear magnetic sensor (61), in its turn belonging to an electronic board or circuit (6) positioned below said slide (3) and said lower shell (5).

5 Said electronic board or circuit (6) comprises, in addition to the electric contacts (63) with the cables (B) for connection to the solenoid valve (Ei), at least one further magnetic rotation sensor (62).

A fixed magnet (7) is constrained to a position corresponding to and opposite said magnetic rotation sensor (62), said fixed magnet (7) being
10 integrally attached to a fixed lower base (8).

Said small lever (1) and said block (10), together with said electronic circuit (6), can rotate around a vertical axis with respect to said fixed lower base (8), so that said second fixed magnet (7) rotates with respect to said magnetic rotation sensor (62).

15 The user, to regulate the mixing ratio of the dispensed water, must use the regulating lever (L), rotating it sideways, while to regulate the flow rate the user must lift or lower said regulating lever (L). In practice, therefore, the user uses the tap with regulating lever (L) as if it were a common tap with hydraulic cartridge.

20 The new electronic device (G) further comprises one or more gaskets (101, 102, 103), for example O rings, suited to insulate the device by preventing water and humidity from getting inside it.

In particular, according to the invention, at least one gasket (101) is positioned between said fixed base (8) and said containment body (9), at
25 least one further gasket (102) is positioned between said slide (3) and said upper shell (2) and finally at least one further gasket (103) is positioned between said upper shell (2) and said containment body (9).

The use of a presence detector can also be included, which regulates the water flow rate by adopting preset values.

Furthermore, a vocal control device can also be employed to regulate the total flow rate and the mixing ratio of the flow being dispensed.

5 Therefore, with reference to the above description and the attached drawings, the following claims are expressed.

CLAIMS

1. Device (G) for mixing water and regulating the flow rate in hydraulic systems for sanitary water, **characterized in that** it comprises at least one electronic board or circuit (6) electrically connected, directly or indirectly, to one or more solenoid valves (Ei) for regulating the flow rate of hot and cold water conveyed to at least one tap (Ri) through supply pipe/pipes (Ti), and wherein the relative displacement of one or more magnets (4, 7) in relation to one or more magnetic sensors (61, 62) of said electronic circuit (6) generates a potential difference that, transmitted to said solenoid valve/valves (Ei), causes it/them to open completely/partially.

2. Device (G) for mixing water and regulating the flow rate according to claim 1, **characterized in that** said electronic board or circuit (6) comprises at least one linear magnetic sensor (61) and wherein the relative linear displacement of at least one magnet (4) in relation to said linear magnetic sensor (61) generates a potential difference transmitted to said solenoid valve/valves (Ei).

3. Device (G) for mixing water and regulating the flow rate according to claim 1, **characterized in that** said electronic board or circuit (6) comprises at least one magnetic rotation sensor (62), and wherein the relative rotation of at least one magnet (7) in relation to said magnetic rotation sensor (62) generates a potential difference transmitted to said solenoid valve/valves (Ei).

4. Device (G) for mixing water and regulating the flow rate according to claims 1, 2, 3, **characterized in that** the relative linear and/or rotary displacement of one or more of said magnets (4, 7) in relation to said magnetic sensors (61, 62) is caused by the linear and/or rotary shift of one or more levers, knobs or other devices directly or indirectly connected to

one or more magnets (4, 7) and/or to one or more of said sensors (61, 62).

5. Device (G) for mixing water and regulating the flow rate according to claims 1, 2, 3, 4, **characterized in that** it comprises:

- at least one small lever (1) connected to a regulating lever (L) of the tap (Ri);
- at least one electronic board or circuit (6) with at least two magnetic sensors (61, 62), of which at least one linear magnetic sensor (61) and at least one magnetic rotation sensor (62);

and wherein:

- the rotation of said small lever (1) on the horizontal plane, determined by the corresponding rotation of the lever (L) of the tap (Ri), causes, directly or indirectly, the relative rotation of at least one magnet (7) in relation to said magnetic rotation sensor (62), generating a potential difference transmitted to said solenoid valve (Ei);
- the rotation of said small lever (1) on the vertical plane, determined by the corresponding rotation of the lever (L) of the tap (Ri), causes, directly or indirectly, the linear shift of at least one magnet (4) in relation to said linear magnetic sensor (61), generating a potential difference transmitted to said solenoid valve (Ei).

