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(54) **Safety system for a bath**

(57) The invention relates to safety system for a bath (1) comprising a detection unit (77) with a controller (7) and a flow sensor (75) which is arranged for measuring a flow of water being supplied to the bath. The sensor is arranged for sending a signal indicative of the measured flow to the controller, and the controller is arranged for determining the total amount of water being supplied to the bath and for calculating the theoretical water level in the bath. When the theoretical water level reaches a predetermined water level, the controller is arranged for terminating the supply of water to the bath and/or discharging the water already in the bath. Preferably the detection unit additionally comprises a level sensor (73) which is arranged for sending a signal indicative of the detected actual water level to the controller. The controller is arranged for comparing the actual water level with the theoretical water level.

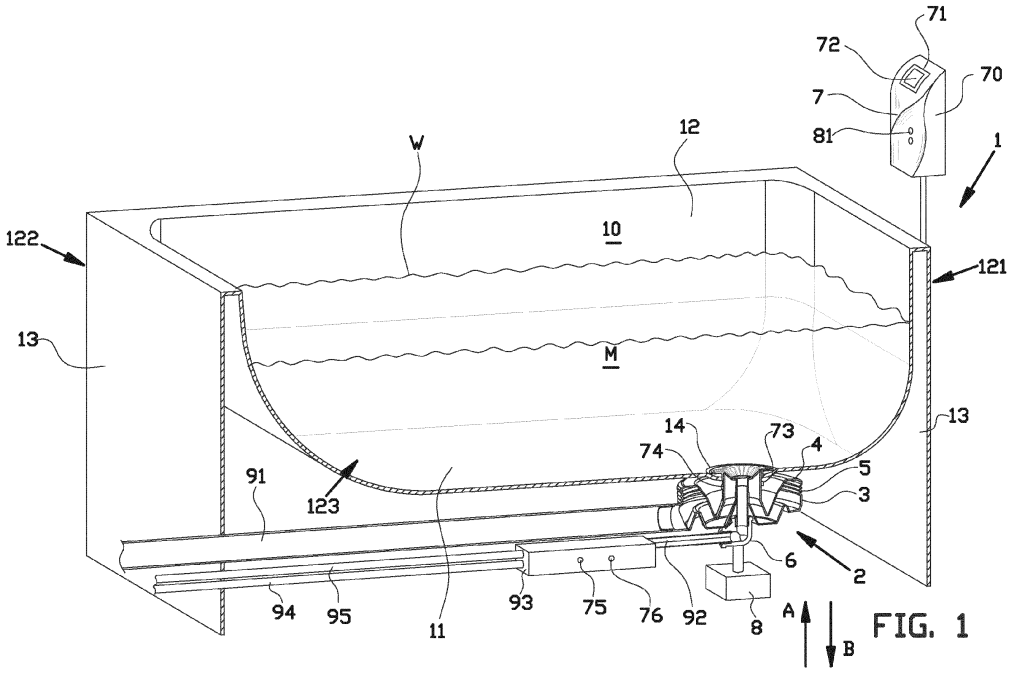

FIG. 1

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Description

BACKGROUND

[0001] The invention relates to a safety system for a bath, in particular for a bath for accommodating a person which is not self-reliant. The invention also relates to a bath comprising said safety system.

[0002] Known baths for accommodating persons who are not self-reliant are provided with safety devices such as a collar for supporting a person's neck above the water level or bath inserts for shortening the sitting area of the bath to prevent the person from sliding underneath the water level. Although these safety devices in some cases do prevent drowning, they do not provide a solution when drowning actually occurs despite the measures taken to prevent drowning. Additionally, these safety devices do not provide a solution to other emergencies, such as the water being too hot for the person accommodated in the bath. Thus, the known baths and devices do not optimally ensure the safety of the person accommodated in the bath.

[0003] It is an object of the present invention to provide a safety system for a bath and a bath comprising said safety system, wherein the safety system provides increased safety for the person accommodated in said bath.

SUMMARY OF THE INVENTION

[0004] According to a first aspect, the invention provides a safety system for a bath, comprising a detection unit with a controller and a flow sensor which is arranged for measuring a flow of water being supplied to the bath and for sending a signal indicative of the measured flow to the controller, wherein the controller is arranged for determining the total amount of water being supplied to the bath over a period of time based on the received signal and for calculating the theoretical water level based on a given volume and shape of the bath, wherein, when the theoretical water level reaches a predetermined water level, the controller is arranged for terminating the supply of water to the bath and/or discharging the water already in the bath. The actual water level in a bath can be difficult to accurately determine, because the water level can be inconsistent due to movements of the person accommodated in the bath. Thus, a theoretical calculation of the amount of water in the bath can be a more reliable parameter for determining and controlling a predetermined water level which is a substantially safe water level.

[0005] In an embodiment, the controller is arranged for subtracting at least part of a given volume of a person that is to be accommodated in the bath from the volume of the bath to obtain a value for the remaining volume of the bath to be filled with water. The accuracy of the determination of the theoretical water level can be increased by subtracting the given volume or water displacement of the person in the bath from the equation.

[0006] In an embodiment, the controller is connected to an alarm unit and is arranged for activating said alarm unit.

[0007] In an embodiment, the detection unit additionally comprises a level sensor which is arranged for detecting the actual water level in the bath and for sending a signal indicative of the detected actual water level to the controller, wherein, upon receipt of a signal from the level sensor, the controller is arranged for comparing the actual water level with the theoretical water level. The combination of both a flow sensor and a level sensor can provide increased safety, for example as a failsafe when one of the sensors malfunctions or by having the controller detect a discrepancy between the two sensors.

[0008] It is preferred that, for calculating the theoretical water, it is taken into account that at least the head and preferably a shoulder portion of the person is not submerged in the water. The theoretical water level thus should be the water level in the bath when the head and preferably a shoulder portion of the person in the bath is out of the water. In an embodiment, the controller is arranged for activating said alarm unit when the actual water level is higher than the theoretical water level, and the difference between the actual water level and the theoretical water level is larger than a predetermined level difference. When the actual water level is higher than the theoretical water level, the person in the bath is submerged more than desired or even fully submerged. In this case the alarm unit is activated.

[0009] In an embodiment, the level sensor comprises a pressure sensor, which is arranged in the bath, preferably in or near the bottom of the bath, or in or near an outlet unit in the bottom of the bath. The position of the water surface in the bath can be difficult to accurately determine, because the position of the water surface can be inconsistent due to movements of the person accommodated in the bath. By measuring the hydrostatic pressure in or near the bottom of the bath, a more reliable parameter for determining and controlling the actual water level is provided.

[0010] In an embodiment, the safety system comprises a person detection unit, wherein the person detection unit comprises a distance measuring unit which arranged at a first side of the bath and above a maximum water level in the bath, wherein the distance measuring unit is arranged for measuring a distance between the first side of the bath and a part of a person in the bath, which part is above said maximum water level. The distance measuring unit is arranged above the surface of the water in the bath and measures the distance along a line of sight which extends over the surface of the water. In particular the distance measuring unit measures the distance between the distance measuring unit and a part of a person which is above the surface of the water.

[0011] The distance measuring unit is preferably arranged at a first side of the bath, and the line of sight extends substantially over the bath to at least the second

side of the bath, which second side is substantially opposite said first side of the bath. When the measured distance is substantially equal or larger than a distance between the first side and the second side, there is substantially no part of the person above the surface of the water, thus the person in the bath is substantially submerged or even fully submerged. In this case the alarm unit is preferably being activated by the controller. In an embodiment, the controller is arranged for activating said alarm unit when the measured distance is larger than a distance between the first side of the bath and the part of the person, at least when the person is sitting in the bath with his back abutting against the second side of the bath.

[0012] Various distance measuring unit can be used. Preferably the measuring unit comprise contactless measuring sensors are applied, such as ultra sound or optical sensors. In an embodiment, the distance measuring unit comprises an optical distance measuring unit, preferably using Infra-Red light.

[0013] In an embodiment, the bath is an elongated bath having two longitudinal sides and two transverse sides, wherein the first side of the bath is one of said transverse sides. Preferably the bath is arranged to provide a seating accommodation at or near the second side of the bath and a foot accommodation at or near the first side of the bath. Preferably the bath comprises a discharge opening in a bottom wall of the bath for draining the bath, if required, wherein said discharge opening is arranged at or near the first side of the bath.

[0014] The combination of a person detection system and a water level control system - the flow sensor and controller - and detection system - the pressure sensor - yields a double acting safety system, which reduces the changes of failure of the safety system and which provides an increased safety for the person accommodated in said bath.

[0015] In an embodiment, the safety system is provided with a mixing unit for mixing hot and cold water into mixed water with a predetermined temperature, wherein the detection unit further comprises a first temperature sensor which is arranged for measuring the temperature of the water at or after mixing, yet prior to entering the bath, and a second temperature sensor for measuring the temperature of the water in the bath, wherein both sensors are arranged for sending signals indicative of the measured temperatures to the controller, wherein, when one of the measured temperatures reaches a predetermined upper value, the controller is arranged for terminating the supply of mixed water to the bath, adjusting the mixing ratio of the hot and cold water and/or discharging the water already in the bath. The combination of both a first temperature sensor and a second temperature sensor can provide increased safety, for example as a failsafe when one of the sensors malfunctions or by having the controller detect a discrepancy between the two sensors.

[0016] Usually a water supply for a bath is provided with a thermostat tap, which ensures that the water supplied to the bath has the required and/or desired temperature. A disadvantage of such thermostat taps is, that the functioning may be deteriorate in time, for example due to scale in the mechanism of the thermostat. In an embodiment, the mixing unit comprises a first valve arranged in the input line for hot water and a second valve arranged in the input line for cold water, wherein the input line for hot water and the input line for cold water are combined at a position downstream from said first and second valves to form a supply line, wherein the flow sensor is arranged in said supply line. Such a mixing unit the use of the thermostat mechanism which is susceptible for scaling, can be avoided and is replaced by a more robust valve system. The valve system of the present invention ensures that the water supplied to the bath is of the correct temperature and provides increased safety for the person accommodated in said bath, even in the long run.

[0017] In an embodiment, the first temperature sensor is arranged in said supply line. The first temperature sensor is thus arranged for measuring the temperature of the water before it enters the bath.

[0018] In an embodiment, the safety system according to invention further comprises a pump for accelerating the discharge of water from the bath. In case of emergency, for example when the alarm unit is activated, the pump can be activated to rapidly discharging the water out of the bath. The pump can increase the flow rate of the water or create suction at the discharge inlet, thereby maximizing the discharge of water from the bath through the discharge unit.

[0019] In an embodiment, the safety system according to invention further comprises a discharge unit for discharging water from the bath, wherein the discharge unit is provided with a discharge inlet which is arranged to be in fluid communication with the bath, a discharge outlet for discharging the water from the discharge unit into an external discharge conduit and a housing extending between the discharge inlet to the discharge outlet, wherein the housing comprises a bottom section and a top section, wherein the bottom section is moveable with respect to the top section between a first position and a second position, wherein, in the first position, the bottom section and the top section together form a trap channel which provides a fluid communication between the discharge inlet and the discharge outlet, wherein, in the second position, the bottom section is in abutment with the top section such that, at the abutment between the bottom section and the top section, a substantially watertight seal is formed in the trap channel between the discharge inlet and the discharge outlet.

[0020] Thus, simply by moving the bottom section of the housing between the first position and the second position, the discharge from the bath can be controlled. When the water from the bath has to be discharged quickly, for example in a case of an emergency where a person is drowning or the temperature of the water is danger-

ously high, the bottom section can be moved quickly into the second position to maximize the discharge of water from the bath.

[0021] In an embodiment the bottom section is arranged to be moveable between the first position and the second position in a substantially translating manner. The bottom section can thus be actuated by a simple, linear actuator. Additionally, contrary to a single rotation, a translating motion is theoretically unlimited. The discharge unit can therefore be designed with a range of translation that is optimized for achieving the required discharge capacity of the discharge unit.

[0022] In an embodiment the bottom section and the top section are interconnected by a collapsible and expandable intermediate section for moving the bottom section between the first position and the second position. The intermediate section can maintain the connection between the bottom section and the top section, while the bottom section is moved with respect to the top section.

[0023] In an embodiment the intermediate section is provided with flexible corrugations for collapsing and expanding the intermediate section. Flexible corrugations can replace a plurality of individually moveable parts to facilitate the expansion or collapse of the intermediate section. Thus, wear and leakage of such individual parts can be prevented.

[0024] In an embodiment the bottom section, the top section and the intermediate section are integrally formed. The sections can be manufactured out of a single piece, for example by blow molding. A single piece can be less prone to wear or leakage when compared to a plurality of individual parts. Thus a simple, compact and reliable construction with minimal components can be achieved.

[0025] In an embodiment the discharge outlet is connected to and moveable with the bottom section. The bottom section can therefore function both as a watertight seal in cooperation with the top section and as a support for the discharge outlet. Thus, a simple, compact and reliable construction with minimal components can be achieved.

[0026] In an embodiment the trap channel is defined by a first bend in the trap channel, wherein the bottom section is provided with a lower barrier which determines an overflow level for the first bend, wherein the top section is provided with an upper barrier which defines a clip level in the trap channel, wherein, in the first position, the clip extends below the overflow level of the bottom section at the first bend. Thus, in the first position, the first bend can trap water which forms a substantially gastight water lock or seal, while, in the second position, the first bend can facilitate a substantially watertight water stop or seal.

[0027] In an embodiment the bottom section is arranged to come into abutment with the clip level of the top section at the first bend. Thus, the shape of the bottom section and the top section as such at the first bend can provide the abutment, without the need for any additional barriers, valves or other sealing components. Thus, a simple, compact and reliable construction with minimal components can be achieved.

[0028] In an embodiment the first bend has the form of a U-shape, wherein the trap channel is further defined by a second bend downstream of the first bend, wherein the second bend has the form of an inverted U-shape which together with the first bend forms an S-shaped series of bends. The second bend allows for the discharge outlet of the discharge unit to be arranged lower with respect to a trap channel having only a single bend.

[0029] In an embodiment the bottom section is moveable from the second position past the first position into an extreme third position, wherein, in the third position, the clip level of the top section does not extend below the overflow level of the bottom section. In situations where the water has to be discharged from the bath extremely quickly, the bottom section can be moved into the third position, in which the water trapping functionality of the trap channel is temporarily at least partly suspended. Thus, the water from the discharge inlet can flow through the first bend and immediately overflow the lower barrier of the bottom section without being hindered by the clip formed by the upper barrier of the top section.

[0030] In an embodiment the trap channel is defined by a second bend downstream of the first bend, wherein the second bend has the form of an inverted U-shape and together with the first bend forms an S-shaped series of bends. The second bend allows for the discharge outlet to be arranged lower with respect to the bath when compared to a trap channel with a single bend.

[0031] In an embodiment the safety system further comprises a supply unit for supplying water to the bath, wherein the supply unit is provided with a supply outlet which is arranged to be in fluid communication with the bath, wherein the supply unit is provided with a stopper at the supply outlet for closing or opening the supply outlet, wherein the supply unit is coupled to the bottom section such that movement of the bottom section also moves the stopper or movement of the stopper also moves the bottom section, wherein, when the bottom section is in the first position, the stopper closes the supply outlet of the supply unit, and wherein, when the bottom section is in the second position, the stopper opens the supply outlet of the supply unit. In this manner, supply and discharge can be automatically alternated.

[0032] In an embodiment the coupling between the bottom section and the supply unit is a mechanical coupling. The mechanical coupling is not prone to electronic failure.

[0033] In an embodiment the supply unit and the bottom section of the discharge unit are arranged to move in unison. Thus, movement of the bottom section between the first and second position can cause an equal movement of the stopper, and vice versa.

[0034] In an embodiment the top section is provided with a fitting element, preferably a grating, for attachment of the discharge unit to the bath, wherein the fitting element comprises a supply opening, wherein the supply

outlet of the supply unit debouches into the supply opening of the fitting element and wherein the stopper cooperates with the supply opening to open or close the supply outlet of the supply unit. The supply opening can thus be arranged at the top section, wherein the supply unit can be moved with respect to the top section to operate the stopper.

[0035] In an embodiment the fitting element is provided with a discharge opening debouching into the discharge inlet of the discharge unit. The discharge opening and the supply opening can be combined in the single fitting element. Thus, the single fitting element attached to the bath can provide both supply and discharge functionality. Additionally a simple, compact and reliable construction with minimal components can be achieved.

[0036] In an embodiment the discharge inlet of the discharge unit has an annular shape that provides a central passage through the housing of the discharge unit, wherein the supply unit is provided with a supply inlet for the intake of water from an external water supply conduit and a supply channel connecting the supply inlet in fluid communication to the supply outlet, wherein supply channel of the supply unit extends through the central passage provided by the discharge inlet of the discharge unit. In this manner, a simple, compact and reliable construction can be achieved wherein supply and discharge functionality is combined.

[0037] In an embodiment the discharge inlet of the discharge unit surrounds the supply outlet of the supply unit. The supply rate of water to the bath is generally less critical than the required rapid discharge of water in case of emergency. By having the discharge inlet at the outside of and surrounding the supply outlet, the diameter of the supply outlet can be kept relatively small yet sufficient for supplying water to the bath at a reasonable supply rate, while the diameter of the discharge inlet can be maximized to allow for rapid discharge.

[0038] In an embodiment at least part of the trap channel has an annular shape surrounding the central passage, wherein at a position along the circumference of the annular trap channel, the trap channel debouches into the discharge outlet of the discharge unit. Due to the annular shape of the trap channel, the trap channel can be arranged around the supply unit, which allows for a more compact assembly of the discharge unit and the supply unit. Furthermore, by having an annular trap channel, the volume of the trap channel can be increased, thereby increasing the capacity of the trap channel and the achievable discharge rate.

[0039] According to a second aspect, the invention provides a bath comprising the aforementioned safety system. The bath incorporating the safety system has the same advantages as the aforementioned safety system for a bath. By incorporating the safety system in the bath rather than adapting an existing bath to be compatible with the safety system, the bath can be sold and installed ready for use. The bath and the safety system can be designed to be compatible and can be assembled in a controlled factory environment.

[0040] In an embodiment the top section is fixedly arranged with respect to the bath, and wherein the bottom section is moveable between the first position and the second position with respect to the bath. The top section can be securely sealed against the bath, thereby preventing leakage. The bottom section can be moved externally, so that the bath itself is not compromised.

[0041] In an embodiment the bath is provided with a bottom and a circumferential wall standing up from the bottom, wherein the bottom and the circumferential wall together define a reservoir for holding water, wherein the discharge unit of the safety system is arranged at the bottom of the bath, in fluid communication with the reservoir. Typically, a bath is installed with some space underneath to accommodate plumbing. Due to the compact design of the discharge unit, this space can be optimally used for allowing the movement of the bottom section of the discharge unit.

[0042] In an embodiment the discharge unit is the only outlet for water from the reservoir at the bottom of the bath. The discharge unit can function both as the regular discharge for water, as well as for the emergency discharge of water.