6. Device (G) for mixing water and regulating the flow rate according to claim 5, **characterized in that** it comprises:

- at least one lower fixed base (8), comprising a fixed magnet (7) integral with it;
- at least one internal block (10) containing at least one slide (3) integral with at least one magnet (4) and on which said small lever (1) rests, directly or indirectly, and wherein said slide (3) translates in relation to said linear magnetic sensor (61) of the electronic circuit (6), positioned

in proximity to said slide (3) and to said fixed base (8) and integral with the block itself (10);

- at least one external containment body (9) constrained to said lower base (8);

5 and wherein the rotation on the vertical plane of said small lever (1) projecting from said containment body (9) causes the displacement of said slide (3) and consequently of said magnet (4) that translates in relation to the corresponding opposing linear magnetic sensor (61) of said electronic circuit (6), while the rotation on the horizontal plane of said small lever (1)
10 causes the rotation of said internal block (10) in relation to said lower base (8) and, consequently, of said magnetic rotation sensor (62) in relation to the corresponding opposing fixed magnet (7).

7. Device (G) for mixing water and regulating the flow rate according to the preceding claims, **characterized in that** said external containment
15 body (9) has overall dimensions that are such as to allow it to be inserted in said known mixer taps.

8. Device (G) for mixing water and regulating the flow rate according to the preceding claims, **characterized in that** each one of said solenoid valves (Ei) connected to said electronic board or circuit (6) comprises:

- 20 - two or more through holes (Fc) and (Ff) for connection to the hot water (Tc) and cold water (Tf) inlet pipes of the hydraulic system for sanitary water;
- at least one further hole (F3) for the insertion of at least one supply pipe (Ti) that conveys the water to the tap (Ri) of the sanitary fixture
25 (Ui) to be served;
- one or more motors (M1) and (M2) of hydraulic valves (W1) and (W2) for opening/closing said holes (Fc, Ff);

- at least one electric control and supply unit (Zi) for receiving and processing the impulses coming from said electronic circuit (6) and for feeding said solenoid valve (Ei) according to said impulses received, in order to control the operation of said motors (M1, M2) and the position of said hydraulic valves (W1, W2), in such a way as to obtain the supply of water already mixed and regulated at the desired temperature and flow rate,

and wherein said solenoid valves (Ei) may be connected to each other and/or to the same two hot water (Tc) and cold water (Tf) pipes, and be positioned side by side or overlapped.