[0043] In an embodiment the discharge unit is arranged completely underneath the bath, preferably hidden from view by a bath casing. Preferably, also the supply unit is arranged completely underneath the bath, preferably hidden from view by the same bath casing. In this manner, an aesthetically pleasing bath can be achieved, from which it is not immediately apparent that it is a bath specially adapted for emergency discharge of water.

[0044] The various aspects and features described and shown in the specification can be applied, individually, wherever possible. These individual aspects, in particular the aspects and features described in the attached dependent claims, can be made subject of divisional patent applications.

BRIEF DESCRIPTION OF THE DRAWINGS

[0045] The invention will be elucidated on the basis of an exemplary embodiment shown in the attached schematic drawings, in which:

figure 1 shows a bath comprising a safety system according to an exemplary embodiment of the invention;
figure 2 shows a schematic representation of th safety system;
figure 3 shows a schematic representation of the working of a safety system with a person detection unit;
figure 4 shows a schematic representation of an example of the development of the hydrostatic pressure in the bath, as a function of time; and
figures 5A, 5B and 5C show the safety system of figure 1 in various steps of operation.

DETAILED DESCRIPTION OF THE INVENTION

[0046] Figure 1 shows a bath 1 comprising a safety system according to an exemplary embodiment of the invention. The bath 1 with the safety system according to the invention can be used for accommodating a person who is not self-reliant, e.g. a person that cannot keep himself from drowning or a person that is not able to assess or act on the temperature of the water contained in the bath 1 in case of an unsafe temperature.

[0047] As shown in figure 1, the bath 1 comprises a bottom 11 and a circumferential wall 12 standing up from the bottom 11. The bottom 11 and the wall 12 define a bath volume 10 for holding water M. The bottom 11 and the wall 12 are supported at a distance from the ground by a bath casing 13. The casing 13 can also hide the plumbing and the part of the safety system which is arranged underneath the bath 1. The bath 1 is provided with a single bath outlet 14 at the bottom 11.

[0048] As shown in figures 1 and 2, the safety system comprises a mixing unit 93 which is arranged between the mixed water conduit 92 and a set of hot and cold water conduits 94, 95 which are typically available in a sanitary environment. The mixing unit 93 comprises various compartments (not shown) in which mixing valves 96, 97 and a block valve 98 are arranged. The mixing unit 93 comprises a first valve 96 arranged in the input line 94 for hot water and a second valve 97 arranged in the input line 95 for cold water, wherein the input line 94 for hot water and the input line 95 for cold water are combined at a position downstream from said first and second valves 96, 97 to form a supply line 92', wherein the flow sensor 75 is arranged in said supply line 92'. If the bath 1 is a bath/shower combination having a separate shower head arranged above the bath 1, then the mixing unit 93 will also include shuttle valves 99, 99' for selecting either the mixed water conduit 92 of the bath 1 or a secondary mixed water conduit (not shown) leading to the shower head.

[0049] In an embodiment of the invention, the safety system comprises a user interface 70 arranged within reach of the person accommodated in the bath 1 or within reach of a nurse monitoring the person accommodated in the bath 1. The user interface 70 is provided with an internal controller 7 which receives signals from various sensors or detection units of the safety system and which sends control signals to the various components of the safety system, for example to the actuator 8 which will be explained in more detail below, and the mixing unit 93. The user interface 70 is provided with a control panel 71 and a display 72 for respectively inputting and displaying parameters associated with or derived from the sensor signals received from the safety system.

[0050] As indicated schematically in figure 2, the control panel may be provided with a manual input buttons 105 for inputting data to the controller 7, such as desired temperature of the water 101, desired height of the water level 102 and weight or volume of the person 100. Preferably these input data is preprogrammed and cannot be changed or inputted without gaining access to the system via a password and/or key, for example a magnetic key 103. In this case, the input buttons 105 are used to select the name of the person who would like to take a bath from a list of preprogrammed persons, which list also comprises the preprogrammed temperature of the water 101, height of the water level 102 and weight or volume of the person 100. The person in the bath can however start the working of the bath by pushing the start button 106, can activate the shower (if present) by pushing the shower button 107 and/or in case of emergency push the alarm button 108.

[0051] The safety system comprises a detection unit 77 which is arranged in the mixing unit 93. The detection unit 77 comprises a flow meter or flow sensor 75 which is arranged in the flow of water being supplied to the bath 1 for measuring said flow of water, prior to it entering the bath volume 10. The flow sensor 75 can for example be located upstream of the supply outlet 61 of the supply unit 6 as shown in more detail in figures 5A, 5B and 5C, preferably in one of the compartments of the mixing unit 93. The flow sensor 75 sends a signal indicative of the measured flow to the controller 7, wherein the controller 7 is arranged for determining the total amount of water being supplied to the bath volume 10 over a period of time based on the received signal. Based on the calculated total amount of water, the controller 7 can then calculate the theoretical water level W based on a given volume and shape of the bath volume 10. When a predetermined water level W is theoretically reached, the controller 7 takes action to prevent the water level W from rising further, e.g. by activating the block valve 98 for terminating the supply of water to the bath volume 10 or, in case of emergency, by discharging the water M already in the bath volume 10. For this purpose, the controller can be connected to the actuator 8 for controlling the discharge unit 2.

[0052] When a user inputs information via the user interface 70 about the person to be accommodated in the bath 1, e.g. about the weight 100, length and or volume of the person, the controller 7 can be programmed to derive and subtract at least part of a volume of the person from the bath volume 10 to obtain a value for the remaining volume of the bath to be filled with water M.

[0053] Optionally, for example as a fail-safe, the detection unit 7 additionally comprises a water level sensor 73. In the embodiment shown the water level sensor 73 comprises a pressure sensor arranged in or near the bottom 11 of the bath 1. In this particular embodiment the pressure sensor is arranged inside a part of the discharge unit 2 which is constantly in fluid connection with the interior of the bath 1. The position of the water surface W in the bath can be difficult to accurately determine, because the position of the water surface W can be inconsistent due to movements of the person accommodated in the bath 1. Although movements of the person accommodated in the bath can also provide variations in the

signal from the pressure sensor 73, measuring the hydrostatic pressure in or near the bottom 11 of the bath 1 provides a more reliable parameter for determining and controlling the actual water level W. An example of the hydrostatic pressure P as measured by the pressure sensor 73 as a function of time t is shown in figure 3. Pressure variations 73' due to movements of the person in the bath 1 are usually characterized by their relatively short time period and/or a substantially random character. Pressure variations 73" due to a total submergence of the person in the bath 1 is usually characterized by a substantial increase in the hydrostatic pressure during a longer time period. In an embodiment the controller 7 is arranged to distinguish between these modes of variations of the hydrostatic pressure, and to activate an alarm unit 15 when an increase of the hydrostatic pressure is measured which can be attributed to a submergence of the person, for example such as the variation 73" in figure 3.

[0054] As discussed above, the level sensor 73, which is arranged for detecting the actual water level in the bath 1, sends a signal indicative of the detected actual water level to the controller 7. In addition or alternatively the controller 7 is arranged, upon receipt of a signal from the level sensor 73, to compare the actual water level with the theoretical water level as calculated from the input from the flow sensor 75, preferably taking the volume of the person in the bath 1 into account, and preferably taking into account that at least the head and preferably a shoulder portion of the person is not submerged in the water. The combination of the measurements of both a flow sensor 75 and a level sensor 73 can provide increased safety, for example as a failsafe when one of the sensors malfunctions or by having the controller detect a discrepancy between the two sensors.

[0055] As discussed above, it is preferred that, for calculating the theoretical water level TWL in the bath, it is taken into account that at least the head and preferably a shoulder portion of the person is not submerged in the water. The theoretical water level thus should be the water level in the bath when a person is in the bath and the head and preferably a shoulder portion of this person in the bath is out of the water. In an embodiment, the controller 7 is arranged for activating said alarm unit 15 when the actual water level AWL is higher than the theoretical water level TWL, and the difference Δ between the actual water level AWL and the theoretical water level TWL is larger than a predetermined level difference. When the actual water level AWL is higher than the theoretical water level TWL, the person in the bath is submerged more than desired or even fully submerged.

[0056] In addition or alternatively, the controller 7 is arranged for terminating the supply of water to the bath volume 10 and/or discharging the water M already in the bath volume 10 either based on a signal from the flow sensor 75 or the water level sensor 73.

[0057] In addition or alternatively, the safety system comprises a person detection unit 81. In the example as shown in figures 1 and 4, the person detection unit 81 is arranged in the user interface 70. The person detection unit 81, may alternatively be arranged separately at a side of the bath 1. As schematically indicated in figure 4, the person detection unit 81 comprises a distance measuring unit which arranged at a side of the bath and above the bath 1. The distance measuring unit 81 is arranged for measuring a distance d between the position of the distance measuring unit 81 at the side of the bath 1 and a part of a person in the bath, which part is above the water level W. The person detection unit 81 are arranged for sending signals indicative of the measured distance d to the controller 7.

[0058] The bath 1 shown in the examples, is an elongated bath having two longitudinal sides and two transverse sides, wherein the measuring unit 81 is arranged on a first transverse side 121 of the bath 1. The bath 1 is arranged to provide a seating accommodation 123 at or near the second side 122 of the bath 1. Preferably the outlet or discharge opening 14 of the bath 1 is arranged in the bottom wall 11, at or near the first side 121 of the bath as shown in figure 1.

[0059] The distance measuring unit 81 is arranged above the surface of the water W in the bath 1 and measures the distance d along a line of sight which extends over the surface of the water, as schematically shown in figure 4. When the measured distance d is substantially equal or larger than a distance between the first side 121 and the second side 122, there is substantially no part of the person above the surface W of the water, thus the person in the bath is substantially submerged or even fully submerged. In this case the alarm unit 15 is activated by the controller 7. Preferably the controller 7 is arranged for activating said alarm unit 15 when the measured distance d is larger than a distance between the first side 121 of the bath 1 and the part of the person which is in the line of sight, at least when the person is sitting in the bath 1 with his or her back abutting against the inner wall of the bath at the second side 122 of the bath.

[0060] Various distance measuring sensor can be applied. Preferably distance measuring comprises an optical distance measuring sensor, preferably using Infra-Red light.

[0061] The combination of a person detection system 81 and a water level control system, comprising the flow sensor 75 and controller 7, and detection system, comprising the pressure sensor 73, yields a double acting safety system, which reduces the changes of failure of the safety system and which provides an increased safety for the person accommodated in said bath 1, in particular an increased safety against drowning.

[0062] In addition or alternatively, the mixing unit 93 is provided with a first temperature sensor 76 which is arranged for measuring the temperature of the water at or after mixing, yet prior to entering the bath 1. The first temperature sensor 76 is part of the safety system. In addition the safety system comprises a second temperature sensor 74 for directly measuring the temperature of the water M in the bath 1. In this particular embodiment

the second temperature sensor 74 is arranged inside a part of the discharge unit 2 which is constantly in fluid connection with the interior of the bath 1. Both sensors 73, 74 are arranged for sending signals indicative of the measured temperatures to the controller 7, wherein, when one of the measured temperatures reaches a predetermined upper value, the controller 7 is arranged for terminating the supply of mixed water to the bath 1, activating the valves 96, 97 for adjusting the mixing ratio of the hot, and cold water, discharging the water already in the bath and/or activating the alarm unit 15. The combination of both a first temperature sensor 76 and a second temperature sensor 74 can provide increased safety, for example as a failsafe when one of the sensors malfunctions or by having the controller detect a discrepancy between the two sensors.

[0063] The safety system comprises a discharge unit 2 for draining or discharging water M from the bath 1, a supply unit 6 for supplying water M to the bath 1 and a detection unit 7 for detecting various parameters of the water M in the bath 1. The discharge unit 2, the supply unit 6 and the detection unit 7 can be applied to the bath individually or in combination, as will be elucidated below.

[0064] Figure 2A shows the discharge unit 2 in more detail. The discharge unit 2 comprises a housing 20 with a discharge inlet 21, a discharge outlet 23 and a trap channel 22 which connects the discharge inlet 21 to the discharge outlet 23. The housing 20 is arranged underneath the bottom 11 of the bath 1. The housing 20 has a substantially annular shape from which only the discharge outlet 23 extends radially. The annular shape defines a center axis S of the housing 20. The discharge inlet 21 and the trap channel 22 are arranged concentrically about the center axis C and - due to the annular shape of the housing 20 - define a central passage 27 in the housing 20 at the center axis S.

[0065] The discharge inlet 21 is connected to or arranged in fluid communication with the bath volume 10 via the bath outlet 14 in the bottom 11 of the bath 1. The discharge outlet 23 is connected to or arranged in fluid communication with an external waste water discharge conduit 91 which is typically available in a sanitary environment. The discharge outlet 23 extends under a substantially right angle with respect to the discharge inlet 21, to allow for horizontal connection to the waste water discharge conduit 91 and vertical connection to the bath outlet 14. Preferably, the waste water discharge conduit 91 is made of a flexible material or has an adapter piece that forms a flexible connecting with the discharge outlet 23. Such flexibility allows for vertical movement of the discharge unit 2 with respect to the horizontal waste water discharge conduit 91.

[0066] The trap channel 22 is of the siphon-type, having a first U-shaped bend 25 for trapping water. The trapped water can form a water seal or a water lock between the discharge inlet 21 and the discharge outlet 23, thereby preventing stench from the sewer from venting into the bath volume 11. In this exemplary embodiment, the trap channel 22 is provided with a second, inverted U-shaped bend 26 which, together with the first bend 25 forms an S-shaped series of bends 25, 26. The second bend 26 allows for the discharge outlet 23 to be arranged below or at the level of the first bend 25. In this exemplary embodiment, the discharge outlet 23 is arranged substantially flush with the underside of the housing 20.

[0067] The housing 20 comprises a bottom section 3 and a top section 4. Throughout the description and in the claims, the terminology 'bottom', 'top', 'upper' and 'lower' refers to the mutual orientation of interrelated components with respect to the vertical or gravitational direction. As such, the bottom section 3 is arranged at the side of the housing 20 facing away from the bottom 11 of the bath 1, while the top section 4 is arranged at the side of the housing 20 facing towards the bottom 11 of the bath 1. The top section 4 is fixedly attached to the bath 4. The bottom section 3 and the top section 4 are interconnected via an intermediate section 5. In this exemplary embodiment, the bottom section 3, the top section 4 and the intermediate section 5 are integrally formed by blow molding an elastomeric, thermoplastic material such as rubber into the required hollow shape. By forming the housing 20 as a single, integral part, leakage can be prevented.

[0068] As shown in figure 2A, the bottom section 3 comprises a bottom wall 30 which forms the lower boundary for the housing 20. The bottom wall 30 is provided with a lower barrier 31 extending upwards towards the top section 4 at the radially outer side of the first bend 25. The lower barrier 31 defines an overflow level for the water trapped in the first bend 25. The bottom wall 30 merges at a radial position of the annular housing 20 into the discharge outlet 23.

[0069] The top section comprises a top wall 40 which forms the upper boundary for the housing 20. The top wall 40 is provided with an upper barrier 41 extending downwards towards the bottom section 3 between the discharge inlet 21 and the lower barrier 31. The lowest point of the upper barrier 41 defines a clip or clip level in the first bend 25. In the situation as shown in figure 2A, the upper barrier 41 extends into the first bend 25 and defines a clip level that is past or underneath the overflow level of the lower barrier 31. The water M has to flow underneath the clip level before reaching the other end of the first bend 25. The overlap distance H1 between the overflow level and the clip level defines the strength of the water lock.

[0070] The discharge unit 2 is provided with a fitting element 45, preferably in the form of a grating, which is arranged to fit and seal the discharge inlet 21 in the bath outlet 14 in the bottom 11 of the bath 1. The fitting element 45 comprises a plurality of discharge openings 46 which are evenly distributed about the center axis C, directly above and in fluid communication with the discharge inlet 21. The fitting element 45 is further provided with a central supply opening 47 which, when combined with the supply unit 6, functions as an integrated bath inlet within the bath

outlet 14 of the bath 1.

[0071] The intermediate section 5 can be formed by any suitable connection that can be contracted and extended, or collapsed and expanded, while maintaining the watertight seal between the bottom section 3 and the top section 4. In this exemplary embodiment, the intermediate section 5 comprises a connecting wall 50 which forms a continuous watertight connection between the bottom section 3 and the top section 4. The connecting wall 50 comprises a plurality of flexible folds or corrugations 51 which form a collapsible and expandable connection, a contractible and extendable connection, or a foldable and unfoldable connection between the bottom section 3 and the top section 4. The intermediate section 5 facilitates the translating movement of the bottom section 3 with respect to the top section 4 in a substantially vertical, upward first direction A and a substantially vertical downward second direction B, parallel to the center axis C. The bottom section 3 can be moved between a first position as shown in figure 2A, a second position as shown in figure 2B and optionally an extreme third position as shown in figure 2C.

[0072] As shown in figure 1, the safety system is provided with an actuator 8, for example in the form of a linear drive, which is operationally coupled to the housing 20, preferably directly to the bottom section 3, to move the bottom section 3 with respect to the top section 4 in the first direction A or the section direction B.

[0073] As shown in figure 2A, the supply unit 6 is provided with a housing 60, a supply outlet 61 at one end of the housing 60, a supply inlet 63 at an opposite side of the housing 60 and a supply channel 62 formed in the housing 60. The supply channel 62 connects the supply inlet 63 to the supply outlet 61. The supply outlet 61 is connected to or arranged in fluid communication with the bath volume 10. The supply inlet 63 is connected to or arranged in fluid communication with a mixed water conduit 92 from which clean water, which is mixed from hot and cold water to a predetermined temperature, is provided. Preferably, mixed water conduit 92 is made of a flexible material or has an adapter piece that forms a flexible connecting with the supply inlet 63. Such flexibility allows for vertical movement of the supply unit 6 with respect to the horizontal mixed water conduit 92.

[0074] In this example, the supply outlet 61 extends through the central passage 27 in the housing 20 of the discharge unit 2, where, at the upper end of the passage 27, the supply outlet 61 is arranged in fluid communication with the supply opening 47 in the center of the fitting element 45. The supply unit 6 is provided with a stopper 65 at the supply outlet 61. The stopper 65 is arranged to engage, come in abutment with or cooperate with the supply opening 47 of the fitting element 45 such that the supply outlet 61 of the supply unit 63 can be selectively closed or opened. Optionally, the stopper 65 is attached to the supply outlet 61 via an extendable part, for example a telescopic section 64, such that the supply outlet 61 can be moved further downwards after the stopper 65 has engaged with the fitting element 45. The supply inlet 63 extends under a substantially right angle with respect to the supply outlet 61, to allow for horizontal connection to the mixed water conduit 92 and vertical connection to the fitting element 47.