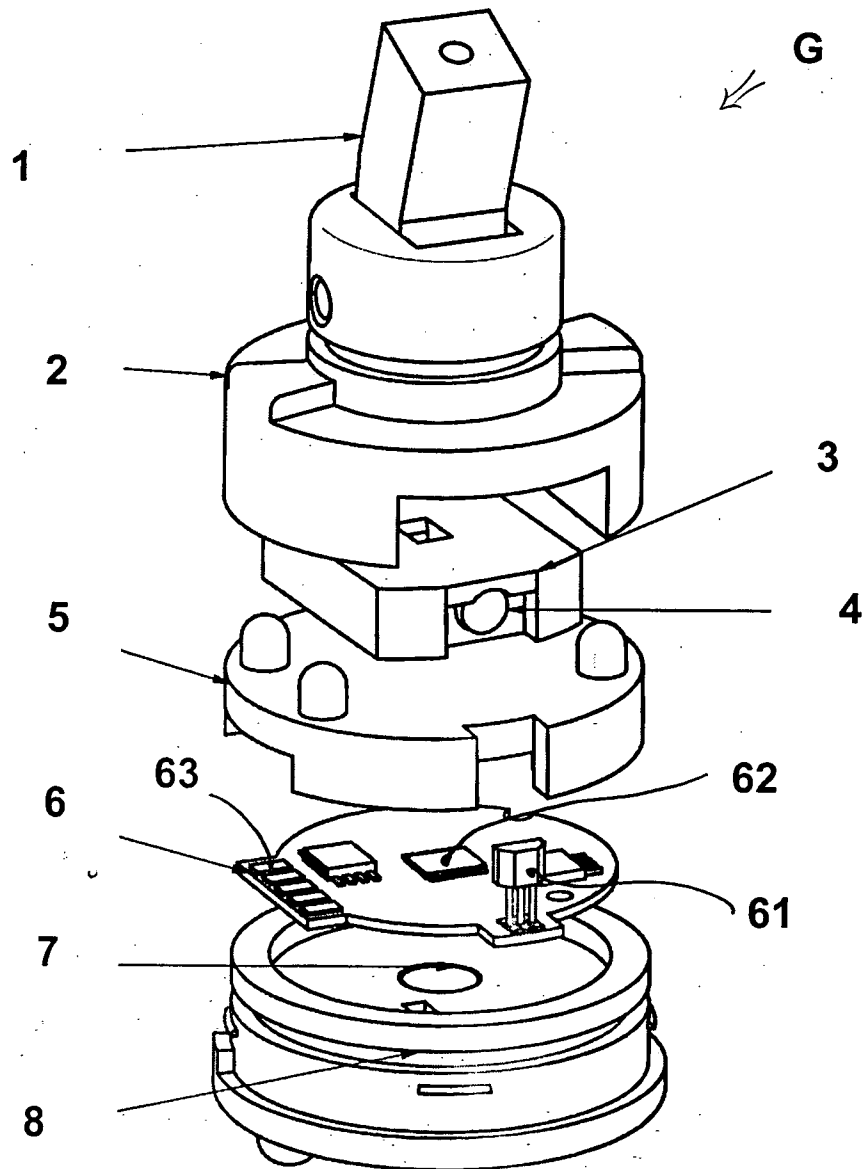


Fig. 1

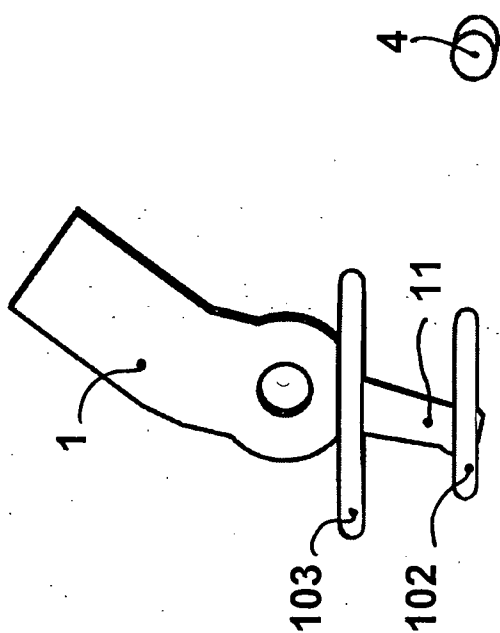


Fig. 2a

Fig. 2c



Fig. 2d



Fig. 2f



Fig. 2h

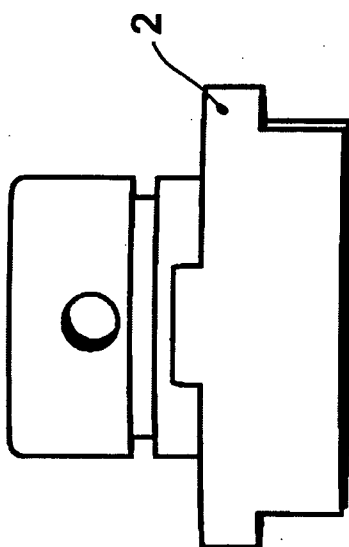