[0075] In the embodiment as shown in figure 2A, the supply unit 6 is operationally coupled to the discharge unit 2, such that a movement of the bottom section 3 with respect to the top section 4 also controls or moves the stopper 65 at the supply outlet 61. Preferably, the supply unit 6 is mechanically coupled to the discharge unit 2, for example at the center passage 27. When the supply unit 6 is fixedly coupled to the discharge unit 2, the discharge unit 2 and the supply unit 6 can be moved in unison between the first position as shown in figure 2A, the second position as shown in figure 2B and optionally the extreme third position as shown in figure 2C.

[0076] The operation of the discharge unit 2 will be described hereafter with reference to figures 2A-C.

[0077] In figure 2A, the situation is shown wherein the bottom section 3 has been moved by the actuator 8 of figure 1 into the first position. In the first position, the trap channel 22 of the housing 20 provides a continuous fluid communication between the discharge inlet 21 and the discharge outlet 23. Thus, water M in the bath 1 is allowed to enter the discharge unit 2 via discharge openings 46 in the fitting element 45 and the annular discharge inlet 21. Due to the annular arrangement of the discharge inlet 21, the capacity of the discharge inlet 21 can be significantly increased, as the water can enter the discharge inlet 21 at any point around its circumference. The water M subsequently flows through the trap channel 22 and exits the housing 20 through the discharge outlet 23. The flow of discharging water is indicated schematically with two arrows D1 and D2. The flow of discharging water D2 that enters the part of the housing 20 which is furthest away from the discharge outlet 23 is collected in the annular trap channel 22 and merges with the other flows of discharging water D1. After all the water M has been discharged from the bath 1, some water will remain in the first bend 25 of the trap channel 22, thereby forming a water lock.

[0078] In figure 2B, the situation is shown wherein the bottom section 3 has been moved by the actuator 8 of figure 1 into the second position. The corrugations 51 in the wall 51 have been contracted, collapsed or folded with respect to their original state as shown in figure 2A, such that the height of the wall 51, and thus the distance between the bottom section 3 and the top section 4 is reduced. In the second position, the bottom wall 30 of the bottom section 3 has approached the top wall 40 of the top section 4 and is in abutment with the top wall 40 at the upper barrier 41. The abutment between the bottom section 3 and the top section 4 forms a water stop or a substantially watertight seal D in the trap channel 22 between the discharge inlet 21 and the discharge outlet 23. Due to the annular shape of the housing 20, the formed seal D extends annularly about the center axis C. The

formed seal D prevents water M from flowing out of the bath 1. Thus, in this situation, the bath 1 can be filled with water M.

[0079] In figure 2C, the situation is shown wherein the bottom section 3 has been moved by the actuator 8 of figure 1 from the second position as shown in figure 2B into the extreme third position. The corrugations 51 in the wall 51 have extended, expanded or unfolded past their normal state as shown in figure 2A. As a result, the height of the wall 51, and thus the distance between the bottom section 3 and the top section 4 has been maximized. The clip level defined by the lowest point of the upper barrier 41 does no longer extend past or underneath the overflow level defined by the highest point of the lower barrier 31, such that the original overlap height H1 as shown in figure 2A is inverted into a clearance height H2. The clearance height H2 between the clip level and the overflow level temporarily terminates or suspends the water lock of the trap channel 22 and increases the flow capacity of the trap channel 22. The water M can immediately flow from the discharge inlet 21 to the discharge outlet 23, as indicated with discharge flow arrows D1 and D2, without having to overcome the siphon effect of the trap channel 22. Thus, the third position of the bottom section 3 allows for rapid or accelerated discharge of the water M from the bath 1.

[0080] The operation of the supply unit 6 in combination with the discharge unit 2 will be described hereafter, again with reference to figures 2A-C.

[0081] As indicated before, the supply unit 6 is mechanically coupled to the discharge unit 2 so as to move in unison with the discharge unit 2. Thus, when the bottom section 3 of the discharge unit 2 moves between the first, second and third position, the supply unit 6 is moved up and down over the same distance.

[0082] When the bottom section 3 is in the first position, as shown in figure 2A, the stopper 65, in cooperation with the supply opening 47 in the fitting element 45, closes the supply outlet 61 of the supply unit 6. Mixed water, supplied through the mixed water conduit 92 cannot enter the bath 1. When the bottom section 3 is moved into the second position, as shown in figure 2B, the stopper 65 will be moved upwards together with the bottom section 3, until it is clear of the supply opening 47 in the fitting element 45. Now the supply outlet 61 of the supply unit 6 is opened and mixed water from the mixed water conduit 92 is allowed to flow via the supply outlet 61 into the bath 1, as indicated with supply flow arrows S. At the same time, the watertight seal D is formed in the trap channel 22 of the discharge unit 2, thereby preventing the water M from flowing out of the bath 1. When the bath 1 is full, a valve, for example the closing valve in the mixing unit 93, can interrupt the supply flow S, such that the filling of the bath 1 is interrupted and the current water level is maintained.

[0083] Thus, by controlling the supply unit 6 together with the discharge unit 2, the supply and discharge of water M into and from the bath 1, respectively, can be automatically alternated.

[0084] When the bottom section 3 is moved from the second position into the third position, as shown in figure 2C, the stopper 65 is moved downwards correspondingly. The stopper 65 engages with the fitting element 45 and closes the supply outlet 61 as the bottom section 3 moves through the first position as shown in figure 2A. Now, the telescopic section 64 starts extending the connection between the stopper 65 and the supply outlet 61 such that the supply unit 6 can be moved further downwards together with the bottom section 3 of the discharge unit 2. Meanwhile, the stopper 65 remains engaged with the fitting element 45 and as such closes the supply outlet 61 of the supply unit 6.

[0085] In an alternative embodiment (not shown) the aforementioned safety system is provided with a pump in the housing 20 of the discharge unit 2 or downstream thereof for accelerating the discharge of the water M from the bath volume 10.

[0086] In summary, the invention relates to a safety system for a bath and a bath comprising said safety system. The safety system comprising a detection unit with a controller and a flow sensor which is arranged for measuring a flow of water being supplied to the bath. The sensor is arranged for sending a signal indicative of the measured flow to the controller, and the controller is arranged for determining the total amount of water being supplied to the bath and for calculating the theoretical water level in the bath. When the theoretical water level reaches a predetermined water level, the controller is arranged for terminating the supply of water to the bath and/or discharging the water already in the bath. Preferably the detection unit additionally comprises a level sensor which is arranged for sending a signal indicative of the detected actual water level to the controller. The controller is arranged for comparing the actual water level with the theoretical water level.

[0087] In addition or alternatively, the safety system comprises a discharge unit for discharging water from the bath, wherein the discharge unit is provided with a discharge inlet, a discharge outlet and a housing, wherein the housing comprises a bottom section and a top section, wherein the bottom section is moveable with respect to the top section between a first position and a second position, wherein, in the first position, the bottom section and the top section together form a trap channel between the discharge inlet and the discharge outlet, wherein, in the second position, the bottom section is in abutment with the top section such that, at the abutment between the bottom section and the top section, a substantially watertight seal is formed in the trap channel between the discharge inlet and the discharge outlet.

[0088] It is to be understood that the above description is included to illustrate the operation of the preferred embodiments and is not meant to limit the scope of the invention. From the above discussion, many variations will be apparent to one skilled in the art that would yet be encompassed by the scope of the present invention.

Claims

1. Safety system for a bath comprising a detection unit with a controller and a flow sensor which is arranged for measuring a flow of water being supplied to the bath and for sending a signal indicative of the measured flow to the controller, wherein the controller is arranged for determining the total amount of water being supplied to the bath over a period of time based on the received signal and for calculating the theoretical water level based on a given volume and shape of the bath, wherein, when the theoretical water level reaches a predetermined water level, the controller is arranged for terminating the supply of water to the bath and/or discharging the water already in the bath.

2. Safety system according to claim 1, wherein the controller is arranged for subtracting at least part of a given volume of a person that is to be accommodated in the bath from the volume of the bath to obtain a value for the remaining volume of the bath to be filled with water, and/or wherein the controller is connected to an alarm unit and is arranged for activating said alarm unit.

3. Safety system according to claim 1 or 2, wherein the detection unit additionally comprises a level sensor which is arranged for detecting the actual water level in the bath and for sending a signal indicative of the detected actual water level to the controller, wherein, upon receipt of a signal from the level sensor, the controller is arranged for comparing the actual water level with the theoretical water level.

4. Safety system according to claim 3, wherein the level sensor comprises a pressure sensor, which is arranged in the bath, preferably in or near the bottom of the bath, or in or near an outlet unit in the bottom of the bath, and/or wherein the controller is arranged for activating said alarm unit when the actual water level is higher than the theoretical water level, and the difference between the actual water level and the theoretical water level is larger than a predetermined level difference.

5. Safety system according to any one of the claims 1 - 4, wherein the safety system comprises a person detection unit, wherein the person detection unit comprises a distance measuring unit which arranged at a first side of the bath and above a maximum water level in the bath, wherein the distance measuring unit is arranged for measuring a distance between the first side of the bath and a part of a person in the bath, which part is above said maximum water level, preferably wherein the distance measuring unit comprises an optical distance measuring unit, preferably using Infra-Red light, preferably wherein the bath is an elongated bath having two longitudinal sides and two transverse sides, wherein the first side of the bath is one of said transverse sides.

6. Safety system according to claim 5, when dependent on claim 2, wherein the controller is arranged for activating said alarm unit when the measured distance is larger than a distance between the first side of the bath and the part of the person, at least when the person is sitting in the bath with his back abutting against a second side of the bath which second side is substantially opposite to said first side of the bath.

7. Safety system according to any one of claims 1 - 6, wherein the safety system is provided with a mixing unit for mixing hot and cold water into mixed water with a predetermined temperature, wherein the detection unit further comprises a first temperature sensor which is arranged for measuring the temperature of the water at or after mixing, yet prior to entering the bath, and a second temperature sensor for measuring the temperature of the water in the bath, wherein both sensors are arranged for sending signals indicative of the measured temperatures to the controller, wherein, when one of the measured temperatures reaches a predetermined upper value, the controller is arranged for terminating the supply of mixed water to the bath, adjusting the mixing ratio of the hot and cold water and/or discharging the water already in the bath.

8. Safety system according to claim 7, wherein the mixing unit comprises a first valve arranged in the input line for hot water and a second valve arranged in the input line for cold water, wherein the input line for hot water and the input line for cold water are combined at a position downstream from said first and second valves to form a supply line, wherein the flow sensor is arranged in said supply line, preferably wherein the first temperature sensor is arranged in said supply line.

9. Safety system according to any one of the preceding claims, further comprising a pump for accelerating the discharge of water from the bath.

10. Safety system for a bath, in particular according to any one of the preceding claims, comprising a discharge unit for discharging water from the bath, wherein the discharge unit is provided with a discharge inlet which is arranged to be in fluid communication with the bath, a discharge outlet for discharging the water from the discharge unit into an external discharge conduit and a housing extending between the discharge inlet to the discharge outlet, wherein the housing comprises a bottom section and a top section, wherein the bottom section is moveable with respect to the top section between a first

position and a second position, wherein, in the first position, the bottom section and the top section together form a trap channel which provides a fluid communication between the discharge inlet and the discharge outlet, wherein, in the second position, the bottom section is in abutment with the top section such that, at the abutment between the bottom section and the top section, a substantially watertight seal is formed in the trap channel between the discharge inlet and the discharge outlet.

11. Safety system according to claim 10, wherein the bottom section is arranged to be moveable between the first position and the second position in a substantially translating manner, preferably wherein the discharge outlet is connected to and moveable with the bottom section, preferably wherein the bottom section and the top section are interconnected by a collapsible and expandable intermediate section for moving the bottom section between the first position and the second position, preferably wherein the intermediate section is provided with flexible corrugations for collapsing and expanding the intermediate section, preferably wherein the bottom section, the top section and the intermediate section are integrally formed.

12. Safety system according to claim 10 or 11, wherein the trap channel is defined by a first bend in the trap channel, wherein the bottom section is provided with a lower barrier which determines an overflow level for the first bend, wherein the top section is provided with an upper barrier which defines a clip level in the trap channel, wherein, in the first position, the clip extends below the overflow level of the bottom section at the first bend, preferably wherein the bottom section is arranged to come into abutment with the clip level of the top section at the first bend, preferably wherein the first bend has the form of a U-shape, wherein the trap channel is further defined by a second bend downstream of the first bend, wherein the second bend has the form of an inverted U-shape which together with the first bend forms a S-shaped series of bends, preferably wherein the bottom section is moveable from the second position past the first position into an extreme third position, wherein, in the third position, the clip level of the top section does not extend below the overflow level of the bottom section.

13. Safety system according to claim 10 11, or 12, further comprising a supply unit for supplying water to the bath, wherein the supply unit is preferably arranged in fluid communication with the mixing unit, in particular the supply line of the mixing unit, wherein the supply unit is provided with a supply outlet which is arranged to be in fluid communication with the bath, wherein the supply unit is provided with a stopper at the supply outlet for closing or opening the supply outlet, wherein the supply unit is coupled to the bottom section such that movement of the bottom section also moves the stopper or movement of the stopper also moves the bottom section, wherein, when the bottom section is in the first position, the stopper closes the supply outlet of the supply unit, and wherein, when the bottom section is in the second position, the stopper opens the supply outlet of the supply unit, preferably wherein the coupling between the bottom section and the supply unit is a mechanical coupling, preferably wherein the supply unit and the bottom section of the discharge unit are arranged to move in unison, preferably wherein the discharge inlet of the discharge unit surrounds the supply outlet of the supply unit.

14. Safety system according to claim 13, wherein the top section is provided with a fitting element, preferably a grating, for attachment of the discharge unit to the bath, wherein the fitting element comprises a supply opening, wherein the supply outlet of the supply unit debouches into the supply opening of the fitting element and wherein the stopper cooperates with the supply opening to open or close the supply outlet of the supply unit, preferably wherein the fitting element is provided with a discharge opening debouching into the discharge inlet of the discharge unit.

15. Safety system according to claim 13 or 14, wherein the discharge inlet of the discharge unit has an annular shape that provides a central passage through the housing of the discharge unit, wherein the supply unit is provided with a supply inlet for the intake of water from an external water supply conduit and a supply channel connecting the supply inlet in fluid communication to the supply outlet, wherein supply channel of the supply unit extends through the central passage provided by the discharge inlet of the discharge unit, preferably wherein at least part of the trap channel has an annular shape surrounding the central passage, wherein at a position along the circumference of the annular trap channel, the trap channel debouches into the discharge outlet of the discharge unit.

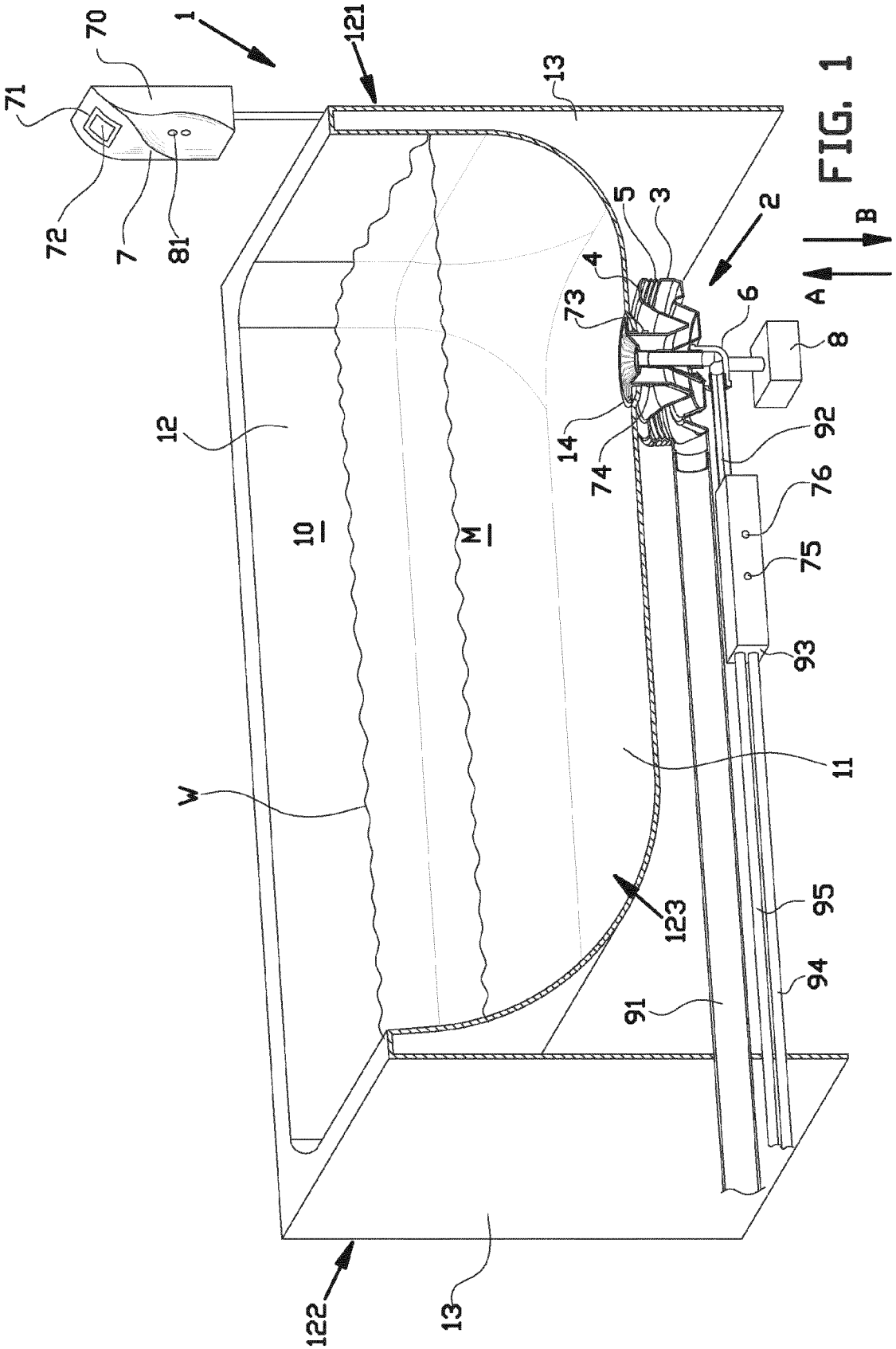
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FIG. 1