Fig. 2b

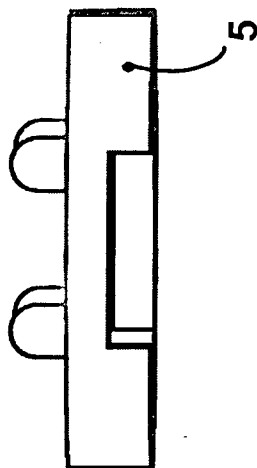


Fig. 2e

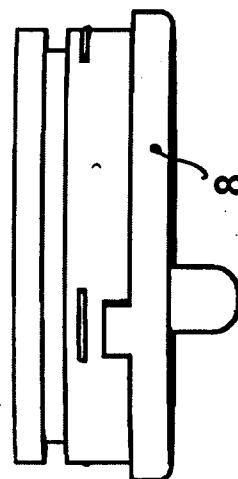


Fig. 2g

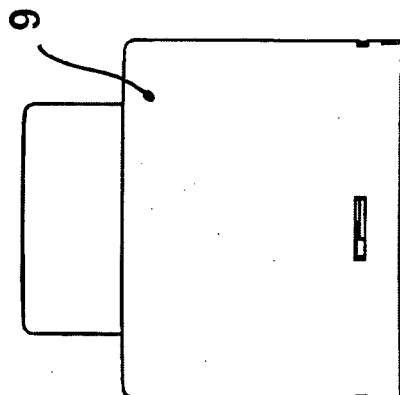


Fig. 2i