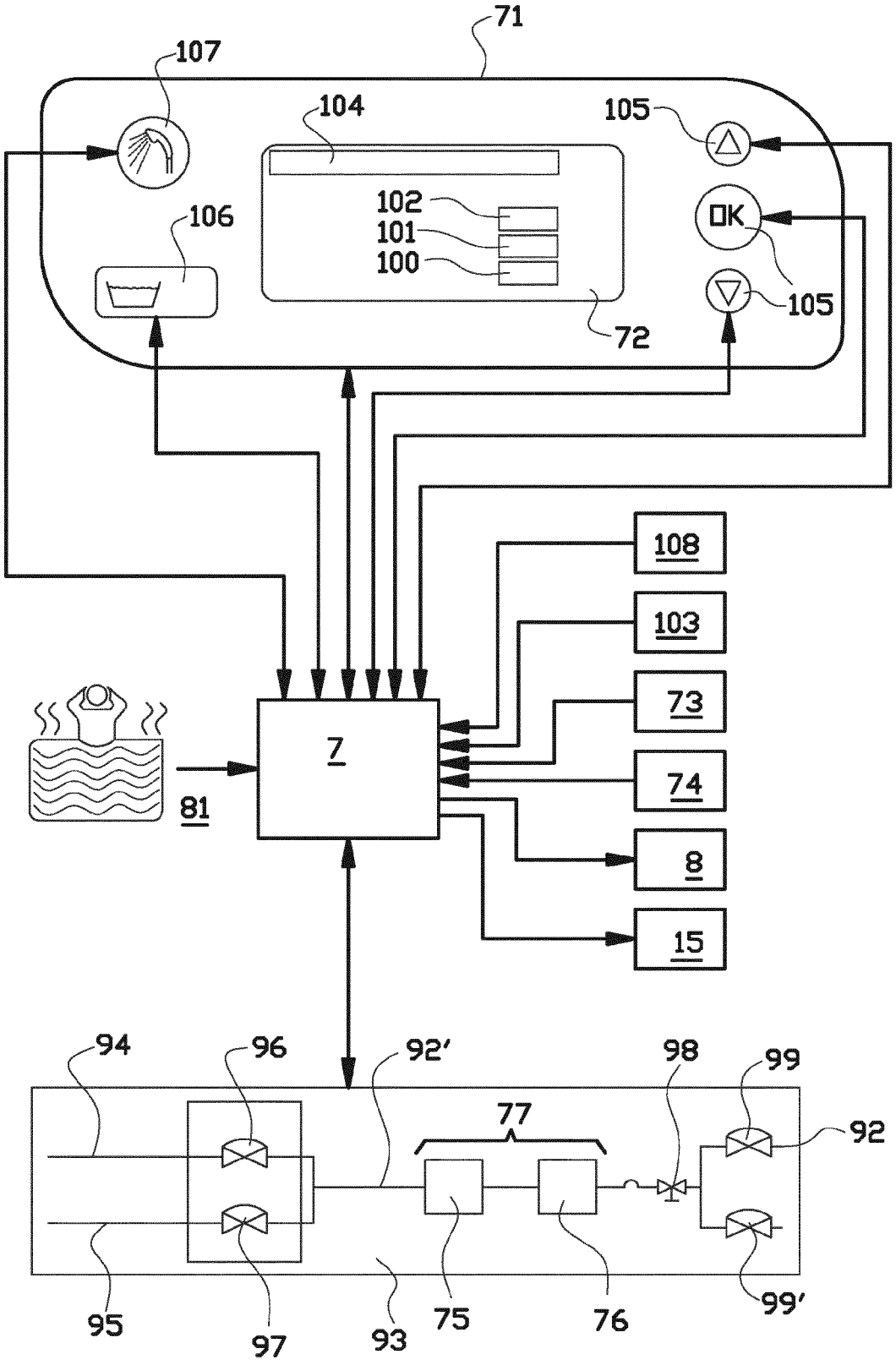
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FIG. 2

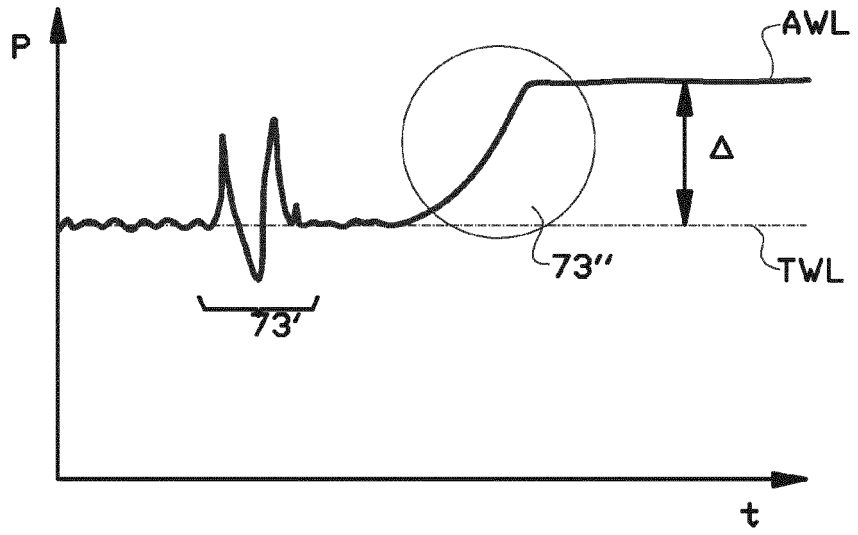

FIG. 3

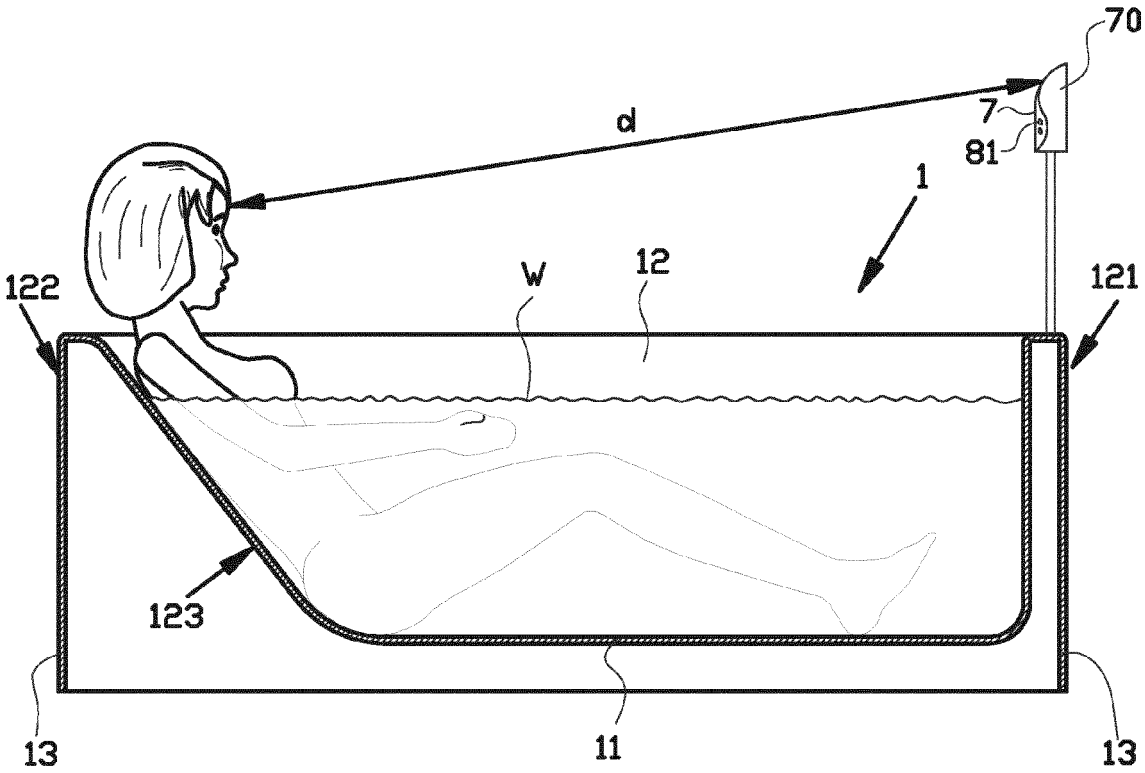

FIG. 4

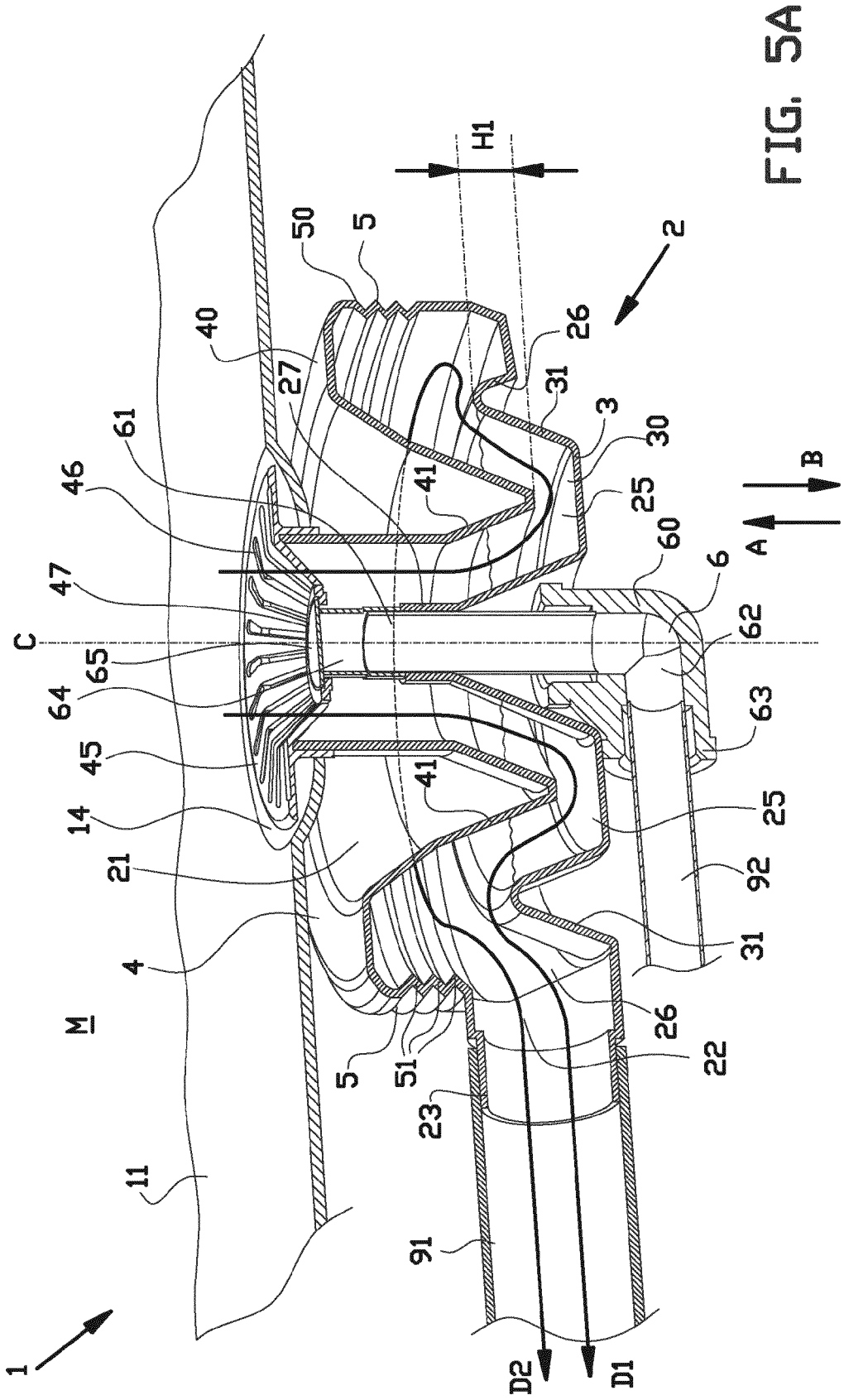
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FIG. 5A