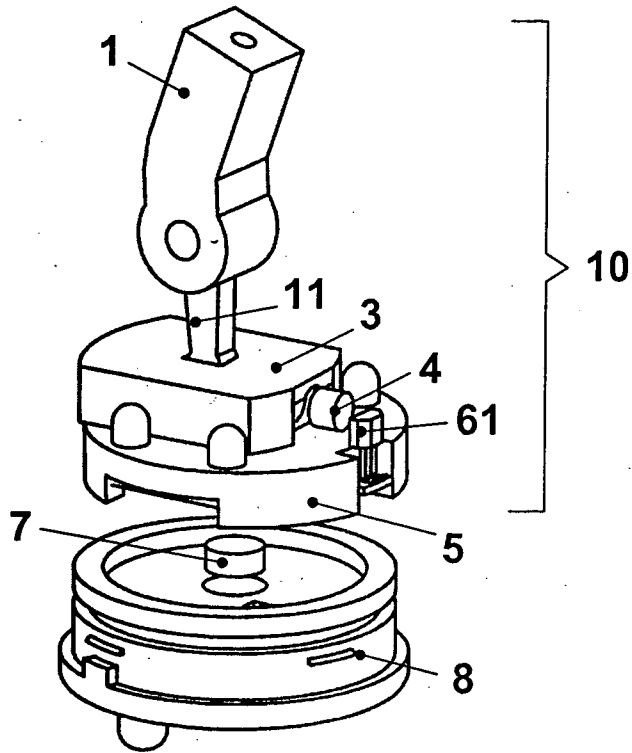


Fig. 3

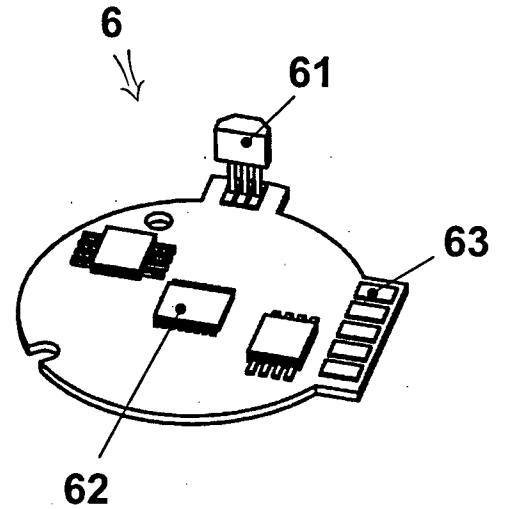


Fig. 3a

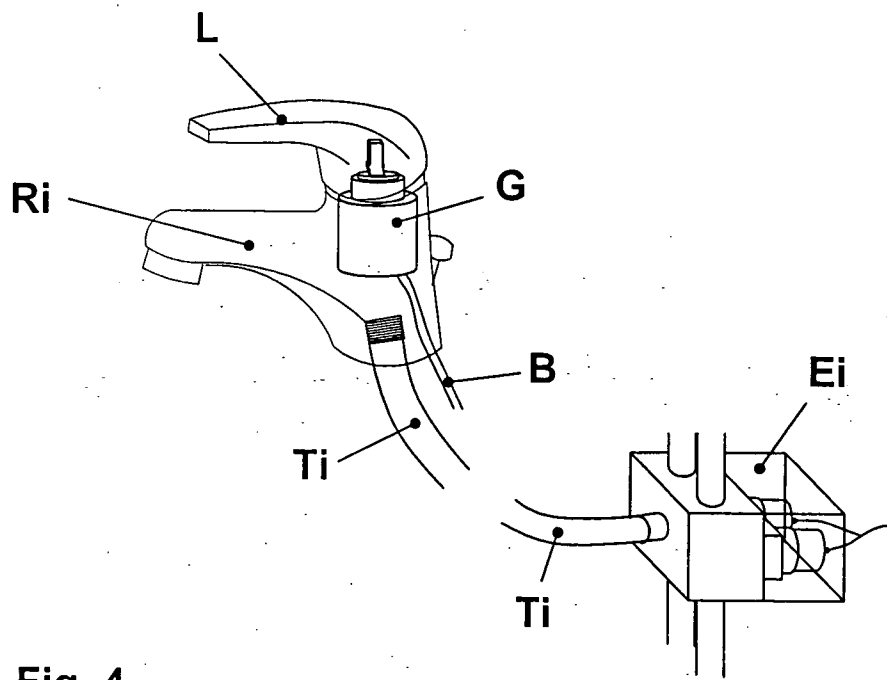
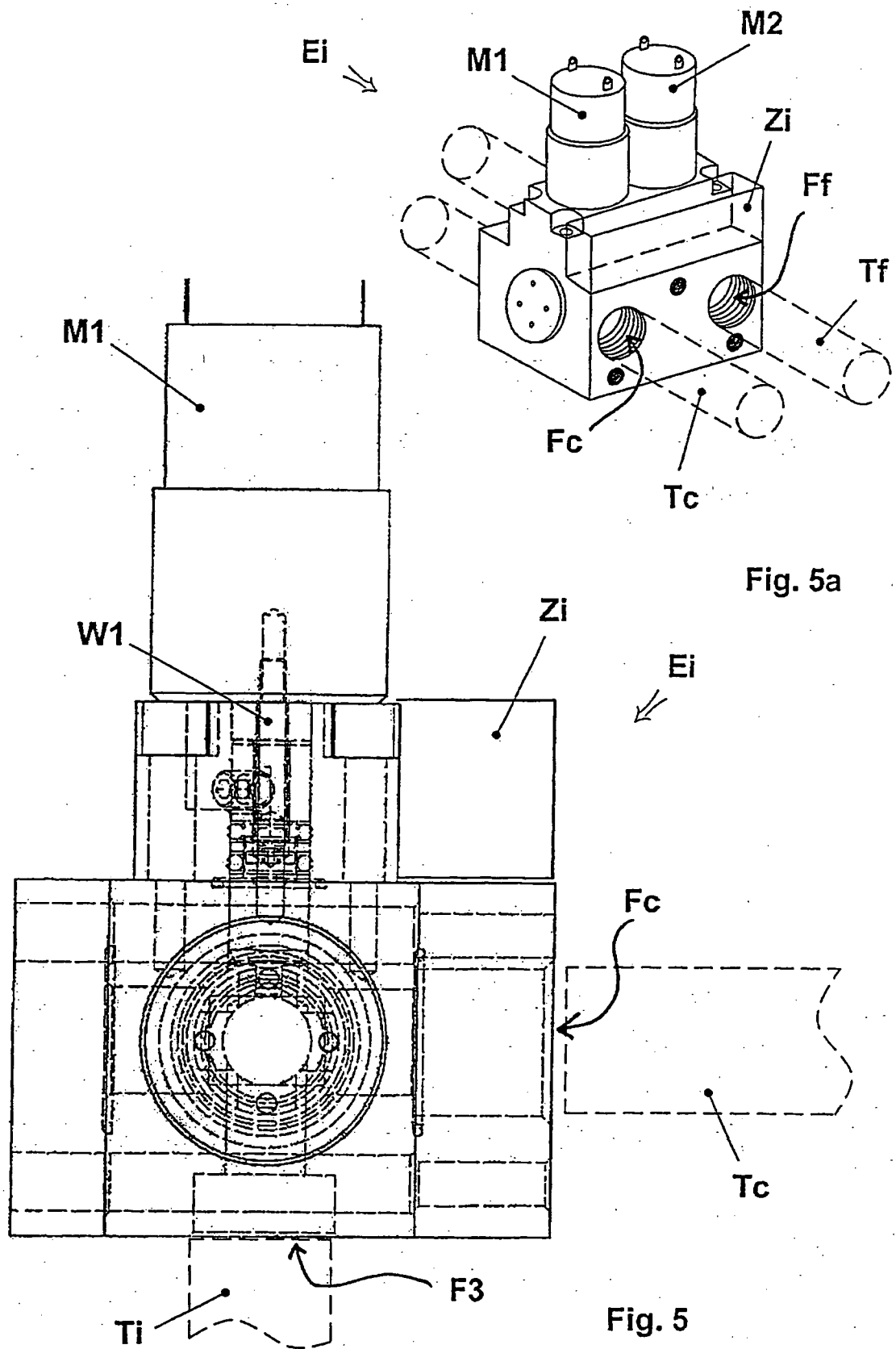


Fig. 4



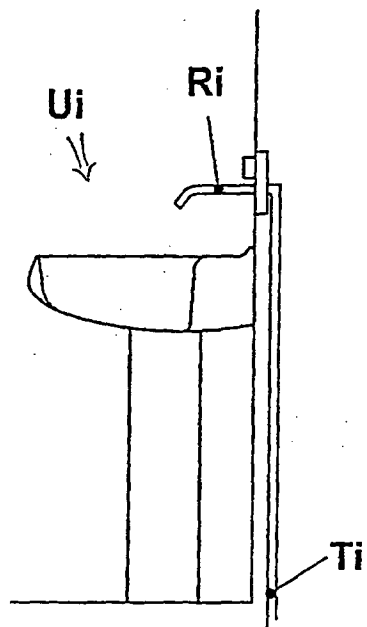


Fig. 7

C ⇒

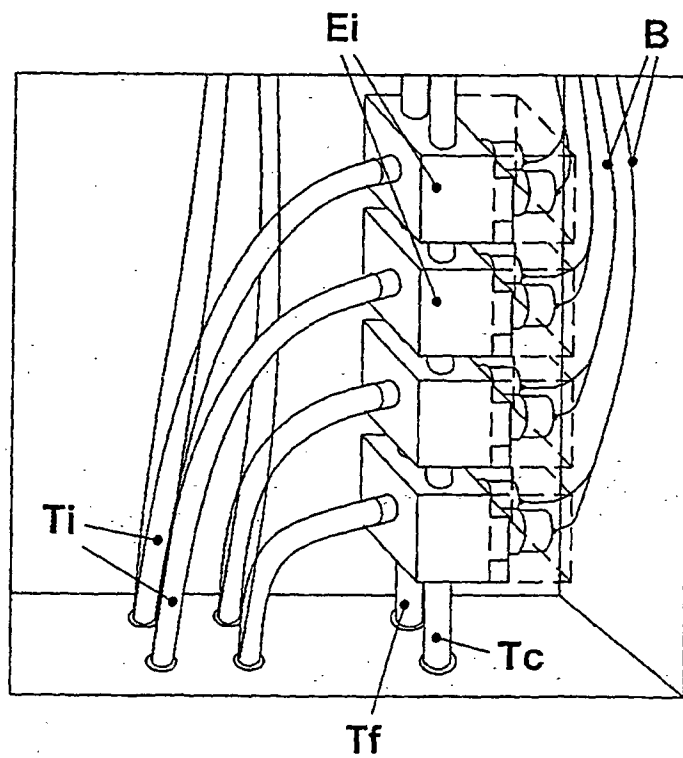


Fig. 6

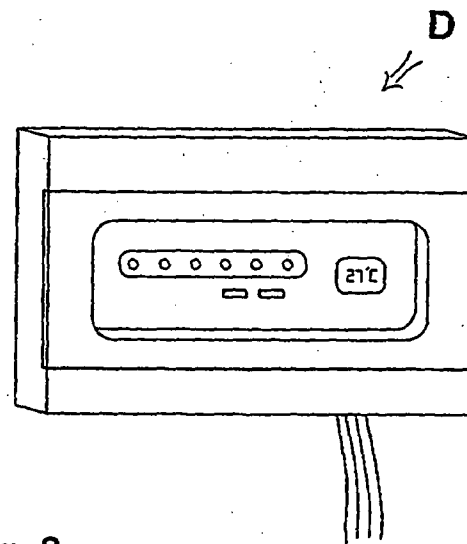


Fig. 8