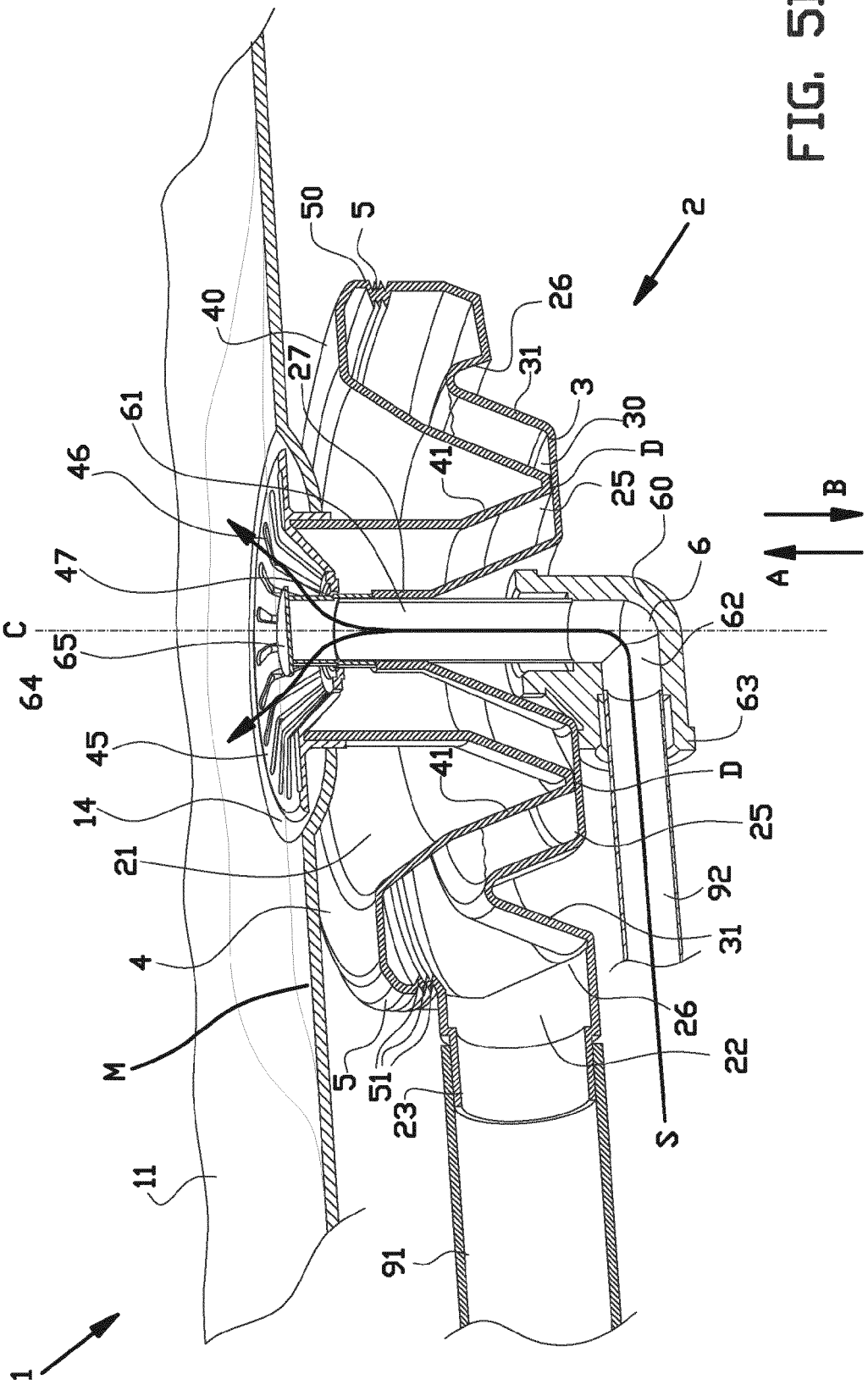
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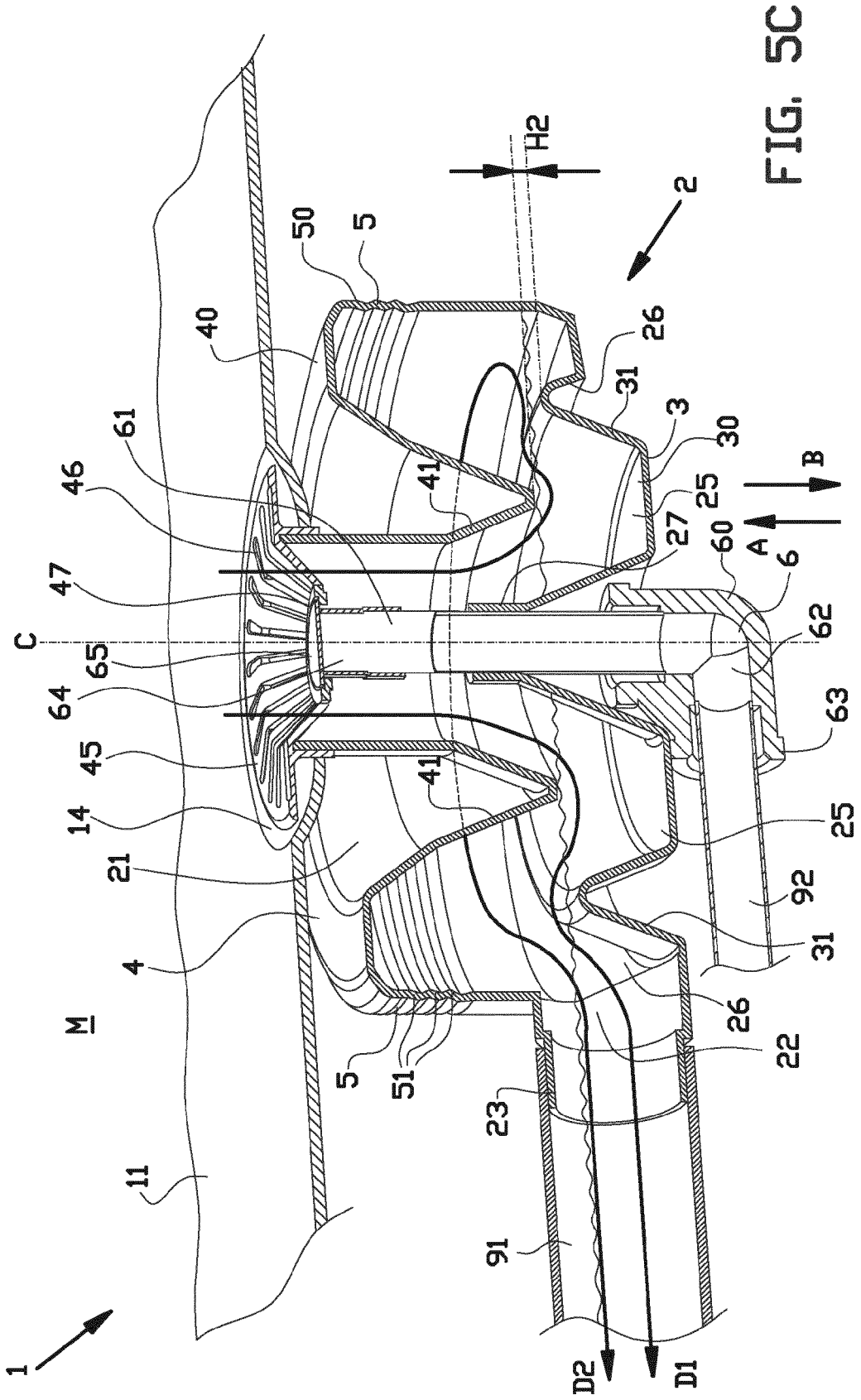
FIG. 5B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91
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D2
D1

FIG. 5C